INTERNATIONAL CIVIL AVIATION ORGANIZATION
NATIONAL ACADEMY OF SCIENCES OF UKRAINE
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

PROCEEDINGS

OF THE THIRD WORLD CONGRESS "AVIATION IN THE XXI-st CENTURY"

"SAFETY IN AVIATION AND SPACE TECHNOLOGY"

Volume 2

September 22-24, 2008
Kyiv, Ukraine

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V.P. Kharchenko, Doc. Sci. (Eng.),
Yu.V. Chynchenko, Cand. Sci. (Eng.)
(National Aviation University, Ukraine)

ANALYSIS OF TECHNICAL AND CULTURAL FACTORS INFLUENCING "AIR TRAFFIC CONTROLLER – PILOT" COMMUNICATION LOOP

Principles of application of information processing models and taxonomies for Air Traffic Control are considered. Analysis of cultural and technical factors influencing "Air traffic controller-pilot" communication loop is given.

Introduction

Aeronautical system of Ukraine requires instruments and methods that can be used to study differences among national cultures and also to elicit differences in employees' perceptions between different organisations or between different groups within the same organisation. Furthermore, for the Air Traffic Management (ATM) error classification, the results from studies considering cultural and organisational differences, suggest that local differences within the "organisational climate" can make a great difference in operational performance and safety [1,2].

In "Air traffic controller (ATCO) – pilot" communication model people are seen as autonomous, intentional beings who interact with the external world. The mind is viewed as a limited capacity processor having both structural and resource limitations. The human is seen as a serial information processor who takes data input, recodes it, stores it, makes decisions and produces output. The communication model "ATCO – pilot" should contain the following elements [1]:

1. A depiction of a message-medium-receiver relationship.
2. An account of the role of feedback (circular model).
3. An account of linguistic factors known to have contributed to incidents and accidents.
4. The context of communication model must be considered, including social and cultural aspects.

An attempt to fulfil all these requirements is made in the communication model shown in Figure 1 [2-4]. This model depicts the pilot–ATCO communication loop and contains cultural, linguistic and technical factors that may result in communication breakdowns in the present Aeronautical system. It may be noted that, in principle, in this model the pilot could also be the sender, and the controller the receiver. Furthermore, the model (Fig. 1) could be used to describe the communication between two adjacent controllers.

Information Processing Models and Taxonomies

The information processing tradition examines human performance by attempting to trace the information flow through several processing stages from information input to response output. The most widely known model of information processing is proposed by Wickens [5] who provides a composite qualitative model of human information processing. This model is elaborated on the basic Stimulus-Organism-Response (SOR) models in order to describe the critical stages of information processing (Fig. 2).

The model (Fig. 2) assumes that each stage of processing performs some transformation of the data and demands some time for its operation. Sensory processing refers primarily to the processing characteristics of the visual, auditory, and kinaesthetic senses. Sensory limitations can affect the quality and quantity of information. The Short-Term Sensory Store (STSS) prolongs a representation of the physical stimulus for a short period after it has terminated.

The STSS demands no conscious attention, preserves most of the physical details of the stimulus and decays rapidly, from less than a second for the short-term visual store (iconic memory), up to eight seconds for short-term auditory memory (echoic memory) and short-term memory of movement and bodily position (kinaesthetic memory).

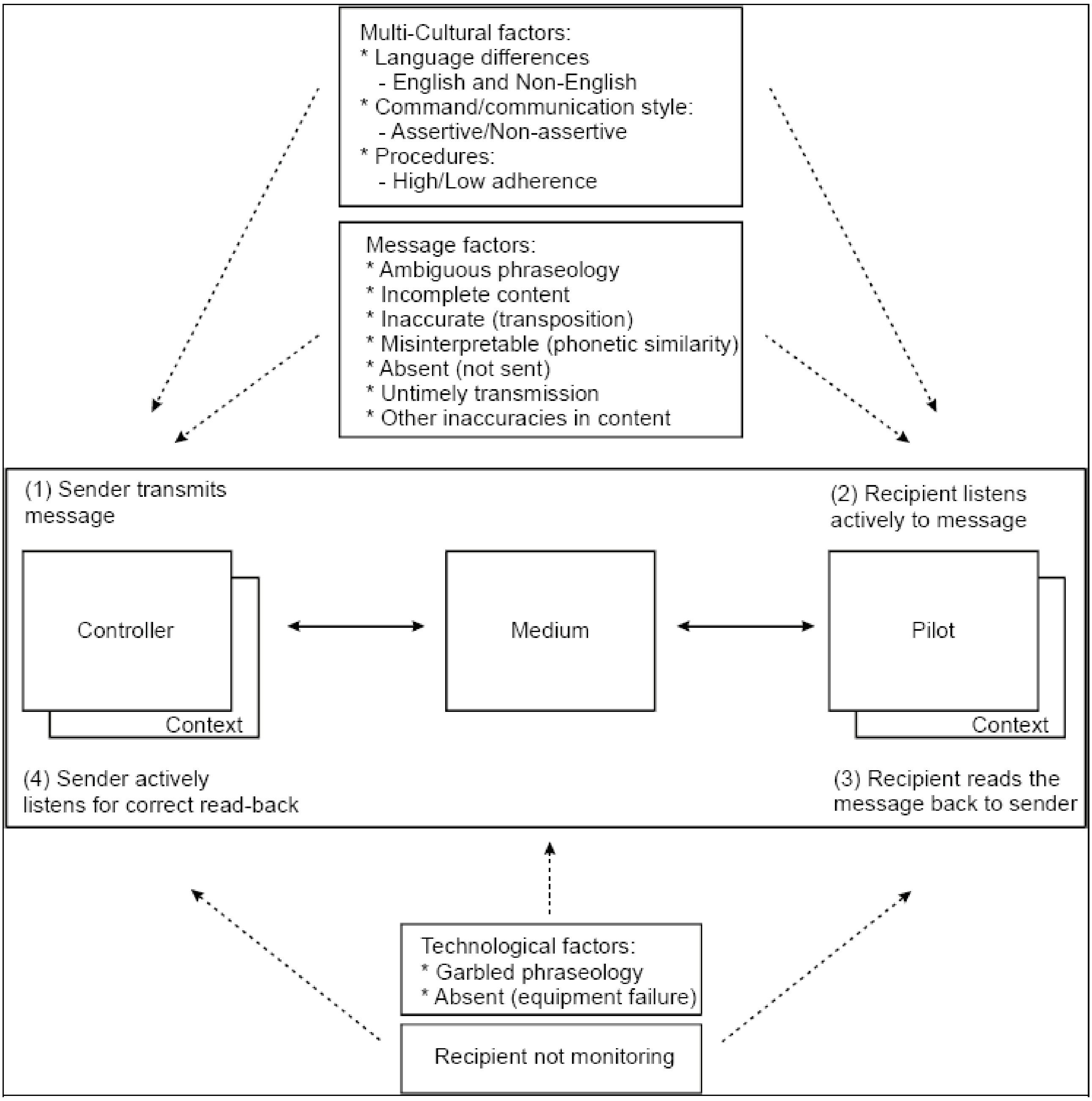

Fig. 1. Pilot–ATCO Communication Loop [2-4]

The stimulus is further processed and is perceived or recognised, and a perceptual decision is made regarding the perceptual category of the stimulus. The perceptual process is a “many-to-one” mapping, so many different physical stimuli may be assigned to one perceptual category (e.g. different aircraft may be assigned to a “fast jets” category), although the individual is able to differentiate between different stimuli. Tasks demand different levels of perceptual processing, from “detection”, through “identification”, to “recognition”. Furthermore, the task may demand that the individual makes one “absolute judgement”, concerning a dimension of one stimulus (e.g. speed), or it may demand “pattern recognition” of a combination of at least two dimensions. Alternatively, “relative judgements” may be required, concerning the relative differences between two or more stimuli (e.g. climb performance). Finally, perception may require “analogue judgements” of differences on a continuous scale.

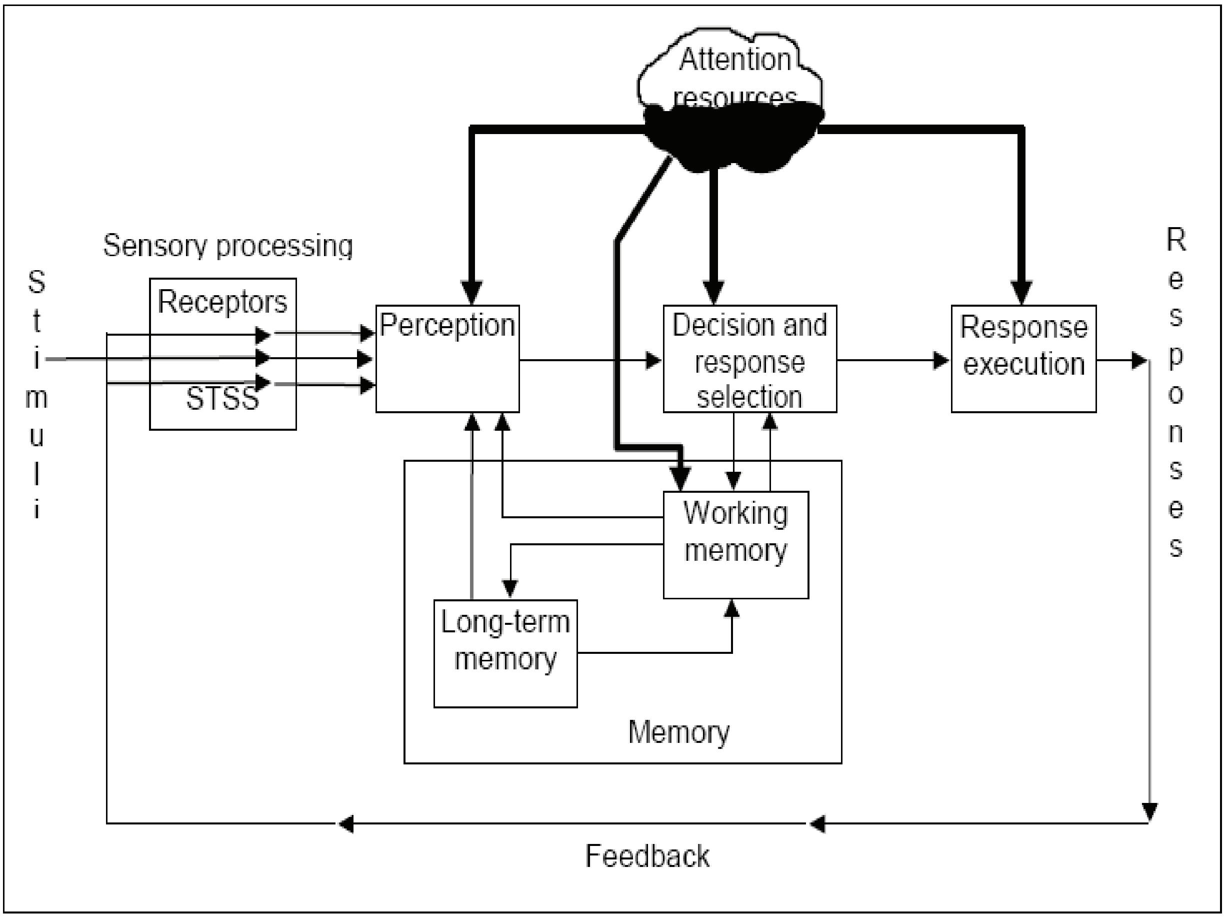

Figure 2. Model of Human Information Processing [5]

In a result of further researches was proposed a modified version of Wickens' Model of Information Processing [6] aimed at understanding the nature and frequency of human errors to aviation accidents implicating the ATM system (Fig. 3). The sensing function samples raw stimuli from the environment and passes sensory information to perception. The role of perception is to assign sensory information to perceptual categories and comprises such sub-functions as signal detection and pattern recognition.

Relevant performance issues of sensing and perception include sensory detection thresholds, limits to sensory discrimination, the loss of vigilance and limits to perceptual attention. Working memory is the centre of conscious behaviour. This appears to better reflect human information processing, since information must necessarily be held in working memory before subsequent mental activity, such as reasoning and response selection, can be conducted.

Long-term memory stores factual knowledge, retains perceptual parameters, and plays a major role in maintaining an internal model of the world, including that of the person themselves. It also maintains representations of tasks to be accomplished to achieve current goals. Storage is apparently not limited but retrieval is limited by many factors.

Central processing includes decision-making and response selection, and limitations to the sub-functions include confirmation bias and speed-accuracy limitations. An executive mechanism allocates mental resources to functions required to perform various competing, concurrent tasks. There are limitations in the human's ability to allocate resources, especially when multiple tasks compete for the same resources. The response function transforms selected responses into motor movements and speech.

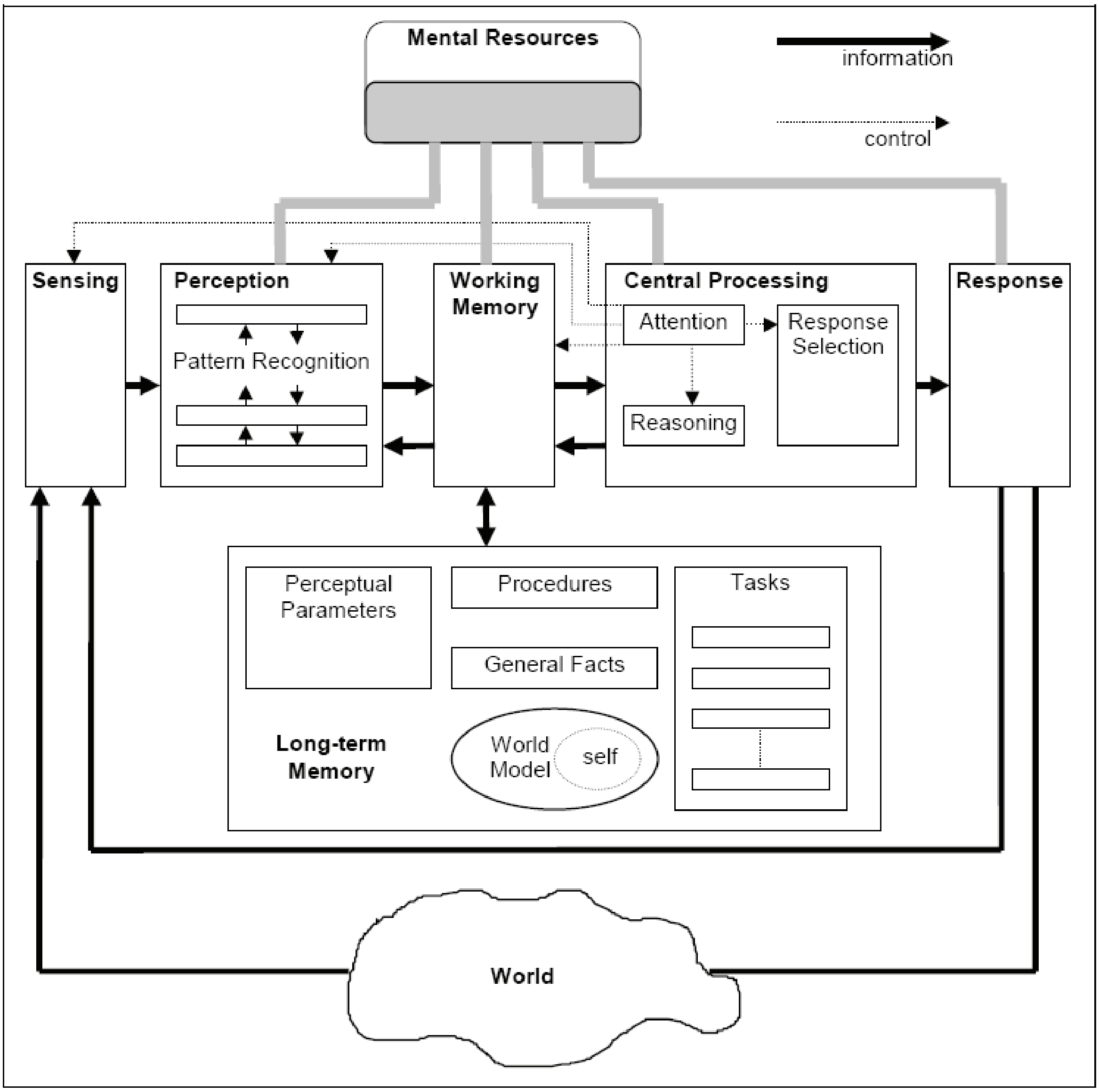

Fig. 3. Model of Human Information Processing [6]

However, perhaps the most useful parts of the elaborated model are the stereotyped rule-based shortcuts in decision-making, between data processing activities and states of knowledge. Changes in the environment are inputs to decision-making, but do not affect the prototypical sequence apart from the skipping of one or more steps.

Murphy Diagrams [7] are diagrammatic representations of error modes and illustrate the underlying causes associated with cognitive decision making tasks. Each "activity" within the decision-making process is shown as a separate diagram. These stages are shown below:

1. Activation/detection of system state signal.
2. Observation and data collection.
3. Identification of system state.
4. Interpretation of situation.
5. Definition of objectives.
6. Evaluation of alternative strategies.
7. Procedure selection.
8. Procedure execution.

An example of a Murphy Diagram is shown in Figure 4.

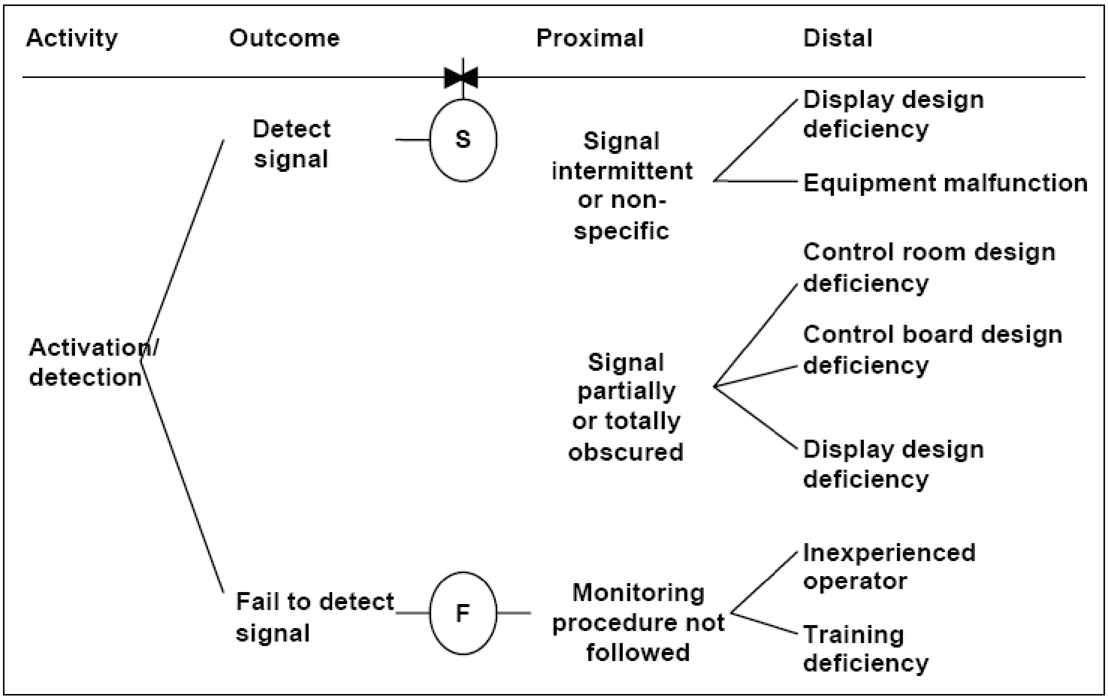

Fig. 4. An example of a Murphy Diagram [7]

Conclusions

The Air Traffic Control system modelling tradition uses concepts from modern control theory to understand human-machine systems. The human is seen in these models as a control or decision element in a closed-loop system, which includes monitoring, communication, supervisory situations, and manual control. As a cybernetic system, feedback plays a central role in guiding behaviour. So in "ATCO – pilot" communication loop the expert possesses an internal representation of the controlled process which enables open-loop behaviour such as anticipation and prediction as well as closed-loop behaviour such as stimulus-response behaviour.

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V. M. Kondratuk, senior researcher,
T. L. Malyutenko, post-graduate student,
National Aviation University, Kiev, Ukraine

WAYS AND METHODS OF TRANSFER NAVIGATION INFORMATION IN REAL TIME

The most perspective methods of transfer correcting information in real time are considered in this paper. One of the most exact modes of determines coordinates is RTK (Real Time Kinematic) mode in real time. For today the level of accuracy RTK mode can reach units of centimetres. Realization RTK mode is provided with a reliable communication facility. Use of a communication facility for transfer complete data of differential correction in real time new requirements to formats and reports of data today are put forward.

Satellite navigation systems are developed continuously. In the world there are created new technologies for solution task of determining position. Now satellite navigation technologies concern to one of technologies most dynamically developing in the world. Using signals of global navigation system possesses a more potential in the decision of many problems in sphere of navigation, a geodesy, cartography, etc. The main advantages of satellite navigation system are global character of a working zone, ability of data transmission of satellite system in any weather conditions, availability of these data at any time year, etc. They realize new opportunities in a safety and effective operation of all types of transport. In the world set of the ground and space functional additions raising accuracy of coordinate's definition of the user is created. This all provides growth of demand for satellite technologies.

Let's consider the most used differential methods raising accuracy of coordinate's definition. Most widespread of them:

- method of coordinates correction;
- method of navigation parameters correction [1].

These two methods are deeply enough investigated by way of practical realization and have found wide application practically from first years of expansion by global navigation satellite system, however, alongside with high efficiency of their use possess the certain disadvantages. The method of coordinates correction, connected with calculation and transfer differential corrections to the consumer to defined navigation parameters can be presented as follows:

$$\begin{aligned} x_b\text{-}xr&=\Delta x \\ y_b\text{-}y_r&=\Delta y \\ z_b\text{-}z_r&=\Delta z \end{aligned} \qquad (1)$$

where x_b, y_b, z_b – basic station coordinates, x_r, y_r, z_r – calculate coordinates of customer, Δx, Δy, Δz – corrections.

One of the requirement this method is a determine coordinates of correction station and the consumer on one working constellation of navigation satellites, and it is desirable, that this constellation was optimum both for correcting station, and for the consumer (maintenance of the minimal geometrical factor of measurements). The given requirement essentially limits an operative range of a differential mode of measurements as use at calculation of coordinate's estimations vectors of correcting station and the consumer of various satellites is inadmissible.

The method of navigation parameters correction is based on formation of correction at correcting station concerning all navigation satellites which are being a zone of radio visibility and transfer their to consumer can be presented in a general view as follows:

$$\Delta r = \sqrt{(x_b - x_s)^2 + (x_b + x_s)^2 + (z_b + z_s)^2} \qquad (2)$$

где x_b, y_b, z_b – basic station coordinates, x_s, y_s, z_s – receiving coordinates from satellite, Δr – pseudorange.

In given case consumer has an opportunity uses corrections in the decision of a navigation problem of those satellites which form for it optimum working constellation. The method of navigation parameters correction has received the greatest distribution and is traditional at realization of a differential mode of satellite navigation. But this method has a disadvantage, which connected with deterioration of navigation definitions accuracy of the consumer at removal from correcting station.

It is connected by that error compensation of correction measurements at increase in distances between correction stations and the consumer become all less effective. The maximal accuracy of navigation definitions in a differential mode at use of separate correction station is achievable at distances between correction stations and the consumer up to 50 and 150 km.

Every year requirements rise not only to the system, but also by the ways and methods of data transmission. For this purpose new standards of data transmission are developed and used. In particular, the greatest interest for today is represented with ways of data transmission by means of wireless communication. For today such standards for information transfer are used: GSM, CDMA, WiMAX, etc.

GSM (Global System for Mobile Communications) - the global digital standard for mobile cellular communication, with division of the channel by principle TDMA (Time Division Multiple Access) and a high degree of safety owing to enciphering with the open key.

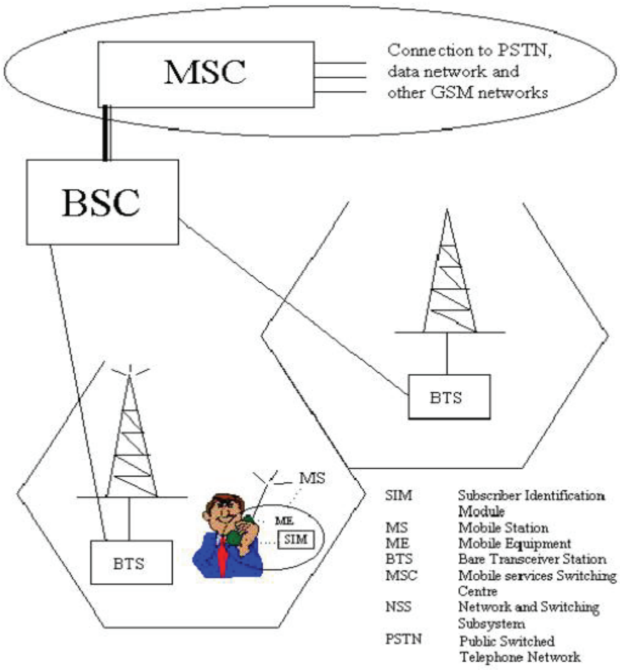

Fig 1. GSM Network overview.

Advantages of standard GSM it is expressed in the following:
- high quality of communication at sufficient density of base stations placement;
- the greater capacity of a network, an opportunity of the big number of simultaneous connections;
- a low level of industrial radio noises in the given frequency ranges;
- the maximal protection against interception and illegal use;
- be widespread, especially in the Europe, a wide choice of the equipment.

But not looking at it there are also disadvantages:
- communication on distance no more than 120 km from the nearest base station even at use of amplifiers and the directed aerials. Therefore for a covering of the certain area is necessary lot of basic stations.

In parallel with GSM develops new standard CDMA. This standard is more perspective.

CDMA (Code Division Multiple Access) - technology of multiple access with code division of channels, the standard of communication of the third generation. Standard CDMA is the digital standard. Multiple access with code division means, that some subscribers can use one radio channel, not being crossed owing to code division of channels. CDMA provides high quality of communication, a low level of noise simultaneously with low capacity of transmitter radiation. Capacity of network CDMA is more, than at any analog or digital standards, owing to an opportunity of repeated use of a network pass band.
Networks CDMA start to grow, and in the near future this standard becomes one of the basic standard, since it can make a competition even to wire communication systems, owing to the indisputable advantages and cheapness.

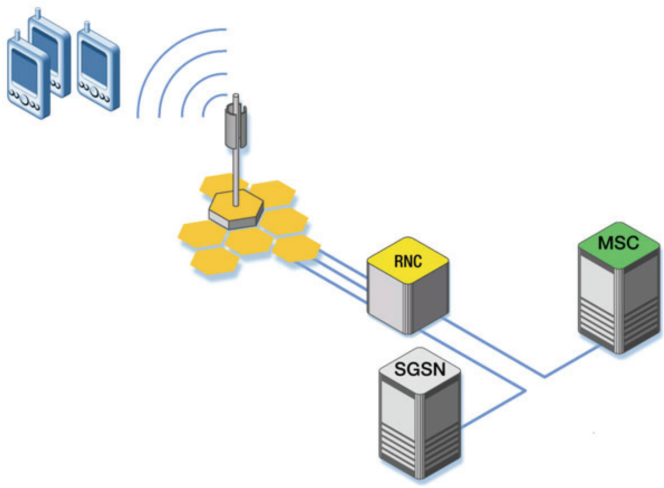

Fig. 2 Principle of work standard CDMA (RNC- remote-network controller, MSC- microstrip coupler, SGSN- serving GPRS support node)

Advantages CDMA following:

- the capacity of base stations increases in 4-5 times - in comparison with GSM;
- absence of frequency planning owing to use of the same frequencies in adjacent sectors of everyone cell;
- the improved security of transferred data;
- the improved characteristics of the covering, allowing to use smaller quantity cell;
- an opportunity of allocation of a demanded frequency band if it is necessary.

One of basic disadvantages CDMA is smaller prevalence in comparison with CSM.

Level with these two technologies had been accepted in 2003 under the standard 802.16 new technology of broadband wireless communication WiMAX (Worldwide Interoperability for Microwave Access). For today this technology receives wide development in many countries of the world, in particular and in Ukraine.

Technology WiMAX allows to work in any conditions, including in conditions of dense city building, providing high quality of communication and speed of data transmission. This technology supports five types of access:

The fixed access. It assumes, that the user device is in one place during all time of contract action with the operator of service.

Nomadic access. Here it is means, that the device stays in one place during all time of a session. If it moves to other point in a zone of the same wireless network (for example, varies cell or sector) the network defines attributes of a subscription and new session is established. The opportunities mentioned earlier are kept.

Portable access. In this mode the device will remain on communication during moving with walking pace in the limited area covered by a wireless network. During session at transition to different cells or sectors of one cell opportunities of management transfer are provided not all.

Simple mobile access. It is understood as ability of the device to not interrupt session for the appendices which are not demanding a mode of real time, at movement with speed of vehicles in a cover zone of a wireless network. Transfer of management at moving between sectors or base stations does a session continuous for all appendices previously mentioned type.

Full mobile access. The given type of access provides a continuous session of communication at movement of the device with high speed in a cover zone of a wireless network. The guaranteed transfer of management at moving between sectors or base stations allows all appendices to work continuously [2].

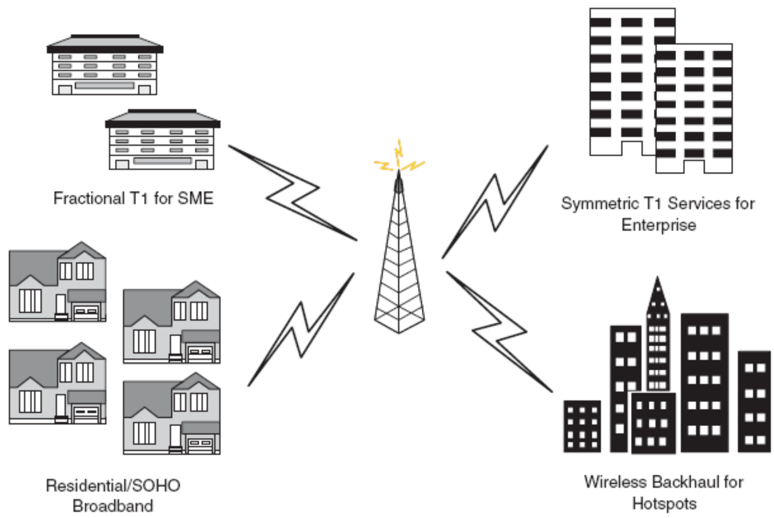

Fig. 3 Work of WiMAX [3]

That these access types could be supported WiMAX two versions of standard IEEE 802.16 have been offered. The first type of standard IEEE 802.16-2004 has been developed for the fixed access from different places. The second type of standard IEEE 802.16e has been developed for mobile access to WiMAX. These two versions WiMAX reflect needs of the market for products which are optimized either for fixed, or for mobile access.

The considered kinds of wireless communication can be applied to the decision of a navigating problem in mode DGPS and RTK.

Essence of DGPS consists in performance of measurements by two receivers GPS: one is established in a defined point - rover, and another - in a point with known coordinates - base station. As the distance from satellites up to receivers is much more than distance between receivers consider, that conditions of signal receptions both receivers are practically identical. So, sizes of mistakes also will be close.

In mode DGPS measure not absolute coordinates of the first receiver, but its position concerning the base receiver. Method DGPS can be used doubly. If it is necessary to calculate coordinates in a mode of real time the reliable radio channel is necessary for transfer of differential corrections. All above listed standards can be used for transfer of the navigation information on a radio channel. The choice of the standard depends on a solved problem and demanded accuracy of definition of coordinates.

One of the high technologies in transfers of the navigation information to real time is RTK (kinematics in real time) - a way providing centimetric accuracy of coordinates in real time. Very often this method use in a geodesy.

Method RTK uses differential GPS measurements on a carrier phase, providing a centimetric level of accuracy in real time.

Measurements on a carrier phase - the most exact method of measurement pseudoranges. Fluctuations of a carrier phase have constant frequency unlike registered on GPS the receiver owing to Doppler effect (some "shift" is formed due to passage by a signal of distance from the satellite up to the receiver). Thus, the measured carrier phase between the satellite and the phase center of the receiver aerial will consist of an integer of phase cycles and a fractional part. Unfortunately GPS the receiver has no opportunity to distinguish among themselves cycles bearing. It can measure a fractional part of a phase, and then trace its change: the initial phase is uncertain. To use a current phase for measurement pseudoranges, this unknown number of cycles or ambiguity should be calculated alongside with coordinates of the receiver.

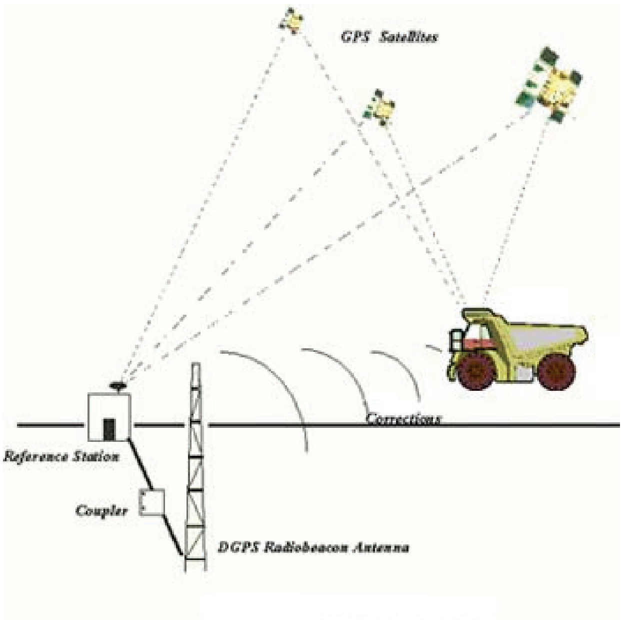

Fig. 4 Differential GPS Broadcast site

In mode RTK for transfer of corrections to the basic the radio channel is used, thus "age" of corrections, as a rule, should not exceed 0.5 - 2 seconds, unlike a code differential mode, where corrections can be updated each 10 seconds.

In code DGPS mode corrections of RTCM SC-104 are usually transferred with speed of 200 bit/c. In RTK speed of data transmission should be not less than 2400 bit/c though speed of 9600 bit/c or 19200 bit/c is more preferable. For realization of correction transfer with similar speed frequency band should be in radio spectrum of very high frequencies (VHF) or ultrahigh frequencies (UHF).

That data transmission in RTK is transferred in UHF and VHF ranges, exists restrictions in its use. In most cases, the maximal range of distribution d in kilometers can be counted under the following formula:

$$d = 3.57\sqrt{k\left(\sqrt{h_t} + h_r\right)}, \qquad (3)$$

where h_t and h_r - heights of transmitter and receiver aerials (in meters), k - the factor of effective radius of the Earth which considers, that distance of radiohorizon, owing to an atmospheric refraction, it is usual more distances of geometrical horizon.

Value k under standard climatic conditions makes 1.33, but it can change from 1.2 up to 1.6 depending on weather conditions. Any obstacles in a way of a radio signal influence length of its distribution. Buildings, crests of mountains, corners of any objects can block or re-reflected radio signal. In some cases, owing to atmospheric anomalies, range of distribution of a radio signal can be more calculated. Even at absence of obstacles, the radio signal after an output from the transferring aerial, according to the law of return squares, has some damping factor. This process sometimes name loss in free space. Besides the reflected signal gets in the receiver together with a "direct" signal, that, deforming it. Thus, the full size of loss of capacity of a signal depends on several factors, including physical features of district, a refraction, presence of buildings or other objects.

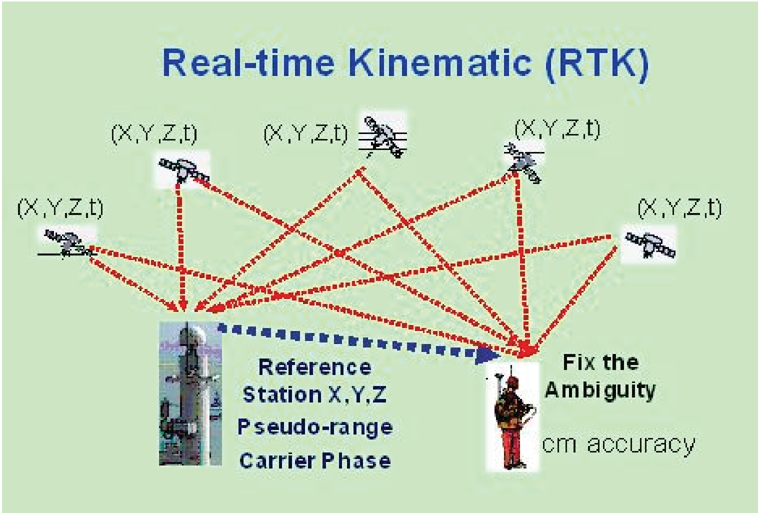

Fig. 5 Overview RTK

During processing measurements GPS (the decision of the second differences) time delays between data base and mobile stations should be considered. At work in real time, the data collected by the base receiver, act on the mobile receiver with some delay. These data should be coded, broadcasted, decoded and transferred in the internal software of the mobile receiver. On performance of these procedures some period of time named by the wait state is required. This size depends on speed of data transmission and can reach 2 sec., that in some cases is unacceptable size for some kinds of kinematic shooting or navigation. In the situations, demanded the minimal wait state, for example high-speed navigation or the machine control, the mobile receiver can extrapolate measurements of base station for an epoch of own current measurements.

Key feature RTK is ability of the sanction of ambiguity, i.e. definition of the whole quantity of cycles, during movement of the mobile receiver. For realization of the given principle the combination of phase data L1 and L2 and technique OTF (On-The-Fly) is used. Technique OTF includes the filter of search and technology of calculation of ambiguity on a method of the least squares. Speed from which this method is realized, depends from of some factors, such as quantity of traced satellites, values PDOP, sizes of noise component of satellite signals. Under favorable conditions, the solution of ambiguity is carried out within 10 seconds [4].

There are two types of techniques RTK-GPS: with one base station RTK and a network of base stations RTK. Restrictions for one base of station RTK consists in distance between the basic receiver and the receiver of the user. This dependence is expressed in an error of an orbit, ionospheric and tropospheric delays. Therefore the distance between receivers is limited about 20 km or less depending on activity of an ionosphere. In a technique with a network of stations RTK there are no such restrictions as in a technique with one station RTK. The distance between receivers about 50-70 km is usual. But, as well as in case of with one station RTK, and in case of a network of stations RTK there are criteria which are necessary for carrying out. It is reliability and suitability (availability) RTK which depends on the successful decision of ambiguity during the shortest periods. In cities with their many barriers (buildings, trees, etc.) suitability can be much more below, than in areas with the open district. In general, dependence on distance of size of displacement and unreliability of the decision of ambiguity - two key problems in existing techniques RTK.

Division of RTK services is possible on local, regional and global [5].

Unfortunately, information transfer on radio channels has a number of disadvantages, which limit use mode RTK. It is limited effective range of a radio channel and the obligatory requirement to presence of direct radio visibility between modems of base station and the mobile receiver. Besides the probability of a radio noise is highest at work in industrial areas.

Therefore, new technologies of information transfer in format Ntrip (Networked Transport of RTCM via Internet Protocol) have been developed and introduced. It is the new format entered by German Federal Agency on Cartography and the Geodesy (BKG) for data transmission in format RTCM by Internet. Format Ntrip has been developed together with company Trimble Terrasat and has good prospects to become the international standard of data transmission of global satellite navigating systems (GNSS).

The majority of software GNSS and devices already has an opportunity to support format Ntrip. Ntrip has received broad support as a method of data GNSS distribution in real time by Internet channels.

Ntrip is the TCP-report on the basis of HTTP. It can be used not only for transfer of the RTCM-information, but also supports all GNSS - formats. The most important is that the new format supports bilateral communication between the user and the transmitter, thus simultaneously transferring hundreds packages of the information for thousand users. Users can obtain data by means of a usual computer, laptop, PDA and GPS-receivers. Features of a new format is the high degree of data safety and economic advantage of their transfer.

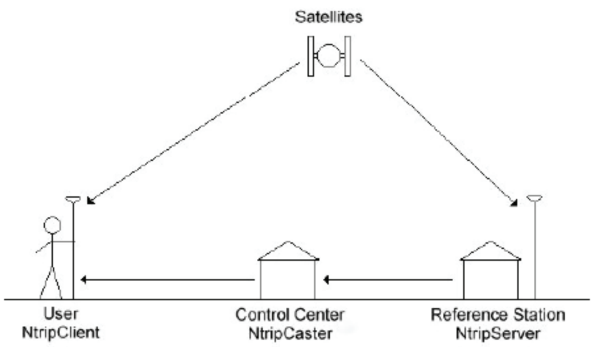

Fig. 6 Principle of work of format Ntrip with use of satellite technologies [6]

As for successful work DGPS or RTK-modes there can be a necessity for transfer a big information simultaneously for thousand users, conceptually new system has been developed. In its basis use of modern standards of a mobile radio communication and safety of information transfer.

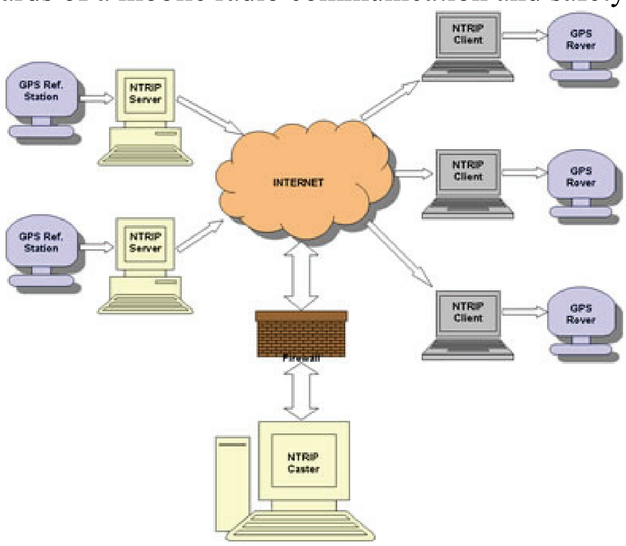

Fig. 7 Principle of work of format Ntrip with use the Internet.

Ntrip protocol (Fig. 8) consists of the following elements:

• NtripSources, which generate data streams at a specific location,
• NtripServers, which transfer the data streams from a source to the NtripCaster,
• NtripCaster, the major system component, and
• NtripClients, which finally access data streams of desired NtripSources on the NtripCaster.

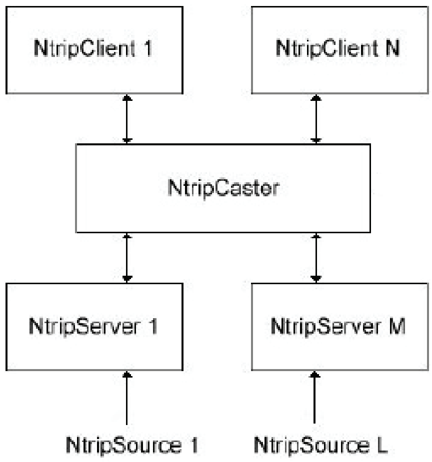

Fig. 8 Structure of Ntrip protocol

The NtripSources provide continuous GNSS data (e.g. RTCM-104 corrections) as streaming data. A single source represents GNSS data referring to a specific location. Source description parameters as compiled in the source-table specify the format in use (e.g. RTCM 2.0, RTCM 2.1), the recognized navigation system (e.g. GPS, GPS+GLONASS), location coordinates and other information. Every single NtripSource needs a unique mountpoint on an NtripCaster. The NtripServer is used to transfer GNSS data of an NtripSource to the NtripCaster.

Report Ntrip is used for transportation of data RTCM of virtual basic station, so-called VRS concepts. Data for this virtual basic station gives unique NtripSource. Then these data send to NtripServer. NtripCaster, represents, basic server HTTP. It collects data from NtripSources and dispatches their users NtripClients. Hundreds devices incorporate in one and too time, using TCP/IP the report. All of them have a point of access in system. Sending correction or the inquiry about the correcting information in a correct format to IP and to port NtripCaster can operate inquiry and make corresponding actions. Authentication users also is possible.

So, the greatest interest for development of transfer of the navigating information for today is represented with technologies RTK and Ntrip.

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Kharchenko V.P., head of aeronavigation service system subdepartment.
Melkumyan V. H., professor of aeronavigation service system subdepartment.
Malyutenko Tetyana, postgraduate student,
(National Aviation University, Ukraine)

APPLIED PROBLEM OF SERVICE TECHNOLOGICAL SYSTEMS DESIGNING

The scientific direction of research from system positions of different aspects of technological systems functioning widely develops. The given work has analysed some aspects of a terminological problem of research theory of technological systems. Definitions of the basic concepts and terms are offered in more details. It to allow using results of researches in industrial sphere, in adjacent areas of manufacture and various fields of society activity. It is allocated a class of technological systems of service type and the structure of the organization and work for designing new (or radical modernization existing) technological system. And also a substantiation of structure and characteristics with using probability methods and some applied sections of fuzzy set theory.

Now there are intensive researches in the field of development and introductions alternative technologies, technological processes (TP). Alternative technologies and technological processes are directed on increase of efficiency production, decrease in capital expenses, operational expenses, environmental safety. Substantially formation of a new scientific direction is incorporated in methodological basis. Don't be discuses title, it is necessary to emphasize, that a number of basic elements of this scientific direction, including terminology, stay in a stage of becoming.

Let's consider some specifications of concepts which are fundamental to this scientific direction.

Known interpretation of the term "technological process" as purposeful change of output production properties with the purpose of production reception with necessary properties. The term "technological process " is a lot of in what narrows opportunities of use of research results in industrial sphere, including new technologies of optimum monitoring systems and production managements in adjacent spheres of a facilities and in diverse fields of society activity.

In the field of research works the concept "technology" and "technological process" is widely used, understanding under these terms processes of formation and granting of various services to users.

Under term "technological process" understanding process or set of the processes directed on achievement of a purpose.

For TP of industrial enterprises the basic purpose is reception of production from raw material. For transport "product" with necessary characteristics is duly and safe delivery of passengers and cargoes in a terminal point of purpose. And for systems of information support "product" is granting of the necessary information to users. It will not difficultly be convinced, that TP is a core during functioning of some the state organizations and enterprises, in an implicit kind described and fixed in statutes, programs and other operating normative documentation. This documentation defines methods and ways of achievement of the basic purpose of their creation and so the decision of strategic and current tactical problems.

Therefore at the use of the term "technological process" it is necessary to understand set of the certain interdependent operations within the limits of the certain system, which is directed on achievement of the basic purpose of its activity.

Definition 1. Technological process is specified and the basic conditions of its functioning are satisfied if are known:

characteristics of "output product" TP;

structure TP and its elements;

function technology and cooperation of elements TP;

function of environmental conditions TP.

Expression for common view of TP is presented in composite functional:

$$F_{TP}(s,t)=F(L_{TP}(v); S_{TP}(y,t); R_{TP}(y,t); T_{x\,TPE}(z,t); D_{TP}(\xi,t)) \quad (1)$$

where $L_{TP}(v)$ – requirement vector for characteristics of "output product" TP;

$S_{TP}(y,t)$ – functional, which defines structure and characteristics of elements TP;

$R_{TP}(r,t)$ - functional, which defines requirements for characteristics of resources (including requirements for experienced personnel), it is necessary for realization TP;

$T_{x\,TPE}(z,t)$ – functional descriptions of function technology and interaction of elements TP;

$D_{TP}(\xi,t)$ – functional, which considers character and a degree of external influence of conditions on stability of characteristics of elements.

In what follows under the term "technology" is understood as the certain set of functional algorithms and interaction of elements of technological process which provides achievement intermediate or an end result during formation of "output product" of TP.

In view of presented above the expanded concept "technological process" under the term "technological system" (TS) is understood set functionally certain interdependent structures (elements). These elements provide purposeful interaction of the basic and auxiliary resources and the personnel within the limits of the set (regulated) technological processes necessary for achievement of the basic purpose of functioning of system.

Depending on the purpose of creation and features of functioning of TS is possible to divide into three basic groups: industrial, service (serving type) and social.

Technological systems of the same groups can differ under characteristics TP, ability of the functioning, set as before them the purpose and problems, on output product, etc.

Simultaneously united in each group TS it is necessary to have the general principles of structure.

Expression for common view of TS is presented in composite functional:

$$F_{TS}(s,t)=F(F_{TP}(s,t); S_{TS}(y,t); R_{TS}(r,t); T_{TS}(z,t); S_{TPE}(z,t); D_{TS}(\xi,t)), \quad (2)$$

where $F_{TP}(s,t)$ – functional of description class of TP, which specified expression (1);

$S_{TS}(y,t)$ – functional, which defines structure and characteristics of elements TP;

$R_{TS}(r,t)$ - functional, which defines requirements for resources (additional for resources of TP), it is necessary for realization TS (in view of structure of control and additional personnel which don't takes directly participation in realization of technological operations TP);

$T_{TSE}(z,t)$ – functional descriptions of function technology and interaction of elements TP;

$D_{TS}(\xi,t)$ – functional, which considers character and a degree of external influence of conditions on quality of function TS.

In practice TS is often united in complex systems with hierarchical structure (factories-manufacturers of production, the enterprise of transport, communication, etc.). In the further for the description of similar systems we shall use the term "complex technological system" (CTS), meaning system hierarchically connected TS which purposeful interaction is provided with achievement of the basic purpose of creation (functioning) complex system. To CTS can include as homogeneous on functional features TS, and TS different groups.

In structure of technological system of serving type can allocate the basic group of TS, which is at the top hierarchical level of system structure , and a number of a hierarchical bottom level TS which are service concerning basic group TS. To the first group concern TS formations and grantings of services under applications of consumers, and TS other group are service respect to TS of the first group.

Interaction TS within the limits of system also can be presented in the form of formation processes of demands and granting of services, where users are TS. This TS users are at higher level of structure CTS. The general block diagram of model CTS, which can serve with the certain restrictions as base station. At research of characteristics of its elements and algorithms of their interaction during functioning and granting "output product" systems it is shown on fig. 2.2.

Model CTS is set hierarchically connected TS with streams of applications and respective services which circulate between them.

So TS-F includes TP formations and grantings of "output product" (services) CTS. The group of other TS plays a role of auxiliary structures of system which provide reliable functioning CTS.

For example, in air transport CTS to the first group belong TS of air activity, to other TS system of air traffic control, TS of maintenance service and repair of aviation techniques, formation TS of a passenger- cargo traffic, etc. Functions of TS-R and TS-U in CTS any class are reduced accordingly to duly maintenance of necessary resources of functioning TP TS-F and to management of processes, which flow in CTS.

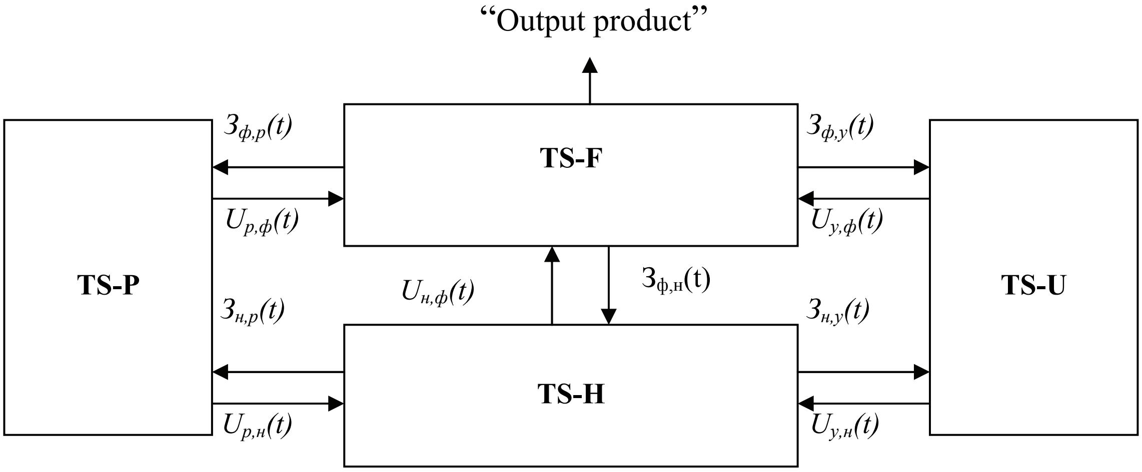

Fig.1.The block diagram of model CTS

The structure of elements and parametrization of characteristics of processes in CTS different classes obviously depend on the purpose of creation and specificity of its functioning.

In volume of the accepted model, in a general view the description of processes which flow in CTS, it is possible to present in the form of the simplified scheme:

Event-Solution- Action

As Event understand occurrence of different excitements with determined and (or) stochastic characteristics. In CTS before event it is possible to carry reception of applications for services, there are factors which destabilize work of TS elements, there is a necessity of updating of resources, introduction of new effective technologies, rational TP, etc.

The Solution provides a choice of strategy, methods, and technologies for maintenance of necessary quality of functioning CTS under condition of event of the certain kind.

Action is understood as realization of decision-making and processes of elimination of possible consequences.

Under stationary conditions of functioning CTS of the characteristic of processes of formation and granting of services, as a rule, are regulated. Exist characteristic for given type CTS of the application of the certain class at the regulated process and granting of the declared services.

In this case the simplified scheme of the description of dynamics of processes in CTS it is possible to transform and submit in the form of the scheme:

Condition-Solution-Action

In this case as a Condition understand potential ability CTS to carry out the functions assigned to it. Depending on condition CTS and its elements under the Solution and Action it is necessary to understand processes of a choice and realization of the certain set of operated influences on the elements of the system necessary both sufficient for support and functioning CTS if necessary restored by a certain degree of quality. Within the limits of this subject domain of research we shall consider some questions of conceptual character which concern problems of designing service CTS, on an example of transport system on structure and characteristics is complex polihierarchical multipleparameter system. Value of parameters CTS in consequence of characteristics stochasticity of structural elements and destabilizing factors generally have the certain disorder in phase space of requirements of applications. So, CTS it is usual with the determined structure and the regulated algorithms of interrelation of its compound TS at the decision of a problem of synthesis and the analysis consider as complex stochastic system.

The basic purpose of functioning service CTS is maintenance of users with set of the certain services with necessary characteristics. Requirements to characteristics of given services ("output product" CTS), usually, define applications of users.
Values of given services CTS parameters in consequence stochasticity of characteristics of structural elements and destabilizing parameters generally will have certain dispersion in phase space of demand requirements.

To characteristics of services ("output product) CTS generally can be presented a vector of requirements of applications of users services $Ls\,(v)$ in the form of complex functional:

$$L_{\mathrm{CTS}}(v)=\{L(v(y,t), L(v(s,t)), L(v(t))\}, \tag{3}$$

where $L(v(y,t)$, $L(v(s,t))$, $L(v(t))$ – functionals, which describe specific requirements to group of characteristics of the services, generated CTS in borders of demand $L_{\mathrm{C}}(v)$.
For example, under $L(v(y,t))$ is possible to admit complex requirements to quantity and quality of characteristics, $L(v(s,t))$ - to characteristics of coordinates of a site of granting of services, $L(v(t))$ -to hour to characteristics, etc.
Value of parameters given CTS services in a consequence of characteristics stochasticity of structural elements and destabilizing parameters generally will have the certain disorder in phase space of demands.
Demand with characteristics $v(y,s,t)$ is necessary to consider for services satisfied if the condition is satisfied:

$$U_{CTS}(v)\in D(L_{\mathrm{CTS}}(v(y,s\ t))), \tag{4}$$

where $U_{\mathrm{CTS}}(v)$ – characteristic of given services;

$D(L_{CTS}(v(y,s\ t)))$, - phase space of admissible values of characteristics of the declared service.

The estimation of efficiency CTS during designing and to its basic characteristics is a lot of substantiation of services in what becomes complicated presence of aprioristic uncertainty of conditions of its functioning, and also stochasticity of parameters of external and internal destabilizing factors.

Formalization of problems of studying of the market of services of service systems at a stage of external designing CTS is connected with greater difficulties through necessity of the account of different often inconsistent factors. After gathering the statistical information of its operating time are usually based on conclusions of experts. Often restrictions concerning assistance by users of the given services which are based on postulates of manner in view of value judgment of experts under condition of the inexact information, at modelling set too asked, that in a final conclusion leads to inadequate real situations of the accepted decisions.

Generally it is necessary to provide conditions of domination of opportunities of system concerning conditions of potential users of services.
Definition 2. The indistinct relation zGy dominates over relation xRy on parameter y, if at equivalent estimation the condition is satisfied:

$$Y_R \subset Y_G\,, \tag{5}$$

where Y_{R} and Y_{G} – set of columns elements of matrixes, that is:

$$Y_K=\{y_{R1}, y_{R2}, y_{R3}, \ldots, y_{Rm}\}, \tag{6}$$

$$Y_G=\{y_{G1}, y_{G2}, y_{G3}, \ldots, y_{Gm}\}. \tag{7}$$

Definition 3. The indistinct relation zGy conditionally dominates over relation xRy on parameter y, if at equivalent estimation the condition is satisfied:

$$\exists Z(c): Y_R \subset Y_G\,, \tag{8}$$

Designing of complex technological systems of service type to a class which transport systems concern. Designing also demands application of the precise scientifically proved structure of the organization and work, from formation of the primary goals of designing to development of alternative variants and a final choice of rational structure and optimum levels of characteristics of the projected system.

The saved up experience of designing polihierarchial complex systems allows to group works from creation new and modernizations or radical reconstruction of the maintained systems on the general stages of external and internal designing.

External designing is understood as process of a substantiation of requirements to external (days off) to characteristics of the projected system, definition of normative-legal base of functioning and the feasibility report on expediency of creation of system.

Works concern to a stage of internal designing with definition of structure, characteristics and interactions of elements of system and algorithms (technologies) which in aggregate provide the responsibility of output characteristics of the projected system to the established requirements. One of the most important features of transport system is functioning as complex technological system with "output produt" in the form of transport services.

Value of parameters of the services given by transport system in consequence of stochasticity of characteristics of structural elements in a general view will have the certain disorder in phase space of requirements of demands.

The vector of requirements of user demands of transport services $Z(v)$ to characteristics of services of transport system $Z_{TC}(v)$ in a general view can be presented in the form of complex functional:

$$Z_{TC}\ (v)=\{v(x,t),\ v(s,t)),\ v(t))\}, \tag{9}$$

where $v(x,t)$, $v(s,t))$, $(v(t)$ – functionals, which describe specific requirements to groups of characteristics of the services, generated within the limits of demands v. For example, $v(x,t)$ is possible to assume complex requirements to quantity and quality of characteristics; $v(s,t)$ - to characteristics of coordinates of a site of granting of services; $v(t)$ - to hour characteristics. The demand consider satisfied if the condition is satisfied:

$$U(L_{TS}(v))\in D(v(x,\ s,\ t)), \tag{10}$$

$U(.)$ – characteristic of given services;

$D(.)$ - phase space of admissible values of characteristics of the declared service.

At a choice of criteria of technical and economic efficiency of functioning of system at this design stage it is necessary to consider inconsistent requirements of the user and the developer. From the user its requirements to characteristics of system most full should be provided. And from the developer charges on creation and operation of system should be minimized. In practice usually find a compromise variant which satisfies to conditions of reception of the greatest effect from target use. Formalization of problems of studying of the market of services of service systems at a stage of external designing of TS is connected with greater difficulties through necessity of the account of different often inconsistent factors.

After gathering the statistical information of its operating time usually prove on conclusions of experts. Often restrictions concerning perception users of the given services who based on postulates of behaviour in view of value judgment of experts under condition of the inexact information, that in a final conclusion lead to inadequate real situations of the accepted decisions.

With the advent of in the middle of 70th years of the theory of indistinct sets and with development of some its applied directions, including indistinct mathematical programming, there were new approaches at the decision of similar problems.

We offer a way of the decision of a problem of formalization of studying of the market of services of service systems at a stage of external designing of TS and a choice of alternative decisions under indistinct target conditions. Let set of potential users X, attributes of offered services Y, restrictions Z and charges on reduction of a level of restrictions C are presented in the form of such ordered sets:

$$\begin{aligned} X &= \{x_1, x_2, x_3, \ldots\ldots, x_n\}, \\ Y &= \{y_1, y_2, y_3, \ldots\ldots, y_m\}, \\ Z &= \{z_1, z_2, z_3, \ldots\ldots, z_k\}, \\ C &= \{c_1, c_2, c_3, \ldots\ldots, c_p\} \end{aligned} \tag{11}$$

Problem of service system lays in maintenance of conditions for satisfaction of requirements of potential users to attributes of the offered services with an opportunity the least additional expenditure. Interaction of elements of sets, we shall present in the form of indistinct relations *xRy, zGy* and *cSy* with functions of an accessory accordingly $\mu_R(x,y)\to|0,1|$, $\mu_G(z,y)\to|0,1|$ and $\mu_S(c,y)\to|0,1|$.

$$R=\begin{array}{c|ccccc|} & y_1 & y_2 & y_3 & & y_m \\ x_1 & \mu_R(x_1,y_1) & \mu_R(x_1,y_2) & \mu_R(x_1,y_3) & \ldots\ldots\ldots & \mu_R(x_1,y_m) \\ x_2 & \mu_R(x_2,y_1) & \mu_R(x_2,y_2) & \mu_R(x_2,y_3) & \ldots\ldots\ldots & \mu_R(x_2,y_m) \\ x_3 & \mu_R(x_3,y_1) & \mu_R(x_3,y_2) & \mu_R(x_3,y_3) & \ldots\ldots\ldots & \mu_R(x_3,y_m) \\ .. & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots \\ x_n & \mu_R(x_n,y_1) & \mu_R(x_n,y_2) & \mu_R(x_n,y_3) & \ldots\ldots\ldots & \mu_R(x_n,y_m) \end{array} \qquad (12)$$

The matrix (11) is the generalized estimation of potential users of the offered service with the given attributes and the certain measure can be interpreted as the requirement to characteristics of services. Therefore under laws it is possible to define a degree of value of its attributes for separate groups of potential users.

$$G=\begin{array}{c|ccccc|} & y_1 & y_2 & y_3 & & y_m \\ z_1 & \mu_G(z_1,y_1) & \mu_G(z_1,y_2) & \mu_G(z_1,y_3) & \ldots\ldots\ldots & \mu_G(z_1,y_m) \\ z_2 & \mu_G(z_2,y_1) & \mu_G(z_2,y_2) & \mu_G(z_2,y_3) & \ldots\ldots\ldots & \mu_G(z_2,y_m) \\ z_3 & \mu_G(z_3,y_1) & \mu_G(z_3,y_2) & \mu_G(z_3,y_3) & \ldots\ldots\ldots & \mu_G(z_3,y_m) \\ .. & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots \\ z_k & \mu_G(z_k,y_1) & \mu_G(z_k,y_2) & \mu_G(z_k,y_3) & \ldots\ldots\ldots & \mu_G(z_k,y_m) \end{array} \qquad (13)$$

Depending on statement of a problem the matrix (13) can be estimated by a degree of influence of resources available in system on attributes of the offered service or a level of satisfaction them process of formation of services with the given attributes.

$$S=\begin{array}{c|ccccc|} & y_1 & y_2 & y_3 & & y_m \\ c_1 & \mu_S(c_1,y_1) & \mu_S(c_1,y_2) & \mu_S(c_1,y_3) & \ldots\ldots\ldots & \mu_S(c_1,y_m) \\ c_2 & \mu_S(c_2,y_1) & \mu_S(c_2,y_2) & \mu_S(c_2,y_3) & \ldots\ldots\ldots & \mu_S(c_2,y_m) \\ c_3 & \mu_S(c_3,y_1) & \mu_S(c_3,y_2) & \mu_S(c_3,y_3) & \ldots\ldots\ldots & \mu_S(c_3,y_m) \\ .. & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots & \ldots\ldots\ldots \\ c_p & \mu_S(c_p,y_1) & \mu_S(c_p,y_2) & \mu_S(c_p,y_3) & \ldots\ldots\ldots & \mu_S(c_p,y_m) \end{array} \qquad (14)$$

The matrix (13) estimates a degree of influence of additional expenditure for reduction of restrictions or increases in opportunities of system due to new capital investments. Functions of an accessory in (12) can be interpreted linguistic variables of type "strongly, "poorly", “not” are influence. In turn in expression (13) also it is possible to interpret linguistic variables of type "more", it is "less", "very much ", "poorly", “not” are effective. In a general view it is necessary to provide conditions of domination of opportunities of the projected system concerning conditions of potential users of services, that is performance of conditions of domination of fuzzy sets. We shall result conditions of domination of fuzzy sets.

Indistinct relation *zGy* strictly dominates over relation *xRy* on parameter y, if at an equivalent estimation the condition is satisfied:

$$Y_R \subset Y_G \,, \qquad (15)$$

where Y_R and Y_G - set of columns elements of matrixes (12) and (13).

If is satisfied condition: $\mu_G(z_l,y_i) \geq \mu_R(x_i,y_j), l=\overline{1,k}, j=\overline{1,m}, i=\overline{1,n},$, for $k \geq n$, that according to conditions of the fuzzy sets presented in [2], the set $Y_G=(y_{G1}, y_{G2}, y_{G3}, ..., y_{Gm}\}$ dominates over set $Y_R=\{y_{R1}, y_{R2}, y_{R3},..., y_{Rm}\}$, so the condition of domination of fuzzy sets presented above is satisfied that is $Y_R \subset Y_G$.

For the proof of domination condition of fuzzy ratio $k < n$ in the resulted fuzzy sets it is enough to replace functions of an accessory $\mu_R(x,y)$ and $\mu_G(z,y)$ with addition:

$\mu_R^{-1} = 1 - \mu_R(x,y)$ i $\mu_G^{-1} = 1 - \mu_G(z,y)$

Not dominating fuzzy ratio *zGy* conditionally dominates over attitude *zGy* on parameter y, if at equivalent estimation the condition is satisfied:

$$\exists Z(c): Y_R \subset Y_G, \tag{16}$$

It is necessary to understand presence of conditions as conditional domination for increase in opportunities of system due to additional capital investments which allow to correct a level of those attributes of services at which conditions of domination are not satisfied. We shall result a following example.

An example. Let it is studied potential opportunities of the market of services of transport system and the offered transport service are estimated by potential users of three social groups $X=\{x_1, x_2, x_3\}$ to attributes the y1-price of the ticket, y2-quality of service and y3 - a regularity of movement. To resources of system which provides these parameters of the offered transport service, vehicles z1, operate technological base z2 and qualification of the personnel z3.

For satisfaction of potential user requirements of transport system services it is necessary to estimate opportunities of system and if necessary to define the additional charges directed on increase of a level of parameters of offered service.

Let's admit, that during the analysis of the received data experts of system have compared with levels of potential user requirements of services and opportunities of system, having reduced them in corresponding matrixes of attitudes $xRy : \mu_R(x,y) \to |0,1|$ i $zGy : \mu_G(z,y) \to |0,1|$.

$$R = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \end{array} \begin{array}{c} \begin{array}{ccc} y_1 & y_2 & y_3 \end{array} \\ \begin{vmatrix} 0,6 & 0,9 & 0,8 \\ 0,7 & 0,9 & 0,8 \\ 1 & 0,3 & 0,7 \end{vmatrix} \end{array} \qquad G = \begin{array}{c} \\ z_1 \\ z_2 \\ z_3 \end{array} \begin{array}{c} \begin{array}{ccc} y_1 & y_2 & y_3 \end{array} \\ \begin{vmatrix} 0,7 & 0,8 & 0,9 \\ 0,7 & 0,8 & 0,8 \\ 0,7 & 0,8 & 0,7 \end{vmatrix} \end{array}$$

The first groups of users demand much of quality of service and a regularity of movement. For users of social group x3 the price of the ticket is the greatest attribute of advantage of transport service. Reduction of indistinct attitudes shows, that opportunities of transport system do not allow to provide in full the requirement of all three groups of poteontial users to attributes of the offered system. We shall enter the average estimations of opportunities of system:

$$\mu(z,y) = \begin{vmatrix} 0, & \mu_G(z,y) < \mu_R(x,y) \\ 1 & , \mu_G(z,y) \geq \mu_R(x,y) \end{vmatrix} \tag{17}$$

$$G_M = \begin{array}{c} \\ z_1 \\ z_2 \\ z_3 \end{array} \begin{array}{c} \begin{array}{ccc} y_1 & y_2 & y_3 \end{array} \\ \begin{vmatrix} 1 & 0 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{vmatrix} \end{array}$$

Thus comfortableness of vehicles is necessary for full satisfaction of requirements of all user groups. And also it is necessary to expand operate technical base of service of passengers for satisfaction of requirements of first two social groups and to reduce the price of the ticket for the third group of potential users of services.

Let for performance of these conditions additional charges make set

$$C=(c_1, c_2, c_3, c_4), \tag{18}$$

c_1 - reduction of incomes of system due to reduction of the price of the ticket;
c_2 - charges on increase in comfortableness of vehicles;
c_3 - charges on improvement operational technical base of transport system;
c_4 - charges on improvement of professional skill of the personnel.

Results estimation to parameters of services also are presented by experts of influence of additional charges on maintenance of requirements in the form of parities $cSy : \mu_S(c,y) \to |0,1|$.

$$S = \begin{array}{c|ccc|} & y_1 & y_2 & y_3 \\ c_1 & 1 & 0 & 0 \\ c_2 & 0 & 0,8 & 0 \\ c_3 & 0 & 0,7 & 0,6 \\ c_4 & 0 & 0,6 & 0,7 \end{array} \quad (19)$$

Let's define other projections of fuzzy ratio S behind the same attributes which demand a correcting, that is

$$\mu_S^{(2)}(c, y_1) = 1, \quad \mu_S^{(2)}(c, y_2) = 0{,}8, \quad \mu_S^{(2)}(c, y_3) = 0{,}7 \quad (20)$$

On the received values of ratio projection the list of the additional charges necessary for satisfaction of users will become

$$C = \{1c_1,\ 0{,}8c_2,\ 0{,}7c_4\} \quad (21)$$

In case of when performance of requirements of all potential users of the offered transport service mismatches conditions (14), the problem of reduction of granting area of service or an admissible level of reduction of the expected income due to loss of the certain quantity of users of different social groups is solved.

In this case the problem of optimization of the sizes of additional charges at an admissible level of profitability transport enterprises is reduced to a problem of indistinct mathematical programming. The offered way on the basis of expert estimations will allow to solve problems of a choice of structure of technological system with use of results of the theory of fuzzy sets from alternative variants under condition of insufficient volume or absence of necessary statistical data at the initial stages of its radical modernization.

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V.P. Kharchenko, Doc. Sci. (Eng.),
O.N. Alexeiev, post-graduate. (Eng.)
(National Aviation University, Ukraine)

SOME ASPECTS OF AUTOMATION SAFETY FLIGHT SYSTEM IN CIVIL AVIATION OF UKRAINE

Aviation industry is the difficult system of the special responsibility and characterized the varieties of solvable task and by the great number of requirements. Decision-making about the choice is the best variant mean of safety flights management in such terms is taken to satisfaction a number of indexes, and in spite of their possible contradiction is not decided problem. For decision this problem it is necessary to create and use computer-integrated facilities of realization of automation processes of safety flights management, on the basis of aggregate base and criteria of prognostication safety level on set interval of time which will allow to realize guarantee approach in relation to providing of normative flights safety level..

Activity of civil aviation of Ukraine science 1998-2007 passed in the conditions of changes which proceed, in the structures of management, both in industry and separate enterprises and airlines. Fashion on creation of «independence state division» into enterprises and industry on the whole in search of economic value drove back the question of safety flights on the second time.

The annual, protracted structural «breaking» with Aviation administration of Ukraine does not give possibility effectively and operatively to manage industry. Existent state structures for today are not ready to carry out effective control and inspection of safety flights, which testifies that safety flights in the aviation of Ukraine not well-to-do.

As an analysis of general estimation of accident rate of civil aviation of Ukraine shows for period of 1998-2007r.r. all aviation adventures took place under act of human, technical and organization factors.

Certainly, that for the decision of problem of automation of management of flights safety, it is expedient to use systems approach to the process of safety flights management on the basis of the complex use:

- methods of authenticity and casual processes;
- laws of distributing of casual sizes;
- apriori and aposteriori estimation of risk factors of accident;
- complex use of algorithms of calculation of point marks indexes of safety flights and automated management it's level.

The Conducted analysis, and also systematization and generalization of problems allowed to set the ways of perfection safety flights control system, define directions them priority researches.

The complex use of mathematical models of prognostication of level of risk and making of managing influences is systematized and carried out, directed on providing of normative level of safety flight.

Lead through the measures of the increase of safety flight, directionally on diminishing of frequency of transitions from the state of safe flight in the states of different exception conditions.

The modified model of logic-probability variants of development exception conditions is created on wing is the analogue of the guided transistor chart which functions for the aggregates of associate, preliminary in number and the high-quality appraised factors of risks and factors which eliminate, preventing or in sort reducing authenticity of development of exception conditions. A model structure allows to synthesize the logic algorithms of authenticity of estimation management of safety flight and determine the ways of increase safety flight level through a management the parameters of P- and P+, including:

Exception of risk factors or minimization of authenticity of their display on wing.

Including (activation) of factors which eliminate, preventing or reducing authenticity of development of exception conditions, or maximization authenticity of blocking by them the proper factors of risk (at absolute prevention accident is examined by some factor (+) .value of authenticity of his influence of P+

At the decision of tasks automation of processes of management safety flights, prognostication, creation of consulting models, will apply neural networks, which, displayed on Fig1.

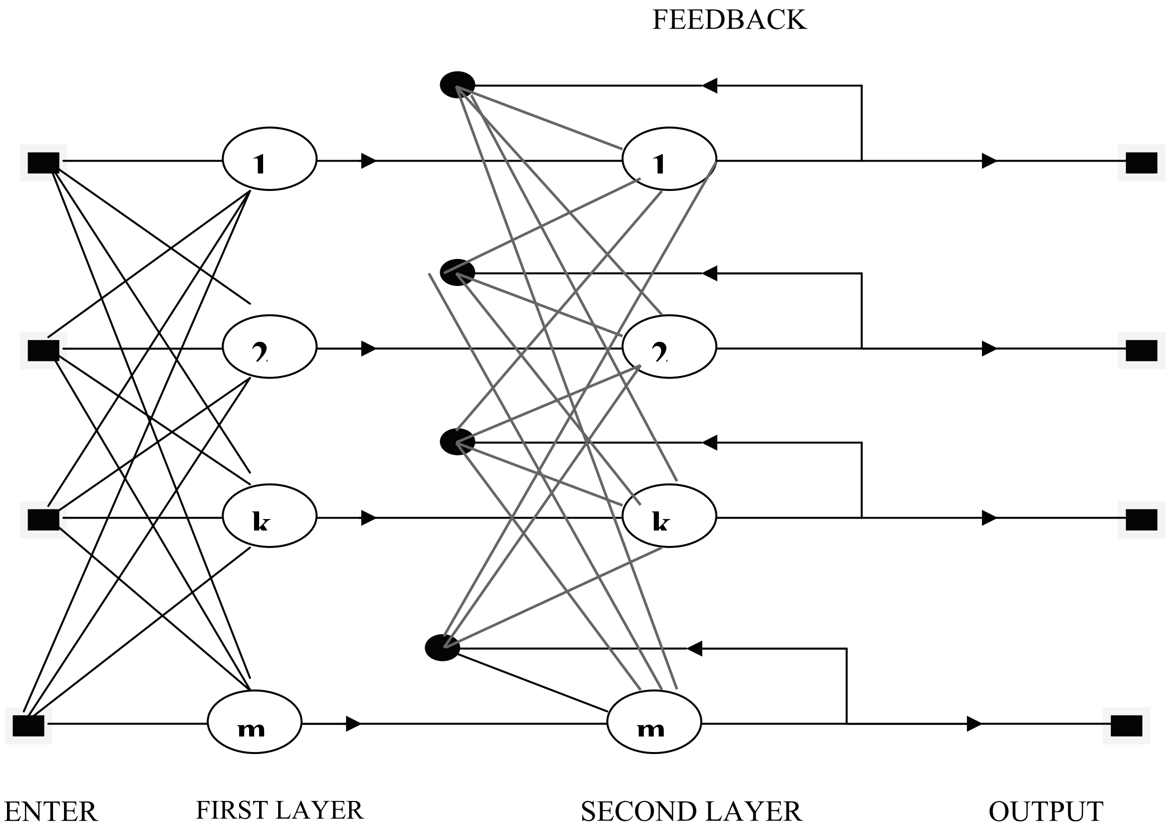

Fig 1. Neural Networks

A network consists of two layers. The first and second layer have for m neurons, where m-the number of examples, by the determined aggregate of possible risks.

The neurons of first layer have for n synapse's, connected with the entrances of network. On the entrance of network an unknown vector, the dimension of which is determined the stream of information on the phenomena, events, actions, and processes which are influence on safety flight. By such method application of neural networks in automatically system of safety flight allows effectively to unite a task a synthesis (prognostication and risk management) and to produce the effective vector of managing influences.

Reason -investigation connection of realization of the active going near the process of prevention of accident is described with the use of structure which reminds the construction of network Petri's. The knots of such network are classes of terms (sets of found out the classification signs of risk factor) and managing influences - accordingly, positions and transitions of network. The simulation network model of the considered task of diagnostics is showed on a fig. 2.

Developed modification of network Petri's, rule their functioning and algorithmic support of imitation of functioning of process of diagnostics allow: to conduct forming of functional model of process of diagnostics; to watch current status of the system of diagnostics; to conduct the generation of variants managing influences by an imitation.

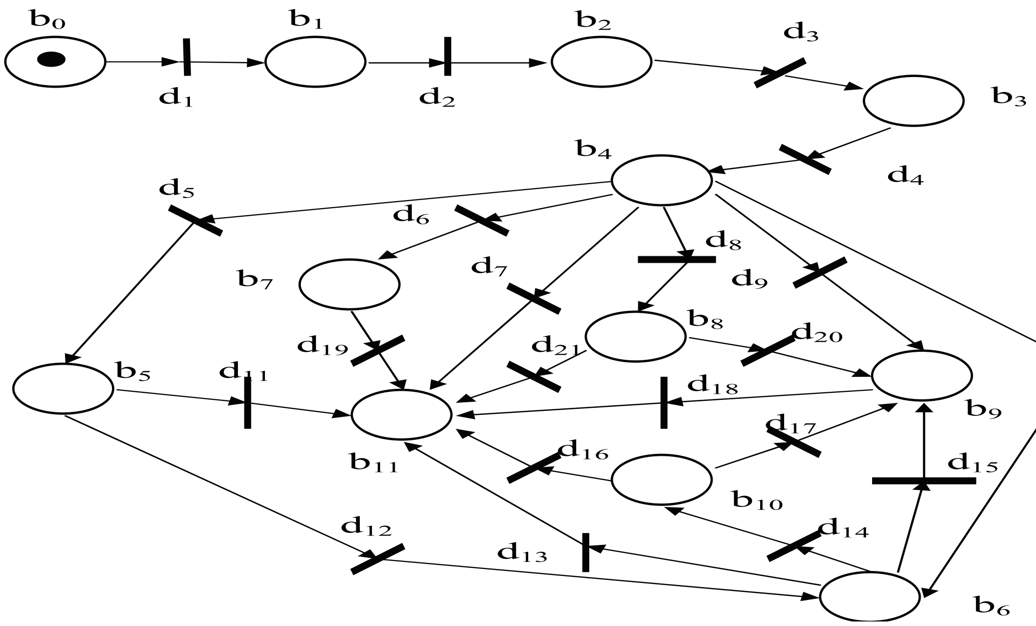

Fig.2 network Petri's

Name	Function of setting
b_0	Authentication probability of risk-factor origin of accident.
b_1	Quantitative estimation of safety flight level.
b_2	Diagnostics of "bottlenecks" is through the private indexes origin of accident risk
b_3	Synthesis of recommendations from the increase of safety flight level
b_4	Estimation of expenses
b_5	Preliminary estimate of efficiency of recommendations
b_6	Analysis and diagnostic

Presented flow-chart of computer-integrated automatically safety flight. Enter of data is carried out through general information from two blocks, used for finding of intermediate parameters on the basis of the complex use of approach of the systems to the process of safety flight management.

Conclusions: The formulated task of creation of methods of development of effective safety flight management has a high scientific and technical value. For its decision it is necessary to develop and realize grounded principles of generalization and synthesis of mathematical models of prognostication and diagnostics of risk factors

methodological questions of creation and application of mathematical models, where basic design of mathematical models of the difficult systems and processes times are certain, methodological going near implementation of the initial stages of design: conceptual design, formalization and algorithmization of models and basis of safety management.

It is necessary as a result:

Grounded and to select priority directions of safety management.

To create conception which provides development of theoretical and methodological bases for the quantitative evaluation of indexes of authenticity of safety flight level;

To carry out complex development of theoretical base for introduction of corporate automatically system of safety flight management , with possibility to provide:

objectivity of operative estimation appearance accident risk;

diagnostics components of enhance able of origin accident risk;

a synthesis of variants of administrative decisions is on the decline of origin accident risk to the normal level;

preliminary estimate of efficiency of the chosen variants of administrative decisions on the indexes of accident warning.

Improved system of quantitative qualititative criteria of the automated diagnostics safety flight managements. Classification of groups of factors which have influence on safety flights got subsequent development, by dividing into risk factors and factors preventing risk;

Theoretical and methodological principles of construction automatically system are first got on the basis of neural networks and elements of artificial intelligence.

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Kolotusha Volodymyr, PhD Technical Science (Ukraine),
Rudas Sergey (National Aviation University, Ukraine)

FORMATION OF AIR TRAFFIC CONTROLLER TEAM ON THE BASIS OF THE MULTI-ASPECT MODEL OF THE INDIVIDUAL CHARACTERISTICS

This article deals with the formation of the air traffic controllers staff on the basis of the models of air traffic controllers' professionally-related characteristics in accordance with the samples of working places at aerodromes.

Development and introduction of the more complicated computer-aided air traffic management systems based on the advanced achievements in the sphere of information technologies, vivid widening of the range and complexity of the questions which enter the sphere of air traffic controllers' professional interests during air traffic service, introduction of the new methods and technological procedures of air traffic service, based on the increased intensity of flights, increasing complexity of the questions air traffic controllers have to be aware of, high level of motivation to do their jobs, policy, followed by EUROCONTROL and European Union concerning general European air traffic controller's license, leads to increased extent of professionally-related knowledge, skills and practices which air traffic controller must possess. All these factors contribute to the extent of knowledge, skills and practices which form the professional model of modern air traffic controller and demand from him/her high or the highest level of qualification to correspond to constantly developing aviation-transportation system.

Ukrainian integration into the European and world aviation community, integration into the International Civil Aviation Organization, European organization for navigation safety facilitated considerable changes in the sphere of adaptation of national rules and procedures to the international standards and recommended practices. Special attention is paid to the professional training of air traffic service personnel. [1, 2].

Teaching process of air traffic controllers Initial Training is divided into[3]:
(Initial Training);
(Unit Training).

Initial Training of air traffic controllers consists of the following stages:
(Basic Training);
(Rating Training).

Initial Training includes technical subjects and ATC theory and simulator under usual working conditions (e.g. without emergency and non-standard situations during air traffic service). The object of initial training is to prepare an ab initio for training at an ATC unit.

Initial Training includes **basic training**, designed to impart fundamental knowledge and skills to enable ab initio air traffic controllers to progress to specialised ATC training, and **rating training** (training in the rating discipline), specialised ATC training to provide knowledge and skills related to a job category and appropriate to the discipline to be pursued in the ATS environment (Rating training might also be provided to training for conversion to another training). Initial Training leads to a Student Air Traffic Controller Licence.

Distribution of air traffic controllers to the corresponding rating:

- ***Aerodrome Control Visual;***
- ***Aerodrome Control Instrument;***
- ***Approach Control Procedural;***
- ***Approach Control Surveillance;***
- ***Area Control Procedural;***

- ***Area Control Surveillance)***

is implemented on the basis of provider orders taking into account students' teaching results and wishes. On completion of initial training students must show correspondence of their professionally-related qualities to the average model of air traffic service specialist. Quantitative indices of professionally-related qualities of the candidate for student-air traffic controller license can be: time spent by student on information exchange during taking aircraft for maintenance, information exchange while delivering aircraft for maintenance, giving clearance for climb (descent), giving instructions concerning direction, possibility to provide air traffic service of the required number of aircraft during limited time, interaction with technical means on working place and so on.

In other words, to show correspondence of own indices of individual activity to the average specialist model, e.g.:

$$\text{Aerodrome Control } (m_{ti}; n_{ti}; c_{ti}) \geq \text{Aerodrome Control Model } (M_{Tconst}; N_{Tconst}; C_{Tconst})$$
$$\text{Area Control } (m_{ti}; n_{ti}; c_{ti}) \geq \text{Area Control Model } (M_{Tconst}; N_{Tconst}; C_{Tconst})$$

Surely, the number and content of technological procedures, where quantitative characteristics are assessed, can vary in accordance with ATCO's job peculiarities in particular sector [4].

But limiting to the corresponding working place in different airports you can find a wide range of quantitative meanings of the required professional qualities. This can be explained by the following example. Airport ***B*** has two runways, complicated pattern of taxiways, air traffic service is provided in accordance to different aircraft categories, the intensity of take-off-landing operations equals 30-35 per hour.

Meanwhile, airport ***C*** has one runway, easy taxiway pattern, air traffic service is provided in accordance to the same aircraft by technical characteristics, the intensity of take-off-landing operations equals to 2-5 per hour. Naturally, quantitative meanings of the required professional qualities will be different.

Thus, after completing rating training Educational Establishment can have some students, who do not correspond to the average specialist model, where under the circumstances of the society low interest of this sphere (lack of candidates to master this job) is quite trustworthy.

By the way, considerable material and human resources have been spent on the student-ATCO license candidate: basic training ≈ 4 months, rating training ≈ 6 months.

To solve this problem you are offered to have a look at the approach based on the individualization of ATCO team formation for the corresponding working place:

Aerodrome Control (m_{ti}; n_{ti}; c_{ti}) ≥	
Aerodrome Control (m_{tj}; n_{tj}; c_{tj}) ≥	Aerodrome Control Model: Airport ***B*** ($M_{T1const}$; $N_{T1const}$; $C_{T1const}$)
Aerodrome Control (m_{th}; n_{th}; c_{th}) ≥	Aerodrome Control Model: Airport ***C*** ($M_{T2const}$; $N_{T2const}$; $C_{T2const}$)
Approach Control (m_{ta}; n_{ta}; c_{ta}) ≥	Approach Control Model: Airport ***A*** ($M_{T1const}$; $N_{T1const}$; $C_{T1const}$)
Approach Control (m_{tb}; n_{tb}; c_{tb}) ≥	Approach Control Model: Airport ***C*** ($M_{T2const}$; $N_{T2const}$; $C_{T2const}$)
Approach Control (m_{tf}; n_{tf}; c_{tf}) ≥	

Initial Training pattern takes the following view, figure 1:

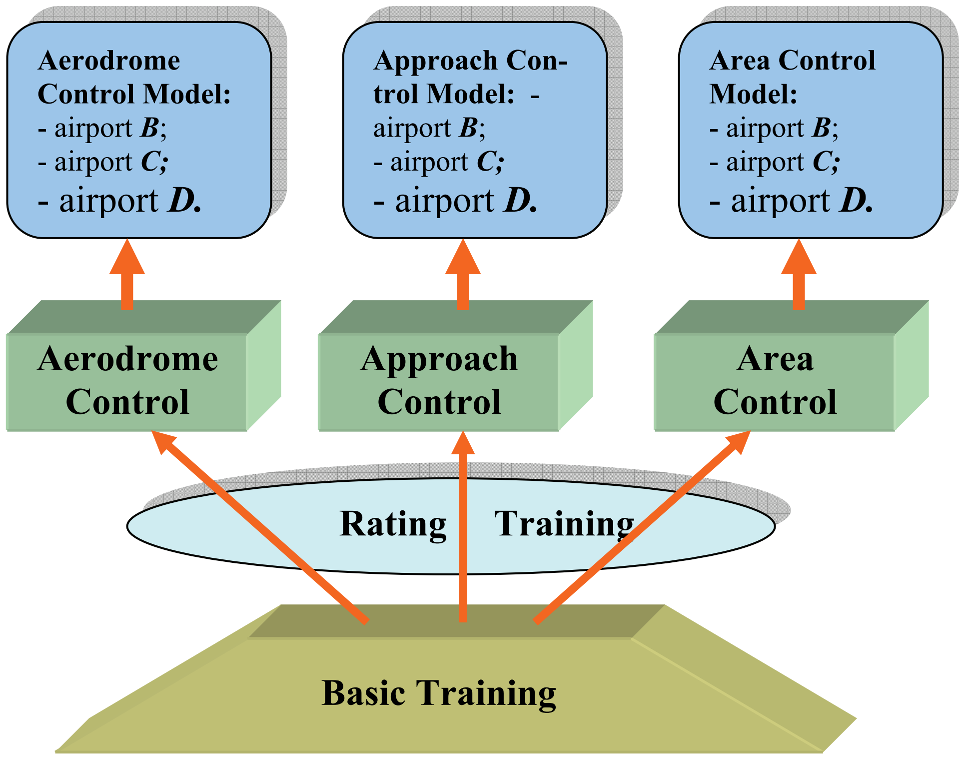

Figure 1. Individualized Initial Training pattern

Conclusion

Suggested approach allows finding individual approach during Initial Training of ATCOs. The presence of the required models of the corresponding working places at different airports will allow covering the wide range of quantitative meanings of the specialist required qualities. Taking into account huge human and material recourses this will help to optimize professional training process.

The presence of the corresponding working places models helps an Educational Establishment to provide purposeful training, choose the needed types of Educational Establishments for the optimal (taking into account advantages and disadvantages) result and thus individualizing the process of training, realizing the principle» needed specialist for the corresponding working place."

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Naumenko K.V., (National Aviation University, Ukraine)

AIROPORT ZONE AIR TRAFFIC CONTROL MULTIPOSITION LOCATING SYSTEM

The subject of consideration in the article is the aircraft control and direction-finding system on the stage of both approaching the airport and taxiing operation in the airflow. The main characteristic features of this process are the exact accuracy of the aircraft position measurement at the expense of optimum filtering and relatively low cost value.

In the air traffic automated process-control system the additional source of information about the aircraft position measurement can be automatic radio direction finders, herewith, it's necessary to admit that no special treatment of the direction-finding information is carried out in the air traffic automated process-control system, except of the line-bearing depiction. Nowadays, the new kinds of air traffic control systems are being worked out, where the direction-finders are the main source of the coordinate information. The key principle of the location data specification in such systems is the triangulation method of calculation.

The determination accuracy of the aircraft guidepath while using the information got by means of multiposition locating radio systems can be essentially raised by means of using algorithms of optimal statistical manipulation of the direction-finding information.

The aircraft location is usually depicted in the scheme as the intersecting point of two position lines minimum. The relative position of the two automatic radio direction finders and aircrafts in the orthogonal axes axis X, Y with the central point in the point of automatic radio direction finder 1 location is depicted on the figure 1.

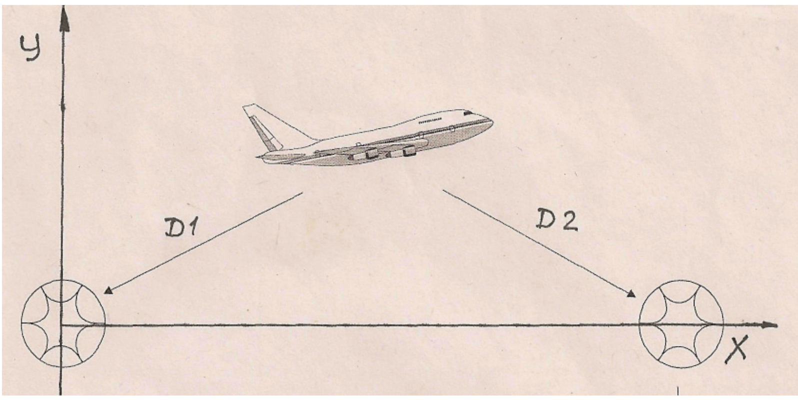

Figure 1.

To solve the problem of the processing and reflection trajectory information processes automatization the recurrent algorithm of the trajectory valuation should be preferably used as the most fast-acting and saving as of the volume of the occupied computer memory. Besides, such algorithms are the best to meet the requirements of the automatic tracking algorithms, based on the procedure of forecast and following correction of the location data according to the results of the received measurements. The well-known Kalman filter can be considered to be such recurrent algorithm of the trajectory valuation.

The potential accuracy which can be obtained as a result of trajectory parameters valuation using Kalman filter is determined by means of solution of an Rikkaty equation, describing error variance valuation development.

The graph of the radial error mean-square value of the aircraft position measurement depending on the aircraft distance from the d base is shown on figure 2.

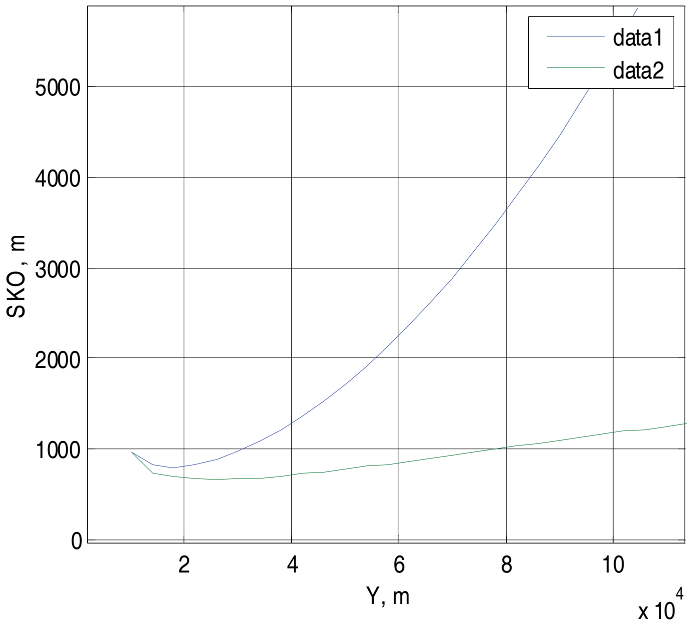

Figure 2: data1- without filtering,
data2- with filtering

One of the variants of solving the assigned task is a ground controlling system implementation consisting of: Receiver/Transmiter Units, Receiver Only Units, Central Station, spread in the airport zone; airborne portion: Mode A/C or Mode S transponder.

The system utilizes a concept similar to Global Positioning System (GPS). GPS provides accurate information by utilizing a single reciver to capture signals transmitted from multiple widely spaced satellites. This system, a beacon multilateration system, uses multiple receivers to capture a signle transmitted signal, aircraft transponder pulses, to calculate the location of an aircraft. The metod of calculation employed is called Time Difference of Arrival (TDOA) processing.

The system is configured with multiple low cost non-rotating sensors installed at convenient location in the terminal area. Each sensor receives, decodes, timestamps,and transmits the data from the transponder reply to Cental Station. The Cental Station compares the reports from multiple sensors to derive a position based on the TDOA. For each pair of sensors an arc can beestablished which represents all of the possible locations of the transponder based on the TDOA recorded by the two sensors.The additional of third sensor allows the creation of a second solution arc. The intersection of these arcs is the location of the transponder`s antenna.

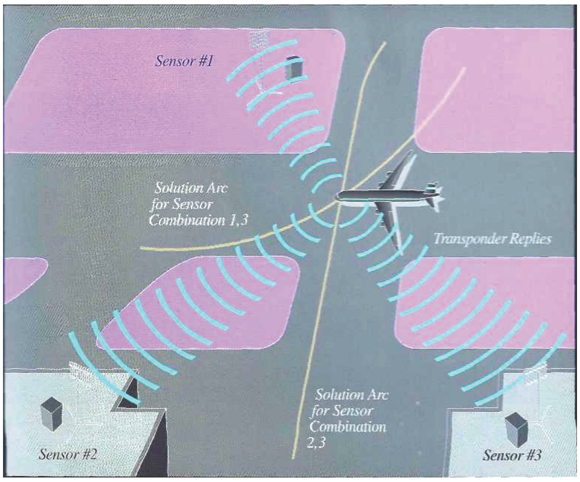

Figure 3.

An important feature of this system is that it works with any aircraft already aquipped with any aircraft already equipped with either Mode A/C or Mode S transponder without additional avionics.

Summary:

The suggested math model allows to define more exact location of the aircraft using the optimal filtration.

The given model can also be used for the implementation in the Ukrainian airports.

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Dr.,Prof. Olena PETRASHCHUK,
Director AEROLINGUA Training Centre (Kyiv)

LEADING AVIATION PERSONNEL TO ICAO LEVEL FOUR

Three stages of the process: a/ benchmarking testing is aimed at screening the initial level of English Language performance in terms of ICAO scale descriptors; b/ training in Aviation English with a focus on oral language ability development; formative assessment is included into the course in order to monitor the students' progress; c/ proficiency assessment according to ICAO scale.

Three important components of the process to be considered, developed and improved: a/ Test of English for Aviation personnel (format and qualities); b/ training of examiners and administrators; c/ training of raters and providing security of data.

Normative documents of Ukraine regarding level 4 mandatory status. Some statistics from AEROLINGUA regarding feasibility (time, costs) to timely reach ICAO level 4 by aviation personnel of Ukraine.

Changing of attitude of controllers and pilots towards the English language knowledge for job purposes: plain English vs English R/T phraseology. Problem of keeping level 4 between test sittings every 3 years.

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S. Demchenko, graduate student NAU, Ukraine

THE SPATIAL ADAPTIVE ANTENNA LATTICE OF SATELLITE RADIO NAVIGATIONAL SYSTEMS

Considered possibility of the use the three-dimensional antenna lattice for building of the adaptive antennas. Brought results of modeling.

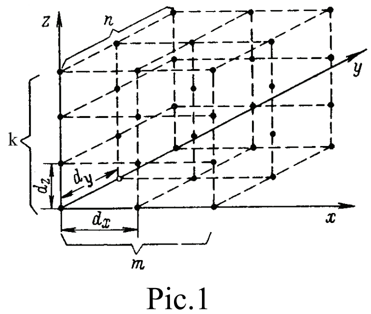
The perspective direction of the decision of the problem of increasing to noise-immunity of the equipment satellite radio to navigations is an use the adaptive antennas [1, 2, 3]. Adaptive antenna (AL), built on the base of the antenna lattices (the AL), allow as a result of analysis signal-hindrance of the situation to form in automatic mode amplitude-phase distribution on elements AL by so as collapses were created in diagram of the directivities toward receipts of the hindrances. The perspective direction of the decision of the problem of increasing to hindrance-immunity of the equipment satellite radio navigational is an use the adaptive antennas [1, 2, 3]. Adaptive antenna (AA), built on the base of the antenna lattices (AL), allow as a result of analysis signal-noise of the situation to form in automatic mode amplitude-phase distribution on element AL by so as collapses were created in diagram of the directivities toward receipts of the hindrances.

The development AA touches variety of questions, in accordance with choice parameter AL, syntheses algorithm to adaptation, account decreases factors.

In literature on adaptive compensation of the hindrances was not accented attention on desk-sides AL.

The Author are received and published some result in area of the building AA with linear and flat AL [4, 5]. In persisting work is for the first time done attempt of the estimation of the possibility of the use the spatial antenna lattices for building AA.

We shall consider the three-dimensional AL, in which radiating elements are located in nodes of the spatial lattice and are oriented parallel axises of the coordinates (pic. 1).



Pic.1

Let begin coordinates complies with one of the tops of the lattice. In directions x, y, z are located by Nx, Ny, Nz radiating element accordingly. The distances between element are dx,dy,dz. Radiators are identical and izotrop. Amplitude sharing the electromagnetic field in aperture even.

As it is shown in [6], multiplier three-dementional AL possible to present in the manner of:

$$f(\theta,\varepsilon)=\sum_{n=0}^{Nx-1}\sum_{m=0}^{Ny-1}\sum_{k=0}^{Nz-1}\exp\psi_{n,m,k} \ ,(1)$$

$$\psi_{n,m,k}=j\frac{2\pi}{\lambda}\left(n\cdot dx\cdot\sin\theta\cdot\cos\varepsilon+m\cdot dy\cdot\sin\theta\cdot\sin\varepsilon+k\cdot dz\cdot\cos\theta\right),$$

θ,ε – corner of the place and azimuth of the direction of receipts,

λ – wavelength of the taken signal.

Coming from (1) multiplier adaptive AL will take type

$$f_A(\theta,\varepsilon)=\sum_{n=0}^{Nx-1}\sum_{m=0}^{N_y-1}\sum_{k=0}^{Nz-1}\ \omega_{n,m,k}\exp\psi_{n,m,k}\ ,\ (2)$$

$\omega_{n,m,k}$ – weight factors of adaptation.

Provided that radiator in plane, perpendicular axises x, y, z have an equal relative amplitude and phase distribution expression (2) possible bring about type [6]:

$$f_A(\theta,\varepsilon) = f_x(\alpha)\cdot f_y(\beta)\cdot f_z(\theta), \quad (3)$$

$$f_x(\alpha) = \sum_{n=0}^{Nx-1} w_n \cdot \exp\left(j\frac{2\pi}{\lambda} n\cdot dx\cdot\cos\alpha\right),$$

$$f_y(\beta) = \sum_{m=0}^{N_y-1} w_m \cdot \exp\left(j\frac{2\pi}{\lambda} m\cdot dy\cdot\cos(\beta)\right),$$

$$f_z(\theta) = \sum_{k=0}^{Nz-1} w_k \cdot \exp\left(j\frac{2\pi}{\lambda} k\cdot dz\cdot\cos\theta\right),$$

$$\cos\alpha = \sin\theta\cdot\cos\varepsilon,$$

$$\cos\beta = \sin\theta\sin\varepsilon.$$

$f_x(\alpha)$, $f_y(\beta)$, $f_z(\theta)$ – present itself multipliers linear AL with directions of receipts of the front of the wave, characterized directing cosine $\cos\alpha$, $\cos\beta$, $\cos\theta$.

α, β, θ – they are calculated in models of the meter, synthesized on criterion of the maximum to functions of the plausibility [1].

Weight factors for each of linear lattices define according to expression [4]:

$$w^{\xi} = [\Phi^{\xi}]^{-1}\cdot\beta^{\xi}, \quad (4)$$

w^{ξ} – vector of weight factors;

Φ^{ξ} – the matrix of the phase distribution taken signal and hindrances along linear AL;

Study to mathematical model, built according to expressions (1-4) it was conducted under the following raw datas:

– the signal deterministic, hindrance casual;– Nx = Ny = Nz = N = 2;

– dx = dy = dz = 0,5λ, , λ = 0,2м;

– when receiving the hindrance with directions $\theta_p = 70°$ и $\varepsilon_p = 19°$, signal – $\theta_c = 20°$ и $\varepsilon_c = 50°$;

– attitude hindrance/signal – 40дБ;

– when averaging on 10^4 realizations;

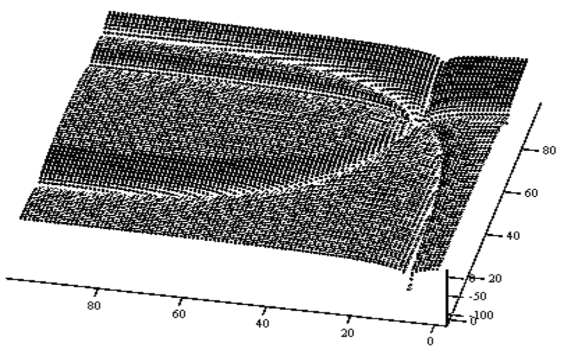
– modeling was conducted for linear, flat and three-dementional AL.

Factor of the suppression of the hindrance was defined according to expression

$$Q = \frac{1}{KR}\sum_{i=1}^{KR} Q_i,$$

$$Qi = 20\lg\left[\frac{1}{N^3}\left|fi(\theta_p,\varepsilon_p)\right|\right] - 20\lg\left[\frac{1}{N^3}\left|f_i(\theta_c,\varepsilon_c)\right|\right],$$

On Pic.2 is diagram of the directivities spatial adaptive antenna for considered to models.



Pic. 2

Following importance of the factors are received Q:

– for linear AL – -55дБ;

– flat AL – -87дБ;

– for three-dementional AL – -119дБ.

What see, accompaniment of the third measurement has allowed to perfect the factor of the suppression of the hindrance AA more, than on 30%.

The improvement of the factor of the noise-balancing exactly to account spatial AL can turn out to be essential, when size antenna in planes are strictly limited. So at accommodation AA on board plane, accompaniment, for instance, one layer of the linen 4-h element AL can turn out to be more acceptable, than increase area linens. At complication of the interconnection of excitement radiating element can be flat.

Besides, can turn out to be the essential accompaniment of the third measurement AL for reduction of the acceptance signal with mirror direction.

Said allows to consider the perspective further studies of the three-dementional adaptive antennas.

The Conclusion:

Using the adaptive antennas for increasing of noise-immunity of the equipment to satellite navigation at present well-known. The Method study of increasing to efficiency of these antennas more so currently that development them in Ukraine is found in initial stage.

The results have shown that using the spatial adaptive lattices in principle allows to perfect the factor of the noise-balancing. The further studies will possible conclude about prospect of their use after undertaking.

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S.G. Raychev, Post-graduate student,
(ATSA, Bulgaria)
Yu.V. Chynchenko, Cand. Sci. (Eng.)
(National Aviation University, Ukraine)

PRINCIPLES OF DEVELOPMENT OF HUMAN ERROR CONCEPTUAL FRAMEWORK AT AIR TRAFFIC CONTROL

Principles of development of human error conceptual framework at Air Traffic Control are considered. Analysis of requirements for an air traffic management human error taxonomy and conceptual framework of HERA are given.

Introduction

In this article are integrated the results of the literature review in the development of a conceptual framework for the Human error in ATM (HERA) taxonomy. The purposes of this article are following:

- the first, a set of requirements for the operational taxonomy are presented. These requirements will become the guiding principles for the taxonomy in terms of its performance, validity and utility. However, these principles are generally high level and will not help to define the detail or even necessarily the structure of HERA.

- the second aspect concerns the conceptual framework or model itself that HERA will be built around. Having reviewed a number of alternatives, one must be selected or adapted which will best help HERA to capture human errors and their causes in an ATM environment.

Within the conceptual framework a further aspect of this article is to define an appropriate structure and format of HERA in terms of what ‘dimensions’ HERA must contain and its overall format.

Requirements for an Air Traffic Management Human Error Taxonomy and Database

Here is represented the list of the key requirements for the proposed human error taxonomy and appropriate database:

1. ***Usable by non-human factors specialists.*** The taxonomy should be usable, after an introduction of a few hours, by experienced ATC-operators and the kind of staff who customarily classify incidents. It is expressly not intended that the users of the taxonomy need to have a professional background in human factors or psychology.

2. ***Robustness.*** The taxonomy, in combination with its user guidelines, should produce reports with little variations, so the same case ought to result in the same classification no matter where, when and by whom it is classified. If not, the output of the taxonomy will depend on uncontrolled and typically undocumented circumstances of use; this in turn will seriously jeopardise the quality of the database that results from the use of the taxonomy.

3. ***Theoretically sound.*** The taxonomy should go beyond a mere empirical classification of data and be based on generally accepted theories of human performance and cognitive processing in real-time domains. In contrast an empirically derived classification scheme is liable to be sensitive to differences in samples (cases on which it is built).

4. ***Inter-cultural reliability.*** Ideally, the taxonomy should yield the same classification in terms of types of errors and causes when the same case is treated by different incident investigators belonging to different operational cultures within the EUROCONTROL area. This requirement constrains the user guidelines and the associated brief introductory training.

5. ***Validated.*** The taxonomy should not only be robust and consistent in use across different users and occasions of use, but it should demonstrate this.

6. ***Comprehensiveness.*** The taxonomy should be comprehensive in the sense that it should

have a classification label for all relevant types of human error in the ATM domain; at the same time, it should aggregate errors in terms of principled error categories in order to provide insight.

7. ***Inclusive of ATM functions and equipment.*** The taxonomy should prompt users to identify failures and errors not only in terms of psychological mechanisms but also in terms of the tasks (functions) and devices or equipment that were being used. Similarly, the database should support queries by reference to the latter terms.

8. ***Comprehensive of human-system interaction failures.*** The taxonomy should allow for classification of human-system interaction failures when relevant (e.g. occurrence of 'mode error' with respect to specific automated equipment).

9. ***Descriptive of errors in terms of work situation.*** The taxonomy should be able to capture analysts' description of the human elements involved in incidents in terms of the actual conditions of work (e.g. handover; high workload).

10. ***Sensitive to single operators, team and interactional aspects.*** The taxonomy should be sensitive to errors (and error-capturing behaviours) at the level of the single operator and at the level of the team; it should therefore also be able to classify communication failures.

11. ***Insightful in terms of practical error reduction strategies.*** The taxonomy should be capable of providing not only a breakdown of causes and factors (human errors, technical and organisational elements) but must also, by virtue of its theory-based character, aggregate "minute human error causes" in terms of larger and operationally meaningful categories. Similarly, it should be able to capture recommendations by general and not just locally meaningful, categories.

12. ***Enhance the discovery of trends, i.e. early warnings.*** The database resulting from the use of the taxonomy should enable end-users of the database to identify trends and suspected trends.

13. ***Sensitive to error detection behaviour.*** The taxonomy should prompt users (classifiers) to record when and by whom irregularities and errors were discovered. It is well-known from a range of field studies in process industry and aviation that far more errors are made than are allowed to influence system behaviour. The errors that are caught are, at their root, typically no different from the errors that are not. It is therefore important to gain knowledge into error detection strategies and factors which enhance their potency. This requirement will shape the fine grained structure of the taxonomy aimed at classifying behaviours observed during simulated or observed sessions.

14. ***Adaptive to future developments.*** The taxonomy should aim to be comprehensive with respect to future developments in technical and procedural systems (e.g. free routes) and should be able to accommodate future ATM developments.

15. ***Allow new ways of categorising data and at the same time stay 'historically robust'.*** While the taxonomy should allow for the introduction of novel distinctions in terms of future ATM functions and equipment, the taxonomy should be 'historically robust' in the sense that cases which are classified by an older version of the taxonomy should be comparable with cases classified by a newer version. There will be a trade-off between adaptability (ability to incorporate novel distinctions and categories) and historical robustness.

16. ***Customisable to different ATM environments yet allowing for the integrity of the database.*** The taxonomy should allow for the possibility that different ATM environments can adapt parts of it (by expansion) to local requirements. The user guidelines shall carefully document how novel (local) categories may be introduced so as not to jeopardise the consistency of data input into the database.

17. ***Consistency.*** While the taxonomy should allow for local adaptations and expansions the interpretation of data should remain invariant across local variations. A given category should not vary in meaning across different entries.

18. ***Consistent with approaches in other domains.*** The taxonomy should be consistent with classification schemes used in other domains, especially in aviation and process control. There are several motives behind this requirement. One is to produce a taxonomy which follows the 'industry standard', another is to allow for comparisons between the ATM domain and especially aviation and other process control areas in order to identify possibly abnormally high rates of specific error categories.

19. ***Both incident report inputs and data from real time simulations and field studies.*** The taxonomy should be able to provide a theory-based classification scheme for not only (a) incident and accident reports from different ATM environments but also (b) data and observations derived from real time simulations or operational sessions.

20. ***Confidentiality.*** The taxonomy should not invite the pillorying of specific sites, organisations or persons. It is important that issues of confidentiality and anonymity are addressed at an early point when the taxonomy and its database are offered to member states. This is not just a point about ethics - numerous taxonomies and reporting schemes have foundered due to a lack of anonymity in their application.

The Conceptual Framework

The literature review has derived several core components of a human error conceptual framework (Figure 1). These core components are listed below:

1. ***A human information processing model*** – appears to be the most relevant model of human performance for ATM because it encompasses all relevant ATM behaviours and allows a focus on certain ATM-specific aspects such as 'the picture' and Situation Awareness (SA).

2. ***External Error Modes*** (EEMs), ***Internal Error Modes*** (IEMs) and ***Psychological Error Mechanisms*** (PEMs) – appear to be the main structural aspects that enable a constructive (precise and helpful) analysis of human errors and they have proven their worth in other industries.

3. ***Performance Shaping Factors*** (PSFs) – are additional factors that relate to error causes, that will be necessary for error reduction analysis.

4. ***Contextual or task-specific factors*** – These task (e.g. strip-marking), information (e.g. flight level) and equipment (e.g. strip) factors must be embedded within the HERA technique, as they make HERA focus on the ATM context, and enable analysis of error trends across errors from various operational units and practices.

5. ***A flowchart format*** – Appears the most usable and robust format to error classification, as shown in other industries.

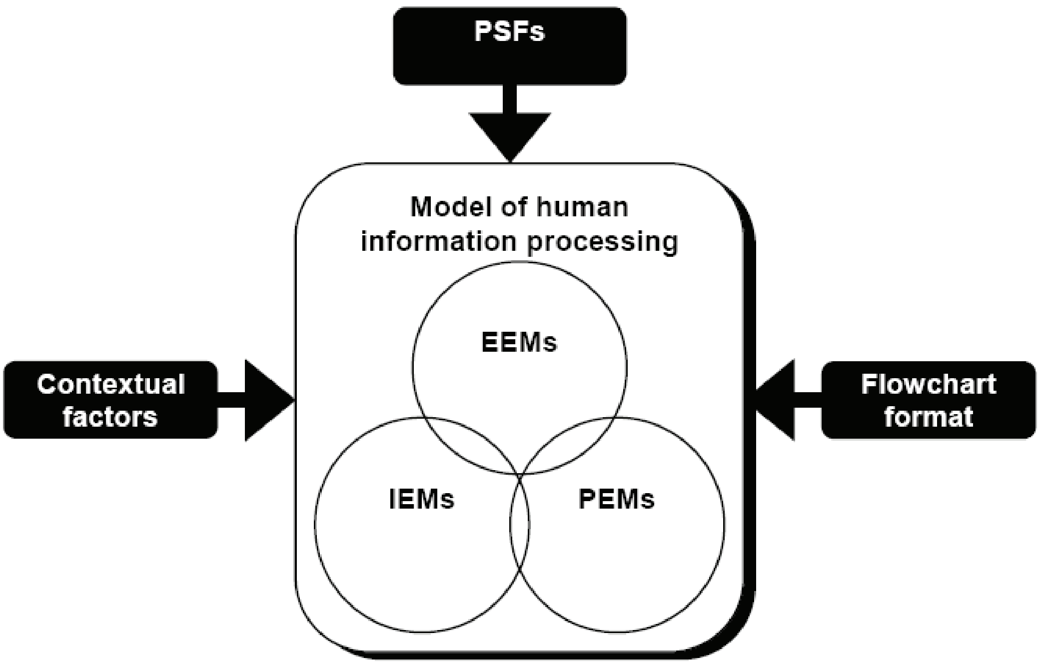

Fig. 1. Conceptual framework of HERA

The model of human information processing provides a good framework around which to base a human error classification system. Wickens' Information Processing Model [1] appears to be the most suitable model, if suitably adapted. Therefore, a number of modifications, which are listed below, are required to make the model more applicable to ATM.

"Working memory" should however follow from "perception". "Working memory" is thought to contain what is traditionally thought of as “the picture”, i.e. the controllers mental representation of the traffic situation. In the enhanced model, this is termed “ATM picture”. However, controllers also have thoughts about themselves and their ability to cope with the traffic situation. This includes factors such as confidence, perception of workload, how situationally aware they feel, etc. In the enhanced model, this is termed “self-picture”. These factors can change dynamically with the ATM situation and so are located in working memory.

“Decision and response selection” is divided into two separate renamed processes [2]:

- “Judgement, planning and decision-making” – this reflects more explicitly the processes of judgement, projection, prediction and planning used in ATM;

- “Judgement” here refers to judging the heading, climb, descend or speed, etc., to achieve separation.

The “mental model update loop” is the flow of information from working memory to long-term memory. The controller’s mental model is updated by new information from perception as well as information from judgement, planning and decision-making. However, all updates to the mental model arrive directly from working memory. Since past decisions and responses as well as perceived information must be processed in working memory initially.

The “picture update loops” represent the flow of information used to update the controller’s ATM picture. Information from perception, long-term memory, and judgement, planning and decision-making is used to update the picture.

With a shift from passive reception to active collection of information attention becomes more focused. Attention can be insufficiently focused in the case of distraction or preoccupation, to too focused in the case of ”visual tunnelling”.

A limited pool of attention is shared between perception, working memory, decision and response selection, and response execution. If perception demands a large supply of attention performance of other functions deteriorates.

Conclusions

Application of HERA will adopt an internal structure of:

- External Error Modes (EEMs) – the external manifestation of the error (e.g. omission).

- Internal Error Modes (IEMs) – the internal manifestation of the error within each cognitive domain (e.g. late detection).

- Psychological Error Mechanisms (PEMs) – the internal mechanism of the error within each cognitive domain (e.g. perceptual tunnelling).

This internal structure allows the analyst or incident investigator to classify errors at three levels of detail. There will always be sufficient information to classify the EEM, and usually there will be enough information to classify the IEM. PEMs add value to the analysis, but are the most difficult level to classify, because there is often insufficient information to determine the PEM.

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O.S. Slyniaev, postgraduate student,
(National Aviation University, Ukraine)

DEFENSE FROM UNAUTHORIZED INTERFERE TO THE AIR TRAFFIC MANAGEMENT

Cyber terrorist attack allows interfering into the target system, control interception, neutralization of network data exchange me or causing other destructive actions. Thereby, the defence system of ATN electrical communication is necessary for protection from unauthorized access. Defence control is necessary for protection of information exchange in applied process.

Means of defence during data handling should be foreseen in boundary systems and means of defence while data transmission should be foreseen in boundary systems and network resource as well.

At ATN network environment the net-to-net structure can consist of privet sub networks or sub networks of common use. The arrangement of the common sub network defence from unauthorized access can be more difficult than one of private network. The detection of unauthorized access in ATN sub network is highly desirable to occur in the entry point to the area.

ATM consists of earth-based and board parts each necessary for safety and affective airplane operation in every stage of flight. The basic element of ATM is air traffic control. Air traffic management need tight interaction of earth-based and board parts with help of definite procedure.

ATM functions include air traffic control, air traffic management ATFM and air space management (ASM). These three elements facilitate the goal achievement at the different stages of the flight. Air traffic acceleration as well as its safety and order assuring is the basic goal of ATM. The effectiveness of this system is a very important thing which is connected with such aspects as the coast of earth-based and board parts implementation as well as its ability to satisfy the users' needs.

The meeting of the next demands is necessary for achieving of the goal described above:

- ATM system should offer the maximum flexibility in air space using to their users; at the same time it should take into the consideration their economic and operational needs as well as the capability of the airports;
- Functional data compatibility, which are transferred by "air-earth" and "earth-earth" channels are also important for global effectiveness providing of the system;
- joint air space using by different categories of users should be organized with maximum flexibility with taking into the consideration of different level of airplanes provision with equipment;
- different components of general system and the main tasks of ATM should be intended for effective common work with the aim of effective and ensuring of trouble-free service of the users from take-off till the landing. International co-operation is necessary for assuring good coordination of aircraft operation while its crossing the state boundaries and as a result it is necessary to make international system.
- ATN should take into the consideration effective common work of authorized civil aviation institutions, aircraft operating agencies and service providers.

The main goal of ATM is to accelerate air traffic and provide its safety and order. For this aim fulfilment the ATM data transmission network is needed, which will provide data exchange needs and will secure general compatibility of different kinds of network using for different categories of final users. The definite kinds of network usage should be provided for the next elements of ATM implementation: air traffic management, air traffic service, air traffic flow management. ATM environment foresees two types of air traffic safety service for providing of safety and regularity of air traffic: air traffic management and flight information service (FIS).

ATFM is the service the main aim of which is to plan the air traffic and to work out the strategy. The ATFM service agrees the flight needs and traffic-carrying capacity of air traffic management providing traffic lowering and the most effective use of available traffic-carrying capacity.

The aim of FIS and alerting service is to give consultation and information to the airplanes for safety and effectiveness of the flights. Such service is connected with safety of the flights and is provided for help given to the pilots in expected and planned flight conditions. These demands grow in bed weather conditions with traffic growth. This kind of service demands such kind of information as weather reports and weather forecasts, notification of the pilots (NOTAM), navigation aids changes and automatic information transmission in the airport area.

Thereby, in XXI century the cyber terrorism became a very important problem before society. Computer attacks became almost unforeseen or observed in the real time. Attack can occur in any time in a country or outside the country caused by teenagers the main aim of whom is to get bright feelings, feel envy to a country, by criminals, spies or terrorists; considerable resources are necessary to define with high probability level, who is responsible for the terrorist act.

There is a dangerous tendency because of rising of technical and technological dependence of our country. The domestic manufacturing of competitive means of information exchange and communications doesn't almost develop. Informational service both as governmental and commercial institutions is made on the basis of foreign technologies and computer technology. The lack of governmental support of domestic fundamental and application investigations in the field of prevention and struggle against the cyber criminals doesn't let to our country to join in the world-wide informational system.

One of the most important questions, which need the prior solving is unauthorised access to the air navigation network. The usage of the most modern technologies and programmes is a very important moment in the problem solving. ATM system elements and ATN network elements should be tested before their being connected to the working network. These tests can be divided into tests which are necessary for usage compliance authorising and tests held for authorising of connection functions.

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V.Sineglazov, Doctor of Engineering, Prof. (National Aviation University, Ukraine)
O.Krasnousova, Cand. of Engineering, A.P. (National Aviation University, Ukraine)
Y.Egorshin, Cand. of Engineering, A.P. (National Aviation University, Ukraine)

THE NEW METHODS OF SIGNAL SPECTRUM DEFINITION

The new methods of signal spectrum definition are offered, in which there is no need to calculate Fourier's and Laplace's integrals. These methods can be used to determine the spectral densities of the integrated and nonintegrated signals.

Introduction and a problem statement

The signals $u(t)$, $v(t)=u(t)\cdot h(t)$, $w(t)=u(t)\left[h(t)-h(t-\text{ф})\right]$ are considered, where $u(t)$ - the oscillations set on the interval $t\in(-\infty;\infty)$; $v(t)$ - the oscillation jump functions; $w(t)$ - the impulses; $h(t)$ - the Heaviside function.

The classical method of spectral density $\dot{S}$ definition consists of Fourier's integral calculation[1]. Frequently $\dot{S}$ is received from the Laplace's operational representation, by substituting p operator for $j\omega$.

These methods cannot be applied to the definition of spectrum $\dot{S}[u],\dot{S}[v],$ if u and v – are the sustained oscillations or the nonintegrated signals [1.2].

Earlier by the specific methods the expressions of $\dot{S}$ have been determined only for some nonintegrated signals, for example in[2]. Often one can face to the incorrect expressions of $\dot{S}$, following from the operational representations [3].

In this work it's offered the methods of definition of the correct expressions of $\dot{S}$ without calculations of Laplace's and Fourier's integrals. These methods are convenient for applying, if $u(t)$-an integrated signal and if $u(t)$ - the sustained oscillations: harmonic, power-type, polynomial functions and their combinations.

Fundamentals

We have grounded and used the following statements for the spectrums of the nonintegrated signals:

1. For the function $v(t)$ the spectrum $\dot{S}$ has two components always[4,5]:

$$\dot{S}[v]=LS[v]+DS[v]\quad, \tag{1}$$

where $LS[v]=\lim L[v]-$ an operational component, $p\rightarrow j\omega$, $DS[v]-$ is the sum of д–functions, д– is a component.

2. There is a functional relation[5]:

$$DS[v]=\sum_{\omega_{\text{п}}} j\text{р}(\text{щ-щ}_{\text{п}})\text{д}(\text{щ-щ}_{\text{п}})LS[v], \tag{2}$$

where $\text{щ}_{\text{п}}$ - the poles for $LS[v]$.

3. For the functions $u(t) = u(t) \cdot h(t) + u(t) \cdot h(-t)$ it's right[5]:

$$\dot{S}[u] = DS[u] = 2DS[v], \tag{3}$$

4. For the functions $u(t) = u_1(t) \cdot h(t) - u_1(t) \cdot h(-t)$ it's right[5]:

$$\dot{S}[u] = LS[u] = 2LS[v], \tag{4}$$

5. For the functions $v(t)$ the derivative representation $v^{(n)}(t)$, irrespective of the initial conditions, is of the form[4]:

$$L\left[v^{(n)}\right] = p^n L[v] = p^n L[u], \tag{5}$$

in comparison to a more tedious classical expression of $L\left[u^{(n)}\right]$,[1].

Fourier right-side representation for the derivative $v^{(n)}(t)$ and the double-sided transformation for $u^{(n)}(t)$ will have the similar form (5).

6. For an antiderivative of time function $u^{(-n)}(t)$ of any order n, there is a ratio[6]:

$$\dot{S}\left[u^{(-n)}\right] = (j\omega)^{-n} \cdot \dot{S}, \tag{6}$$

if an of any order is central (central antiderivative function - CAF), i.e. an integration constant C is equal to zero every time.

7. It's possibly to represent the function $v(t)$ as a CAF relative to $h(t)$ or to 1, when $u(t)$ is a polynomial of a power of n:

$$\mathrm{v}(t) = \sum_{i=0}^{n-1} a_i h^{(-i)}(t), \qquad \mathrm{v}(t) = \sum_{i=0}^{n-1} a_i (1)^{(-i)} h(t), \tag{7}$$

where a_i -the weight factors.

8. It's possibly to represent the function $w(t)$ as a CAF relative to $\delta(t), \delta(t-\tau)$ or to $y_0(t), y_0(t-\tau)$, when $u(t)$ is a polynomial,

where $y_0(t) = \frac{1}{2} Sgnt = \delta^{-1}(t)[6]$:

$$\left.\begin{aligned} w(t) &= \sum_{i=1}^{n+1} \left[c_i \delta^{(-i)}(t) + d_i \delta^{(-i)}(t-\tau)\right], \\ w(t) &= \sum_{i=1}^{n+1} \left[c_i {y_0}^{(-k)}(t) + d_i {y_0}^{(-k)}(t-\tau)\right] \end{aligned}\right\} \tag{8}$$

where c_i, d_i – the certain weight factors; $k = i - 1$.

The offered methods

On basis of use of the expressions (1)...(8) the some methods of a signal spectrum definition are offered.

In the *first method*, the expressions of $\dot{S}[v]$, $\dot{S}[u]$ are found by the known expression of $L[u]$, using (1) and (2).

In the *second method* the expressions of $\dot{S}[v]$, $\dot{S}[u]$ are found by the known expression of $v^{(n)}(t)$, using (5), (1) and (2).

In the *third method* the expressions of $\dot{S}[v]$ are found in case when $u(t)$ represents a CAF in respect of 1, using (6) and (7).

In the *fourth method* the expressions of $\dot{S}[v]$ are found when $v(t)$ represents a CAF in respect of $h(t)$, using (6) and (7).

In the *fifth* method, using (8), the expressions of $\dot{S}[w]$ are found in case when $w(t)$ represents a CAF in respect of $\delta(t)$, i.e. the integrated signal $w(t)$ represents the sum of nonintegrated signals.

In the *sixth method*, using (8), the expressions $\dot{S}[w]$ are found in case when $w(t)$ represents a CAF in respect of $y_0(t)$, i.e. the integrated signal w represents a sum of the nonintegrated signals.

In the *seventh method*, using of (5) and (6), the expressions of $\dot{S}[w]$ are found, when $u(t)$ is a polynomial or power function, resulting from the view of $w^{(n+1)}(t)$.

Examples of use

Let $u(t)=1\sin\omega_0 t$, $v(t)=u(t)\cdot h(t), w(t)=u(t)\left[h(t)-h(t-\tau)\right], \tau=\dfrac{\pi}{\omega_0}$.

In the first method one can use the known expression: $L[\mathrm{v}]=\omega_0/\left(\omega_0^2+p^2\right)$. It results from (1): $LS[\mathrm{v}]=\omega_0/\left(\omega_0^2-\omega^2\right)$. From (2) it follows: $DS[\mathrm{v}]=0.5j\pi[\delta(\omega+\omega_0)-\delta(\omega+\omega_0)]$. From (2) it follows the known expression $\dot{S}[u]=2DS[v]$. Knowing $LS[v]$, we receive:

$$\dot{S}[w]=LS[\mathrm{v}(t)]-LS[-\mathrm{v}(t-\tau)]=\left(1+e^{-j\omega\tau}\right)\cdot\omega_0/\left(\omega_0^2-\omega^2\right)$$

In the second method, writing down $\mathrm{v}_2=-\omega_0^2\mathrm{v}+\omega_0\delta(t)$, subject to (5), we have: $L\left[\mathrm{v}^{(2)}\right]=-\omega_0^2L[\mathrm{v}]+\omega_0=p^2L[\mathrm{v}]$,

from here it follows: $L[\mathrm{v}]=\omega_0/\left(\omega_0^2+p^2\right)$ and further we can define $LS[v], \dot{S}[v], \dot{S}[u], \dot{S}[w]$ as we do in the first method.

Let $u_1(t)=t^2, v_1(t)=t^2\cdot h(t), w_1(t)=t^2\left[h(t)-h(t-\tau)\right]$.

In the third method we'll represent $t^2=0,5\cdot(1)^{(-2)}$. Then, subject to (6), we'll receive: $\dot{S}[u_1]=0.5\cdot 2\pi\delta(\omega)(j\omega)^{(-2)}$. Then, subject to (3), we have: $DS[\mathrm{v}]=0.5\pi\delta(\omega)(j\omega)^{(-2)}$. Subject to (2), we have $LS[\mathrm{v}]=0.5(j\omega)^{(-3)}$. $LS[v]=0,5(j\omega)^{-3}$.

In the fourth method we'll represent: $v_1(t)=0,5h^{(-2)}(t)$. From here it follows:

$$DS[\mathrm{v}]=0.5(j\omega)^{(-2)}\left[(j\omega)^{-1}+\pi\delta(\omega)\right]$$

In the fifth and in sixth methods we use:

$$\mathrm{v}_1(t)=u_1(t)[y_0(t)-y_0(t-\tau)]=t^2y_0(t)-(t-\tau)^2y_0(t-\tau)-2\tau(t-\tau)y_0(t-\tau)-\tau^2y_0(t-\tau).$$

Then from (8), subject to the spectrums: $\dot{S}[\delta]=1$ or $\dot{S}[y_0]=(j\omega)^{-1}$, we shall receive:

$\dot{S}[w_1(t)]$.

In the seventh method we differentiate $w_1(t)$ three times and receive:

$w_1^{(3)}=2[\delta(t)-\delta(t-\tau)]-2\tau\delta^{(1)}(t-\tau)-\tau^2\delta^{(2)}(t-\tau)$.

From here it follows: $\dot{S}[w_1]=\dot{S}[w_1^{(3)}]/(j\omega)^3=(j\omega)^3\left[2\left(1-e^{-j\omega\tau}\right)-2j\omega\tau e^{-j\omega\tau}+\omega^2\tau^2 e^{-j\omega\tau}\right]$

Conclusions

On basis of statements (1)…(8) one has offered the several methods of the signal spectrum definition without calculating Fourier's and Laplace's integrals.

These methods have allowed receiving the correct expressions of spectrums for the multitude of nonintegrated signals.

The proposed methods turn out to be convenient:

- for definition of spectrums of the integrated signals (for the impulses, for example), specified by the polynomial time functions
- for definition of the complex amplitudes of the harmonics of periodic processes (which occur in the pulse converter circuits, for example).

These methods allow also verifying easily and confirming practically all the known expressions of spectrums and operational representations of the signals are in the reference books.

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Chumachenko E.I., Cand.Tech.Sci. (National Aviation University, Ukraine)
Khimina N.V., The post-graduate student (National Aviation University, Ukraine)

IMITATING MODELING OF DYNAMICS OF VIRTUAL OBJECTS

For visualization of dynamics the embedded loops of constructing of spatial curves are built with the use of generators of numbers, that allows to get realistic enough dynamic images in an arbitrary time scale factor. In the set scopes, set angle of slope of charts of functions of curvature and twisting, and also moments. It is thus possible to manage the linear in time bulge of the represented lines.

The increase of a learning efficiency of the operators is connected to development high-quality simulators, in which the visualization of virtual objects is carried out and the task on imitating modeling of their dynamics is decided.

For the decision of a task of modeling of dynamics of virtual object the subsystem of modeling is used which on the basis of mathematical model of dynamics of object carries out the decision of the appropriate system of the differential equations.

The task of visualization can be divided into two subtasks:

- Visualization of object;
- Visualization of an environment (landscape, sky).

In turn tasks of visualization of object includes visualization of the form and color.

Generally block diagram of a subsystem of visualization simulator is submitted in a fig. 1.

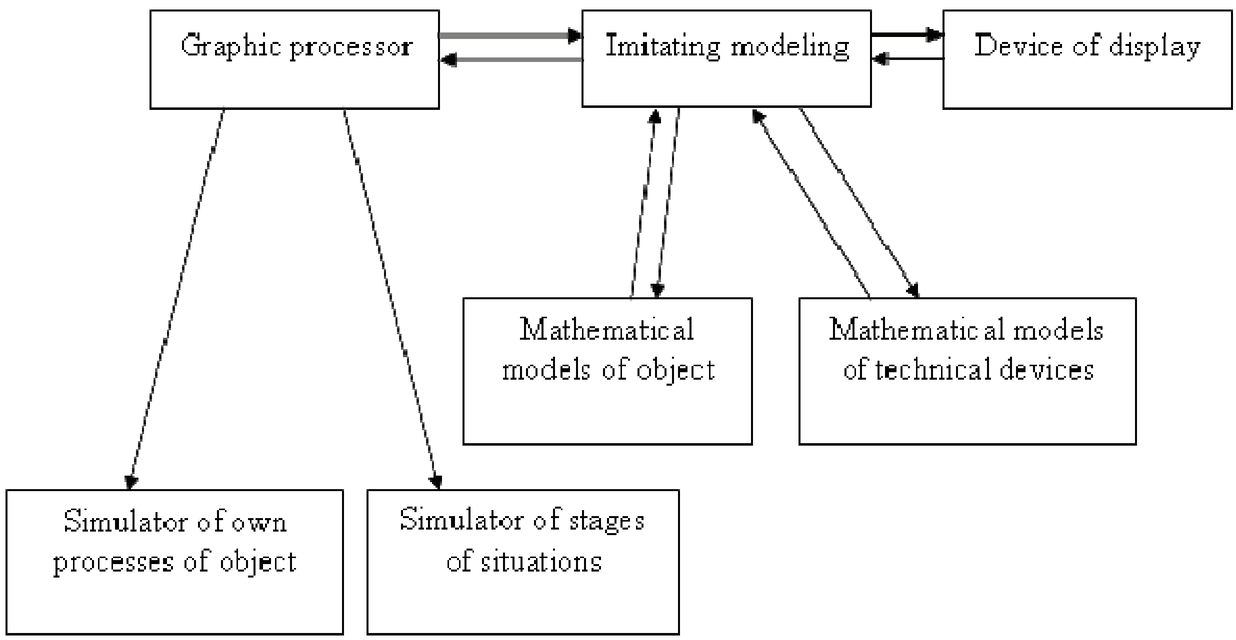

Fig. 1 Block diagram of a subsystem of visualization

Task of imitating modeling of virtual object divide on the following components:

- the simulator of own objects, where is stored the information on the form of object;
- the simulator situations of stages, where is stored the information on artificial objects, such as weather conditions. [1]

The imitating modeling of virtual objects can be divided into such components:

- The geometrical description of object, which defines its situation in space (components of the geometrical description can have the static and dynamic forms);
- colors the description of object intended for a storage to the information on its kind and the form. [2]

The block diagram of imitating modeling of virtual objects is submitted in figure 2.

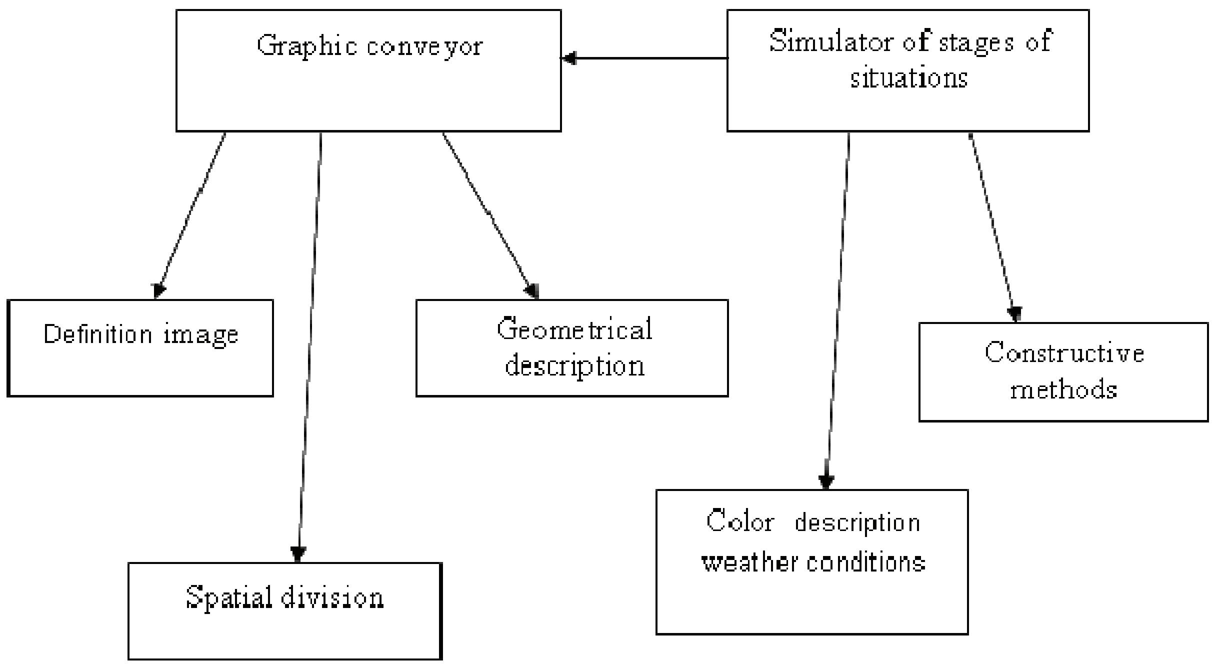

Fig. 2 Block diagrams of imitating modeling

The imitating modeling of object uses the following data:

- parameters of system of display;
- a situation of the observer;
- the classification description of object;
- the geometrical description of object.

In imitating modeling at creation of the images use elementary particles of the image. The geometrical description of dynamics of objects in imitating modeling of real time uses the limited compartments of surfaces 1-st and 2 about - graphic elementary particles of the image. [3]

For the description graphic elementary particles of the image the surfaces given by the equations in the implicit form are used:

$$F(x, y, z) = 0.$$

The examples graphic elementary particles of the image in imitating modeling are submitted in the table 1.

In imitating modeling of dynamics of virtual object geometrical elementary particles of the images transform as follows:

1. Moving.
2. Turn.
3. Deformation.
4. Cutting off.

Table 1

Graphic elementary particles of the image	The equation of a surface	Parameters of the equation
Plane	$\frac{x}{a}+\frac{y}{b}+\frac{z}{c}-1=0$	$k_1=k_2=k_3=D=p_1=p_2=p_3=1$ $s_1=a$; $s_2=b$; $s_3=c$;$t_1=x$; $t_2=y$; $t_3=z$
Cylinder	$\frac{x^2}{a^2}+\frac{z^2}{c^2}-1=0$	$k_1=k_3=D=1$; $k_2=0$; $p_1=p_3=2$ $s_1=a$; $s_3=c$; $t_1=x$; $t_3=z$
Ellipse	$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}-1=0$	$k_1=k_2=k_3=D=1$; $p_1=p_2=p_3=2$ $s_1=a$; $s_2=b$; $s_3=c$; $t_1=x$; $t_2=y$; $t_3=z$
Cone	$\frac{x^2}{a^2}-\frac{y^2}{b^2}+\frac{z^2}{c^2}=0$	$k_1=k_3=1$; $k_2=-1$; $D=0$; $p_1=p_2=p_3=2$ $s_1=a$; $s_2=b$; $s_3=c$; $t_1=x$; $t_2=y$; $t_3=z$

At modeling virtual object use of the given transformations allows to create the forms and objects of the given form.

The specified approach to modeling dynamics of virtual object was realized at modeling simulators for training the operators by the easy plane.

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V.M. Sineglazov (National Aviation University, Ukraine)
A.V. Fedosenko (National Aviation University, Ukraine)

THE DEVELOPMENT OF THE AUTOMATED PROJECTING SYSTEM OF GAS DISTRIBUTED NETWORKS

The new statement of the task of throttle's selection which provides the necessary flow distribution has been offered. The universal method of special search for the decision of the design statement of selection of throttle's parameters is offered. The use of the offered method will allow solving tasks for an arbitrary criterion function. The base systems of the equations for the design and mixed task of calculation of pressure differences in throttles is analyzed

The actuality of the investigation.

The air and liquid distributive systems are widespread technical objects. These are systems of ventilation, swapping, the distribution of various liquids and gases, the distributive part of fuel systems and air-conditioning systems of aircrafts, etc. For simplicity any of such systems we will name as a network.

For any technical object or device to the process of its working out is preceded the works on designing. The purpose of designing of gas and liquid distributive systems consists of such selection of aggregations and pipelines that the working capacity of system in all range of modes of its functioning is provided. The restrictions arising thus are connected with the discontinuity of the pipeline's diameters, by the limited choice of types of aggregations (pumps, fans, etc.), by the admissible diameters of pipes, by the flow velocity of a working body in them (air, gas, kerosene, water etc.). The other restrictions are possible also. In particular, when the problem of optimum designing of system is considered, the criterion function concerns to them (weight, cost, power losses, etc.).

The scientific actuality of work is: the scientific problem of modeling of flow's distribution of the liquefied liquids the distributive systems of which are characterized by that the fluidity modes can be critical (the flow velocity is equal to the velocity of a sound in a flow, and the correct determination of pressure difference is able only in a direction “against a flow”) and differences of pressures on central elements are significant, and the mathematical models of elements of such systems in most cases have difficult structure where the pressure difference cannot be described by the obvious dependence.

The statement of the investigation problem.

The finding of unknown pressure difference on a throttle is the problem statement, having found of which, it is possible to select the constructive characteristics of an element which provide the necessary pressure difference.

For the reception of the problem decision of a finding of unknown pressure's differences on throttles it is used the first and second Kirhgof's laws and also a finding method at width.

The I Kirhgof's Law. The algebraic sum of expenses in knot is equaled to zero [1]:

$$\sum_{k=1}^{n} G_k = 0, \quad (1)$$

For writing down of the first Kirhgof's law the rule of signs is arbitrary accepted, for example: the expenses which enter into the knot undertake with a sign "plus" and that leave with a sign "minus".

The writing down of the law for knot (fig. 1): $G1 - G2 + G3 + G4 = 0$

The first Kirhgof's law for the difficult scheme with the allocated closed contour is written in the same way: (fig. 2)

The II Kirhgof's law. The algebraic sum of differences of pressures of the closed contour is equaled to zero [2]:

$$\sum_{k=1}^{m} \Delta P_k = 0, \quad \textbf{(2)}$$

For the writing down of the second Kirhgof's law the direction of detour of a contour is arbitrary chosed, for example, in clockwise direction. The differences of pressures which coincide with a detour direction, register with a sign "plus", incoincident - with a sign "minus".

The II Kirhgof's law for the closed contour (fig. 3) is written as: $\Delta P_2 + \Delta P_1 - \Delta P_4 - \Delta P_3 = 0$

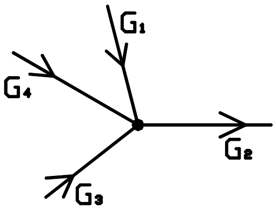

Fig. 1

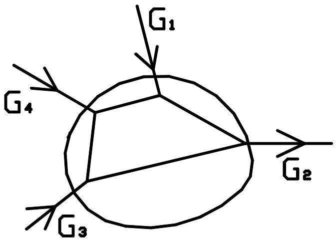

Fig. 2

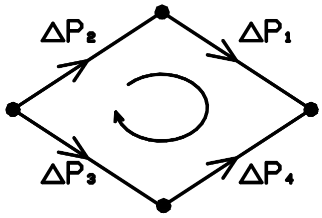

Fig. 3

If contours have always been closed, and pressure and expenses have been set then it would be possible to use the I and II Kirhgof's laws. But in hydraulics we have a situation when the count opened on a contour and on a number of borders of the count the fixed expenses and values of pressure are set.

In system there are branches which have some pressure difference ΔP, it is caused along with any factors to which different resistances on pipe-bends diameters of pipes etc are belong. For one branch it is easy enough for find, it will be equaled to a difference of pressures between the second and first knot [3]:

$$\Delta P_i = P_{last.} - P_{initial}, \quad \textbf{(3)}$$

where $P_{last.}$ and $P_{initial}$ are pressure in knots in the end and at the beginning of a branch.

The finding method at width. There is a standard procedure which is called as a finding method at width for counts which allows providing the condition $P_2 = P_2^{'}$ much faster and easier, and we will use it.

If it is set a count $\Gamma = (B,\ E)$ (fig. 4) and the initial top *s*, the algorithm of a finding at width regularly bypasses all the reached values from top *s*. The algorithm has the name a finding at width, as a finding "front" (between the passed and not passed tops) monotonously extends along all its width. That is, the algorithm passes all tops in distance *k* before passing tops in distance *k+1* where B are tops of the count, E are the internal knots, *k* is a length of a step which is equal to one branch.

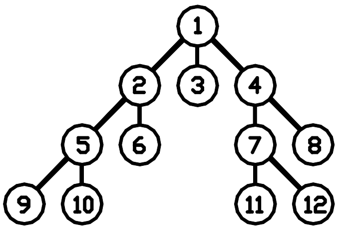

Fig. 4

Thus, for the problem of finding of unknown pressure differences on throttles the standard procedure of a method of a finding at width is realized as follows: we begin the procedure from any knot, always we choose the boundary with the set pressure (it is very important) because, if to choose with the initial expense then it is impossible to find the pressure in the following knot. In hydraulics in order there was the definiteness at calculations it is always necessary should be set at least one pressure. At first the one branch is covered, from the initial knot we go on one step. One step is a length of a branch which is equal to unit, or more precisely is a length of a step which is equal to one branch.

Review of existent solutions of the given problem.

The pressure difference in a branch. In hydraulics, more often the pressure difference in any *i*-th branch write down in the form of usual function of the expense, but actually it very difficult [4]:

$$\Delta P_i = k_i \cdot G_i \left| G_i \right|^{m-1}, \quad (4)$$

where k_i is a coefficient which depends on a number of factors, such as: ζ is a factor of hydraulic resistance of a branch; F is the cross-section area; g is a substance density; $m = 2 = const$.

That is k_i is a function from above told values, basically for each knot k_i is found individually as, in each knot there are dividers of pipes diameters, and also a number of other factors.

Search of unknown expenses. We will show the ring knots concerning to which we build systems of the equations according with II Kirhgof's law (fig. 5):

For fig. 5 we write down the system of the contour equations having united formulas [2] and [3], thus we use a finding method at width. Signs we account, going against a direction of arrows concerning rings, but, taking into account the signs of a direction of a difference of pressure differences between the knots ΔP. If arrows coincide, then we take with a sign «-» if do not coincide then we take with sign «+» [5]:

$$\sum_{i=1}^{n} \Delta P_i = P_{last\_knot} - P_{initial\_knot}, \quad (5)$$

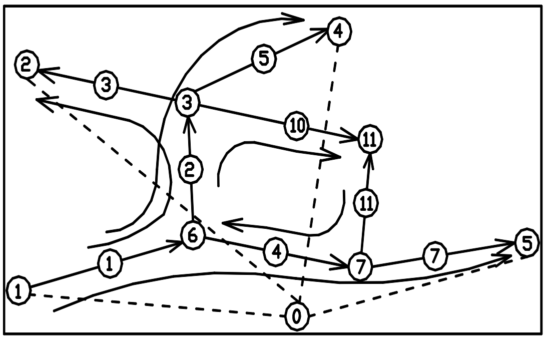

Fig. 5

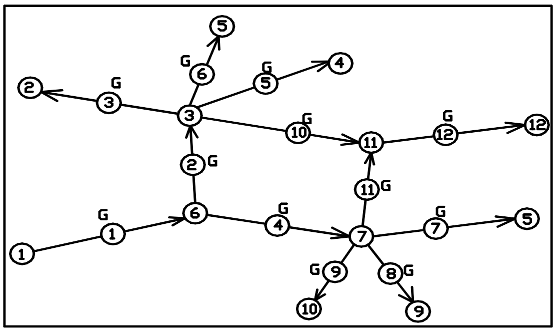

Fig. 6

Let's write down system of the equations of II Kirghof's law for the count shown in fig. 5 [6]:

$$\begin{cases} -\Delta P_3 - \Delta P_2 - \Delta P_1 = P_2 - P_1 \\ -\Delta P_5 - \Delta P_2 - \Delta P_1 = P_4 - P_1 \\ -\Delta P_7 - \Delta P_4 - \Delta P_1 = P_8 - P_1 \\ -\Delta P_{11} - \Delta P_4 + \Delta P_2 + \Delta P_{10} = 0 \end{cases} \quad (6) \qquad \begin{cases} Knot\ 6: G_1 - G_2 - G_4 = 0 \\ Knot\ 3: G_2 - G_3 - G_6 - G_5 = 0 \\ Knot\ 7: G_4 - G_7 - G_{11} - G_9 - G_{10} = 0 \\ Knot\ 11: G_{10} - G_{11} - G_{12} = 0 \end{cases} \quad (7)$$

The right part of the fourth equation from system [6] is equated to zero as our system is girdled according to the second Kirghof's law.

Let's analyze system of the equations [6]. From this system of the equations we see, that we have 4 equations and eight unknown ones. The following system of the equations undertakes according to the first Kirghof's law (full conformity between the law of preservation of weight and a condition of unambiguity of determination of pressure in knots).

The first four equations are written down in system of the equations [6], and other four equations (as unknown 8 values) will be proceeding from the I Kirghof's law (fig. 6) where we denote the directions of expenses from internal knots, that is we have the directions of branches and taking into account a direction of branches the corresponding systems of the equations will be written down. We take a sign which enters from knot - «+» if leaves - «-». It means that in knot 6, it will be the fifth equation to the system of the equations [6], for the third knot - the sixth etc. [7].

Thus, we have found four equations which give us the chance to define unequivocally expenses in links.

The problem decision of a finding of the equations by the decision of nonlinear system of the equations.

Let's copy our system of the equations accordingly to system of the equations [6] and [7] in [8]:

In order to find the expenses we will substitute the formula [4], namely $\Delta P_i = k_i \cdot G_i |G_i|^{m-1}$, and then we will have the following [9]:

$$\begin{cases} -\Delta P_3 - \Delta P_2 - \Delta P_1 = P_2 - P_1 \\ -\Delta P_5 - \Delta P_2 - \Delta P_1 = P_4 - P_1 \\ -\Delta P_7 - \Delta P_4 - \Delta P_1 = P_8 - P_1 \\ -\Delta P_{11} - \Delta P_4 + \Delta P_2 + \Delta P_{10} = 0 \\ G_1 - G_2 - G_4 = 0 \\ G_2 - G_3 - G_6 - G_5 = 0 \\ G_4 - G_7 - G_{11} - G_9 - G_{10} = 0 \\ G_{10} - G_{11} - G_{12} = 0 \end{cases} \quad (8)$$

$$\begin{cases} -k_3 \cdot G_3 |G_3|^{m-1} - k_2 \cdot G_2 |G_2|^{m-1} - k_1 \cdot G_1 |G_1|^{m-1} = P_2 - P_1 \\ -k_5 \cdot G_5 |G_5|^{m-1} - k_2 \cdot G_2 |G_2|^{m-1} - k_1 \cdot G_1 |G_1|^{m-1} = P_4 - P_1 \\ -k_1 \cdot G_1 |G_1|^{m-1} - k_4 \cdot G_4 |G_4|^{m-1} - k_1 \cdot G_1 |G_1|^{m-1} = P_8 - P_1 \\ -k_{11} \cdot G_{11} |G_{11}|^{m-1} - k_4 \cdot G_4 |G_4|^{m-1} + k_2 \cdot G_2 |G_2|^{m-1} + k_{10} \cdot G_{10} |G_{10}|^{m-1} = 0 \\ G_1 - G_2 - G_4 = 0 \\ G_2 - G_3 - G_6 - G_5 = 0 \\ G_4 - G_7 - G_{11} - G_9 - G_{10} = 0 \\ G_{10} - G_{11} - G_{12} = 0 \end{cases} \quad (9)$$

Thus, we have eight equations and eight unknown values. The four values of expenses are known. The problem of a finding of unknown values is executed.

There is also the Newton-Rafsona method for the decision of system of the nonlinear equations through the search of derivatives. The Newton-Rafsona method is difficult enough for realising in programming. In the formula [9] we have always the module, therefore a derivative always will be positive in this connection the presence of the uniform decision is proved. And thus, if the decision exists, the conclusion becomes, that it always can be found.

The offered solution. *The problem decision of nonlinear system of the equations with expenses in programming by the way of «cycling» is* the easiest method for the realization of the decision of system of the nonlinear equations in programming.

Let's copy system of the nonlinear equations [9] as follows [10].

Let's write down all the expenses which are unknown, these are expenses in knot G_1, G_2, G_3, G_4, G_5, G_7, G_{10}, G_{11}, and so in the problem the values - G_6, G_8, G_9, G_{12} are known and set. Let's write down the unknown values that they are equal to «1», and the known value, for example, some known numbers which it is specified in the problem, for an example we take, that $G_6 = 5$, $G_8 = 8$, $G_9 = 9$, $G_{12} = 10$. That is there will be some array from known and unknown values (G_1, G_2, G_3, G_4, G_5, G_6, G_7, G_8, G_9, G_{10}, G_{11}, G_{12}), which will look as follows: (1, 1, 1, 1, 5, 1, 1, 8, 9, 1, 1, 10). The substitution instead of unknown expenses «1» gets out just because faster by means of the computer through some function (procedure) to calculate expenses. Then we will copy the eighth equation concerning G_{11} from system of the equations [8]: $G_{11} = G_{12} - G_{10}$. We find to that will be equal G_{11}: 10-1=9. We write down the value G_{11} in our array, i.e. our array will have the following kind: (1, 1, 1, 1, 5, 1, 1, 8, 9, 1, 9, 10).

The expression of unknown value of the expense from the following equation is the following step, for an example the equation seven from system of the equations [10] will be: $G_4 - G_7 - G_{11} - G_9 - G_8 = 0$, in the given equation the values of expenses G_8 and G_9 are known, other unknown values logically should be equaled to 1, but it is not absolutely so as «1» we take only as initial value, other values we take from the previous found values from system of the equations, in it is the sense of our method then it will look as follows as we already in one equation from system of the equations have expressed one value, this value G_{11} concerning it we have no right to express more equations, and that value which we receiveed in the previous expression of function through G_{11}, we write down as G_{11}: $G_4 - G_7 - G_{11} - G_9 - G_8 = 0$, we will express in the given equation G_7: $-G_7 = -G_4 + G_{11} + G_9 + G_8$, having substituted the value we will receive the following: $-G_7 = -1 + 9 + 9 + 8 = 25$, $G_7 = -25$.

That is, there will be a system of the equations in which unknown expenses through some functions will be written down which will follow from the equations concerning to which they will be expressed, that is [11]:

$$\begin{cases} -k_3 \cdot G_3|G_3|^1 - k_2 \cdot G_2|G_2|^1 - k_1 \cdot G_1|G_1|^1 = P_2 - P_1 \\ -k_5 \cdot G_5|G_5|^1 - k_2 \cdot G_2|G_2|^1 - k_1 \cdot G_1|G_1|^1 = P_4 - P_1 \\ -k_1 \cdot G_1|G_1|^1 - k_4 \cdot G_4|G_4|^1 - k_1 \cdot G_1|G_1|^1 = P_8 - P_1 \\ -k_{11} \cdot G_{11}|G_{11}|^1 - k_4 \cdot G_4|G_4|^1 + k_2 \cdot G_2|G_2|^1 + k_{10} \cdot G_{10}|G_{10}|^1 = 0 \\ G_1 - G_2 - G_4 = 0 \\ G_2 - G_3 - G_6 - G_5 = 0 \\ G_4 - G_7 - G_{11} - G_9 - G_8 = 0 \\ G_{10} + G_{11} - G_{12} = 0 \end{cases} \quad (10),$$

$$\begin{cases} G_{1x} = f(G) \\ G_{2x} = f(G) \\ G_{3x} = f(G) \\ \ldots\ldots = f(G) \\ G_{Nx} = f(G) \end{cases} \quad (11)$$

where from G_{1x} to G_{Nx} are functions of unknown expenses in branches.

Thus, carrying out step by step each equation many times, we will come to that the values which will leave, will differ from previous found at first on integers, then on the tenth, and further on the 100-th.

The equation concerning the count for throttles. For the given problem again таки we will show the count of our topology of a grid (fig. 7). It is necessary to define at once where there will be throttles. A throttle is the device in the form of the valve for the regulation of pressure of a liquid, steam or gas (getting them by pipelines). Basically they put on all boundary branches and somewhere in a ring in one place in order the expenses could be controlled through a ring. Throttles should provide the necessary expenses at the set boundary conditions.

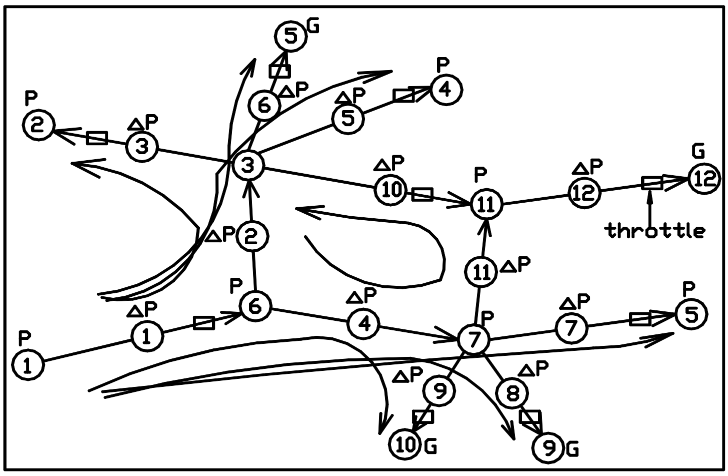

Fig. 7

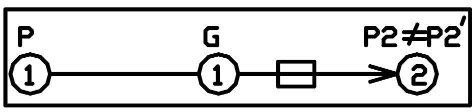

Fig. 8

For an example we will show the following: if we take one branch, for an example we will show it in fig. 7 and pressure is known at the beginning and in the end of a branch, then expense in a branch is known, then by the pressure P_1 and under the set expense it is possible to define the pressure P_2. But it will not be P_2, and there will be some $P_2^{'}$ (fig. 8). Therefore that they were identical, it is necessary to add pressure difference on a throttle. If this difference is positive then all is normal if it is negative - such cannot be because then instead of a throttle it is necessary to put the fan, the compressor, pumps etc. In general, a problem is no fans, compressors. There are only throttles that are some devices which limit expenses. Then there is a condition of equality of pressures in knots and a condition [12].

There are eight equations, and these eight equations, we break into the following values: on known and unknown values. Behind the known expense, setting any value of pressure, we can write down ΔP_1 taking into account throttles as follows [13]:

$$\Delta P_{ithrottle} \geq 0\,, \qquad (12), \qquad\qquad \Delta P_i = \Delta P_{i,0} + \Delta P_{i,throttle} = x_i \qquad (13)$$

Considering this problem, we look at the following if there is a throttle, the pressure will be already a little changed. We conclude system of the equations concerning fig. 7 similarly, as well as for system of the equations [6]. The number of the equations will be equaled $KU - 1 +$ number of cycles of a count [14], where KU is a number of boundary knots. Here signs have very much great value, and all the equations are written down through ΔP_1.

Substituting all these values and if all unknown values to transfer to the right part then we will receive the following [15]:

$$\begin{cases} \Delta P_1 + \Delta P_2 + \Delta P_3 = P_1 - P_2 \\ \Delta P_1 + \Delta P_2 + \Delta P_6 = P_1 - P_5 \\ \Delta P_7 + \Delta P_2 + \Delta P_5 = P_1 - P_4 \\ \Delta P_1 + \Delta P_4 + \Delta P_7 = P_1 - P_8 \\ \Delta P_1 + \Delta P_4 + \Delta P_8 = P_1 - P_8 \\ \Delta P_1 + \Delta P_4 + \Delta P_9 = P_1 - P_{10} \\ \Delta P_2 + \Delta P_{10} - \Delta P_{11} - \Delta P_4 = 0 \\ \Delta P_1 + \Delta P_2 + \Delta P_{10} + \Delta P_{12} = P_1 - P_{12} \end{cases} \qquad (14)$$

$$\begin{cases} x_1 + x_2 + x_3 = \Delta p_1 \\ x_1 + x_2 + x_6 = \Delta p_2 \\ x_1 + x_2 + x_5 = \Delta p_3 \\ x_1 + x_4 + x_7 = \Delta p_4 \\ x_1 + x_4 + x_8 = \Delta p_5 \\ x_1 + x_4 + x_9 = \Delta p_6 \\ x_2 + x_{10} - x_{11} - x_4 = \Delta p_7 \\ x_1 + x_2 + x_{10} + x_{12} = \Delta p_8 \\ x_2 = 0 \\ x_4 = 0 \\ x_{11} = 0 \end{cases} \qquad (15)$$

- there, where throttles are not present, x-es are equal to zero; - also we have 11 equations and 9 unknown values. This is a problem of linear programming (SLAE) which can be solved by the addition of additional conditions that is a system of inequalities $x_i \geq 0$, where $i = 1 \div 12$, and there should be the purpose functions that is a function where the sum $x_i \rightarrow \min$.

Conclusions: The new problem statement of selection of throttle's parameters which provides the necessary flow distribution where pressure differences on throttles are unknown values is offered. The base systems of the equations for the design and mixed task of calculation of differences of pressure for throttles are described. In case of the detailed design it is shown, that at linearity of criterion function it can be led to the task of linear programming. The universal method of special search for the decision of the detailed design of selection of throttle's parameters which allow solving tasks for any criterion function is offered. The method of the decision of the detailed design on the basis of achievement algorithm of border in special cases of criterion function and for a treelike system graph is offered.

Thus, the algorithm of reduction of number of unknown values in the task of calculation of unknown pressure differences for throttles has been developed. The algorithm consists of 8 basic cycles: a cycle of creation of the count of a network topology; a cycle of indications of expenses and pressure in the count and their values; a cycle of direction's indications of flows; a cycle of writing down of the equations in accordance with the formula [5]; a cycle of writing down of system of the equations according to consequences of integration of I and II Kirghof's laws in gas hydraulic system; a transition cycle to a finding of unknown expenses; a cycle of the decision of a problem of a finding of the equations by the decision of nonlinear system of the equations; a cycle of writing down of SLAE for throttles according to the equation concerning the count for throttles and also it is solved by its known methods.

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I.Yu. Sergeyev, PhD, National Aviation University, Ukraine)

VOLTMETERS: SOLARTRON MODELS 7065, 7071, AND 7081 ADC ANALYSIS

This paper describes the analysis and design of an ADC, which is used in precision voltmeters. As an example Solartron models 7065, 7071 and 7081 are considered.

Abstract: It is possible to obtain the conversion equation of the ADC on the basis of the integrator charge balance [1 - 8]. But such balance is not achieved in all cases, because certain conditions (considered later) are required for this. Then, after an abrupt change of the input voltage the output code changes from cycle to cycle according to geometrical progression [2, 5]. The conversion equations describing the transition process of the output value and the errors due to the unideality of the ADC elements are obtained. Finally, the results of computer simulation using the above analysis are presented.

1. Introduction

The block diagram of the ADC [5] is shown in Fig. 1 and the waveform in points 1, 2, 3 and 4 respectively - in Fig. 2.

Using notations of Fig. 2 it is possible to obtain the conversion equation of the ADC on the basis of charge of the integrator circuit [2]. If the sum of charges flowing through the three inputs of the integrator equals zero, then the following equation holds:

$$\frac{2U_x T}{R_x C} = \frac{\Delta T E}{R_2 C},$$

where $\Delta T = t_B - t_H$; $E = E_1 = |-E_2|$; U_x is input voltage;

(for notation other members refer to the diagrams in Fig. 2).

It's possible to write:

$$\Delta T = \frac{U_x 2TR_2}{ER_x} \quad (1) \qquad \text{and} \qquad N = -\frac{U_x N_o R_2}{ER_x} \quad (2),$$

where $N = \Delta T f_o$ and $N_o = 2Tf_o$.

Note, that the balance of charges at the integrator is not achieved in all cases. Certain conditions are required for this and these we shall consider later.

2. The conversion equation

Suppose, that at the start of the 1-st cycle of interest an abrupt change of the input voltage took place from $U_x^{(o)}$ to U_x (see Fig. 2). Let us see, how shall the time intervals $t_{1H}^{(i)}$, $t_{2H}^{(i)}$, $t_{2B}^{(i)}$

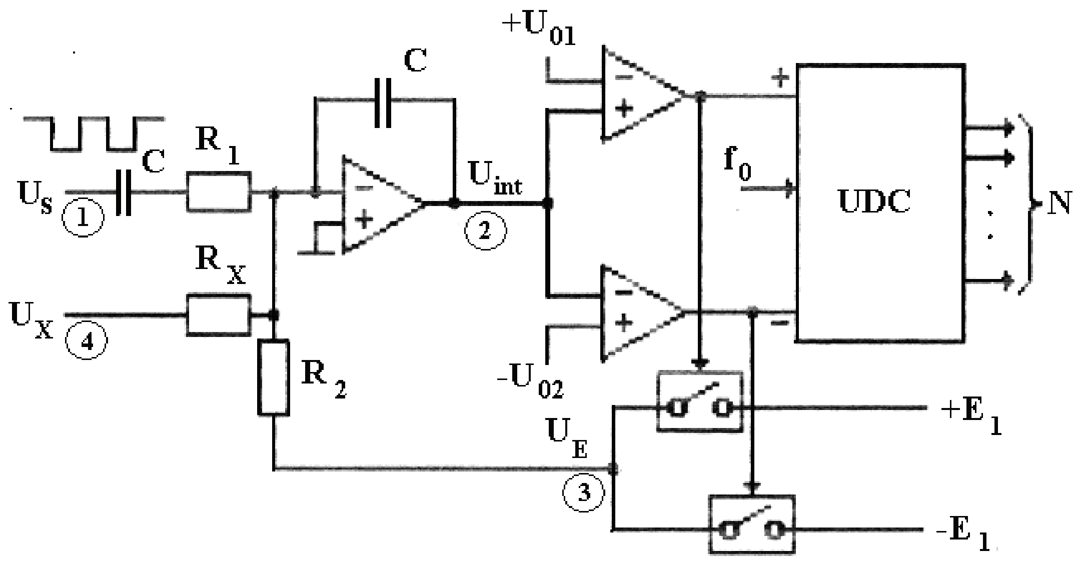

Fig. 1

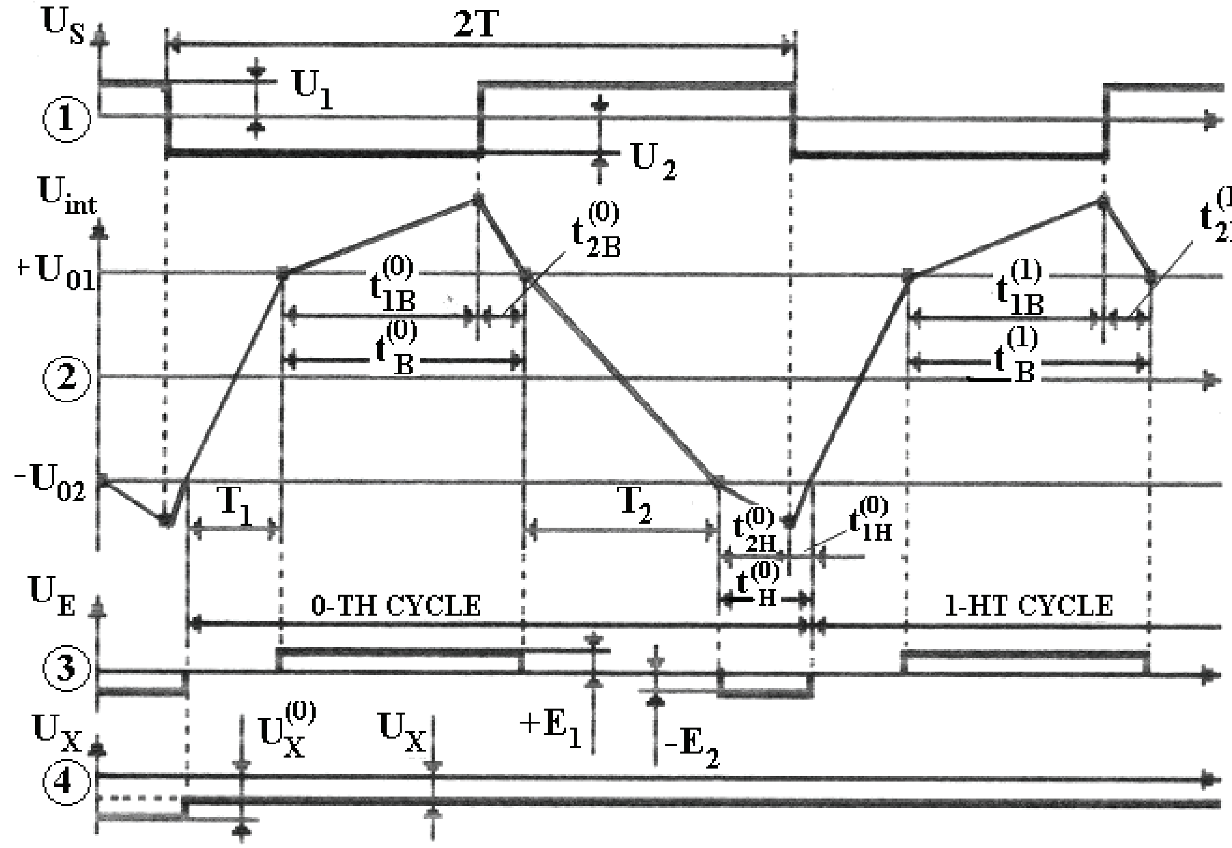

Fig. 2

and $t_{1B}^{(i)}$ change from cycle to cycle (i - denotes the number of the cycle). It can be shown that:

$$t_{1B}^{(1)} = T - T_1 - t_{1H}^{(0)}, \tag{3}$$

$$t_{2B}^{(1)} = -t_{1B}^{(1)} \cdot \frac{U_x - U + E}{U_x + U + E}, \tag{4}$$

$$t_{2H}^{(1)} = T - T_2 - t_{2B}^{(1)}, \tag{5}$$

$$t_{1H}^{(1)} = -t_{2H} \cdot \frac{U_x + U - E}{U_x - U - E}, \tag{6}$$

$$T_1 = \frac{(U_{O1} + U_{O2})RC}{U_x - U} = -\frac{2U_O RC}{U_x - U},$$

$$T_2 = \frac{(U_{O1} + U_{O2})RC}{U_x + U} = \frac{2U_O RC}{U_x + U}.$$

Here we assume that $R_1 = R_2 = R_x = R;$ $U_{O1} = |-U_{O2}| = U_O;$ $U_1 = |-U_2| = U;$ $E_1 = \|-E_2\ | = E|$.

Substituting (5), (4), and (3) into (6), we obtain an expression for determining the time interval t_{1H} in the first cycle:

$$t_{1H}^{(1)} = -(T - T_2)\frac{U_x + U - E}{U_x - U - E} + t_{2B}^{(1)} \cdot \frac{U_x + U - E}{U_x - U - E} = -(T - T_2)\frac{U_x + U - E}{U_x - U - E} - t_{2B}^{(1)} \cdot \frac{U_x + U - E}{U_x - U - E} \cdot \frac{U_x - U + E}{U_x + U + E} =$$

$$= -(T - T_2)\frac{U_x + U - E}{U_x - U - E} - (T - T_1)\frac{U_x + U - E}{U_x - U - E} \cdot \frac{U_x - U + E}{U_x + U + E} + t_{1H}^{(0)} \frac{U_x + U - E}{U_x - U - E} \cdot \frac{U_x - U + E}{U_x + U + E} = A_{1H} + t_{1H}^{(0)} \cdot B, \tag{7}$$

where $A_{1H} = -(T-T_2)\dfrac{U_x+U-E}{U_x-U-E} - (T-T_1)B;\quad B = \dfrac{U_x+U-E}{U_x-U-E}\cdot\dfrac{U_x-U+E}{U_x+U+E}.$

Using (7) as a recurrent formula, it is possible to obtain expressions for determining the time interval t_{1H} in the subsequent cycles:

$$t_{1H}^{(2)} = A_{1H} + t_{1H}^{(1)}\cdot B = A_{1H}(1+B) + t_{1H}^{(0)}\cdot B^2,$$

$$t_{1H}^{(3)} = A_{1H} + t_{1H}^{(2)}\cdot B = A_{1H}(1+B+B^2) + t_{1H}^{(0)}\cdot B^3,$$

. . . .

$$t_{1H}^{(n)} = A_{1H} + t_{1H}^{(n-1)}\cdot B = A_{1H}\sum_{j=1}^{n} B^{j-1} + t_{1H}^{(0)}\cdot B^n. \qquad (8)$$

We can see now that the last expression is comprised of two parts – a geometric progression with the ratio B, which converges when the inequality |B| < 1 is satisfied, and of a diminishing in the absolute value member $t_{1H}^{(0)}B^n$ (under the same condition) [2].

It is obvious that if the above inequality is satisfied the time interval t_{1H}, after the transition process is over, acquires a constant value and can be found (using the common formula for a geometric progression) in the following way:

$$t_{1H}^{(\infty)} = \lim_{n\to\infty} t_{1H}^{(n)} = \frac{A_{1H}}{1-B}. \qquad (9)$$

It can be seen that $t_{1H}^{(\infty)}$ acquires its constant value in an interactive way.

For the interval t_{2H} the following expressions can be obtained in an analogous way:

$$t_{2H}^{(1)} = A_{2H} + t_{2H}^{(0)}\cdot BD\ , \qquad (10)$$

where $A_{2H} = -A_{1H}\dfrac{U_x-U-E}{U_x+U-E} = (T-T_2) + (T-T_1)\dfrac{U_x-U+E}{U_x+U+E},$

$$D = \frac{U_x-U-E}{U_x+U-E}\cdot\frac{U_x^{(0)}+U-E}{U_x^{(0)}+U-E},$$

$$t_{2H}^{(n)} = A_{2H}\sum_{j=1}^{n} B^{j-1} + t_{2H}^{(0)}\cdot B^n D. \qquad (11)$$

$$t_{2H}^{(\infty)} = \frac{A_{2H}}{1-B} \quad \text{or} \quad t_{2H}^{(\infty)} = -t_{1H}^{(\infty)}\cdot\frac{U_x-U-E}{U_x+U-E}. \qquad (12, 12a)$$

For the time interval t_{2B}:

$$t_{2B}^{(1)} = T - T_2 - A_{2H} - (T-T_{2O})BD + t_{2B}^{(0)}\cdot BD \qquad (13)$$

where T_{2O} - it is the time interval T_2 before the 1-st cycle beginning,

$$t_{2B}^{(n)} = T - T_2 - A_{2H}\sum_{j=1}^{n} B^{j-1} - (T-T_{2O})B^n D + t_{2B}^{(0)}\cdot B^n D, \qquad (14)$$

$$t_{2B}^{(\infty)} = T - T_2 - \frac{A_{2H}}{1-B} \quad \text{or} \quad t_{2B}^{(\infty)} = T - T_2 - t_{2H}^{(\infty)}. \qquad (15, 15a)$$

For the time interval t_{1B}:

$$t_{1B}^{(1)} = -(T-T_2)\frac{U_x+U+E}{U_x-U+E} + A_{1B} + (T-T_{20})BD\frac{U_x+U+E}{U_x-U+E} + t_{1B}^{(0)}\cdot BDF\ , \qquad (16)$$

where $A_{1B} = A_{2H}\dfrac{U_x+U+E}{U_x-U+E};\quad F = \dfrac{U_x+U+E}{U_x-U+E}\cdot\dfrac{U_x^{(0)}-U+E}{U_x^{(0)}+U+E},$

$$t_{1B}^{(n)} = -(T-T_2)\frac{U_x+U+E}{U_x-U+E} + A_{1B}\sum_{j=1}^{n} B^{j-1} + (T-T_{20})\frac{U_x+U+E}{U_x-U+E}B^n D - t_{2B}^{(0)}\cdot B^n DF, \qquad (17)$$

$$t_{1B}^{(\infty)} = -(T - T_2)\frac{U_x + U + E}{U_x - U + E} + \frac{A_{1B}}{1 - B}, \tag{18}$$

$$t_{1B}^{(\infty)} = -t_{2B}\frac{U_x + U + E}{U_x - U + E}. \tag{18a}$$

It is obvious that the expressions giving the initial values of $t_{1H}^{(0)}$, $t_{2H}^{(0)}$, $t_{2B}^{(0)}$ and $t_{1B}^{(0)}$ can be obtained from expressions (9), (12), (12a), (15), (15a), (18):

$$t_{1H}^{(0)} = \frac{A_{1H}^{(0)}}{1 - B^{(0)}};$$

$$t_{2H}^{(0)} = \frac{A_{2H}^{(0)}}{1 - B^{(0)}} \quad \text{or} \quad t_{2H}^{(0)} = -t_{1H}^{(0)}\frac{U_x^{(0)} - U - E}{U_x^{(0)} + U - E};$$

$$t_{2B}^{(0)} = T - T_{20} - \frac{A_{2H}^{(0)}}{1 - B^{(0)}} \quad \text{or} \quad t_{2B}^{(0)} = T - T_{20} - t_{2H}^{(0)};$$

$$t_{1B}^{(0)} = -(T - T_{20})\frac{U_x^{(0)} + U - E}{U_x^{(0)} - U + E} + \frac{A_{1B}^{(0)}}{1 - B^{(0)}} \quad \text{or} \quad t_{1B}^{(0)} = -t_{2B}^{(0)}\frac{U_x^{(0)} + U + E}{U_x^{(0)} - U + E},$$

where $A_{1H}^{(0)}$, $B^{(0)}$, $A_{2H}^{(0)}$, $A_{1B}^{(0)}$ are equal to A_{1H}, B, A_{2H} and A_{1B} respectively when $U_x = U_x^{(0)}$.

On the basis of the above expressions it is rather easy to write the conversion equation of the considering ADC. For the steady state, using equations (9), (12), (12a), (15), (15a), (18) and (18a) respectively:

$$\Delta T = t_B^{(\infty)} - t_H^{(\infty)} = t_{1B}^{(\infty)} + t_{2B}^{(\infty)} - t_{1H}^{(\infty)} - t_{2H}^{(\infty)} = \frac{U_x 2T}{E}, \tag{19}$$

$$N = \Delta T f_O = \frac{U_x N_O}{E} \tag{20}$$

or, substituting for generality $\frac{U_x}{R} = \frac{U_x}{R_x}$ and $\frac{E}{R} = \frac{E}{R_2}$, we obtain expressions (1) and (2) respectively.

The conversion equations for the transition process of the output value can be written analogous to expressions (1), (2), (19) and (20), using equations (8), (11), (14) and (17).

Note, that expressions (7), (10), (13) and (16) are linear difference equations. While solving them with the help of the Z-transform, it is easy to obtain equations (9), (12), (15) and (18).

The considered ADC can be described by the generalized structure, first proposed by the author [2]. The result of analysis of this generalized structure [2] is fully applicable to the error analysis of the considered ADC (and similar ones). It makes possible the formulation of the requirements to all the ADC blocks and parts and to the input signal. As a result we can correctly synthesize this unit.

As was shown above the output value after a change of the input settles according to a geometric progression law with a ratio B. Fig. 3 plots B versus U_x. Specific points of the curve are as follows:

1. $U_x = 0$; $B = \frac{a^2}{b^2} = \frac{(U - E)^2}{(U + E)^2}$, where $a = U - E$; $b = U + E$.
2. $B = 0$; $U_x = \pm a$.
3. $B = \pm 1$; $U_x = \pm\sqrt{\frac{a^2 + b^2}{2}} = \sqrt{U^2 + E^2}$.

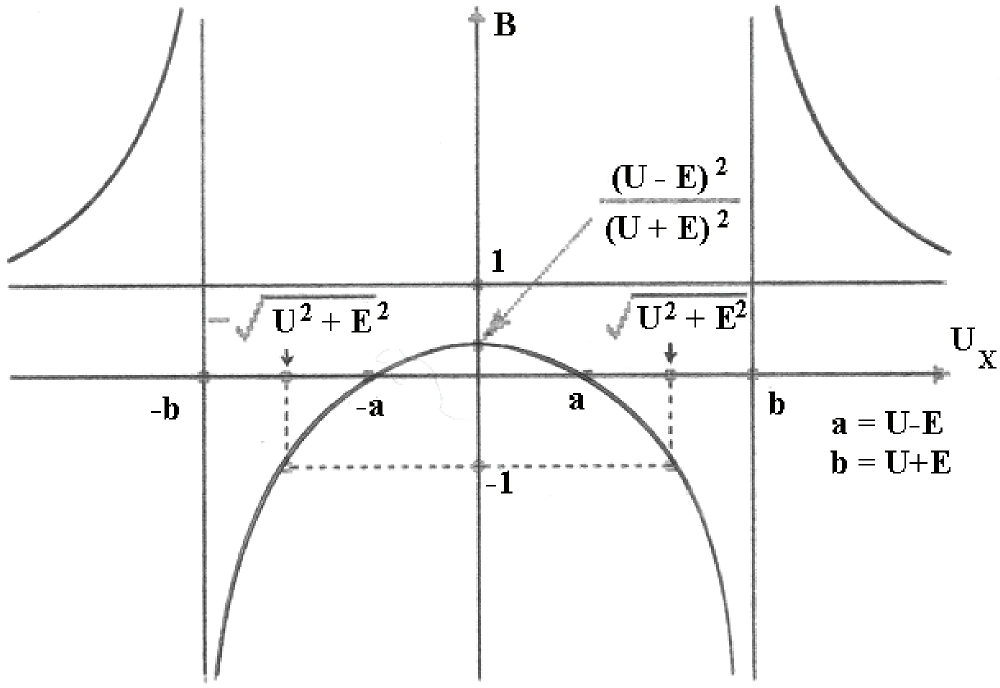

Fig. 3

Thus the range of U_x, where the inequality |B| < 1 is satisfied, is described by: $U_x \le \left|\sqrt[\pm]{U^2+E^2}\right|$. Note however that in reality the range of the input signal U_x of the considered ADC is smaller then that, given by above inequality. The reason is that when $|U_x| = |U-E|$ the waveforms of the integrator output at time intervals t_B and t_H become horizontal lines. The ADC is inoperative when the modulus of the input voltage is equal to or greater than this value. If we take into account the necessity of some headroom for ensuring the comparator switchover at the start and in the end of time intervals t_B and t_H, then the limits of the real input voltage range are further reduced in comparison to $|U-E|$.

3. Instrumental errors

Using the above analysis it is easy to obtain expressions, describing the errors due to the unideality of the ADC elements.

Thus, for example, the unideality of the analogue switches - the lag in turning on and off, can be taken into account by an equivalent making of Δt_B^H and Δt_H^H shorter and Δt_B^K and Δt_H^K longer of time intervals t_B and t_H (see Fig. 4). The increment of the output value ΔT due to this (the absolute error) can be presented by the following expressions:

$$\Delta\Delta T_t = \Delta t_H^H - \Delta t_B^H + \Delta t_B^K - \Delta t_H^K$$

and the relative error:

$$\gamma_t = \frac{\Delta\Delta T_t}{\Delta T} = \frac{\Delta t_H^H - \Delta t_B^H + \Delta t_B^K - \Delta t_H^K}{t_H - t_B}.$$

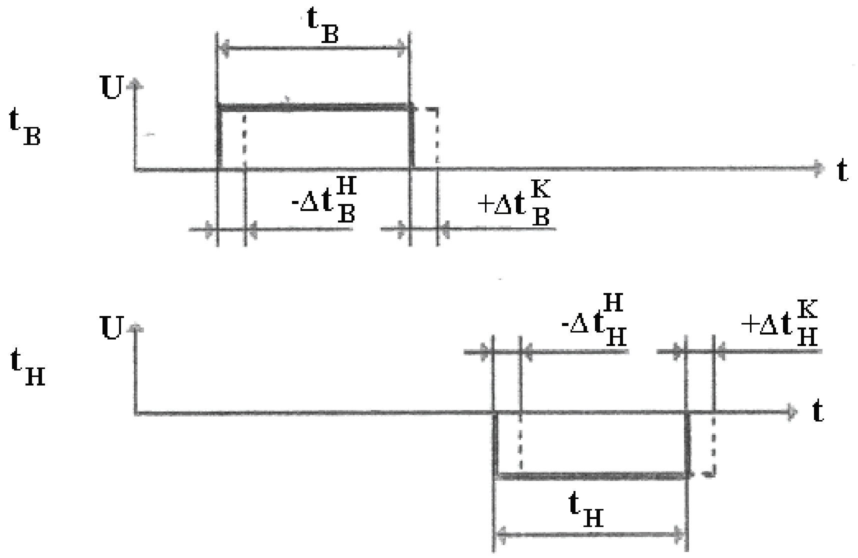

Fig. 4

It can be seen from these equations that considerable mutual compensation of lag times of turning on and off can be achieved in the considered ADC.

The relative error due to the variations of the bias and the input current difference of the integrator amplifier is given by

$$\gamma_{U_{OS,\Delta I}} \leq \frac{2T}{U_x C}\left[\Delta U_{OS}\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_x}\right)+\Delta\Delta I\right],$$

where ΔU_{OS} and $\Delta\Delta I$ are the absolute increments of the bias voltage and the input current difference correspondingly.

The relative error due to the unideality of the reference voltage sources can be found according to the formula:

$$\gamma_{T(E)} = \frac{R_x E(t_H \gamma_{E2} - t_B)}{2TU_x R_2}$$

where γ_{E1} and γ_{E2} are the relative errors of the voltage sources E_1 and E_2; $E_1 = E(1+\gamma_{E1})$; $E_2 = E(1+\gamma_{E2})$.

4. Dynamic error

The dynamic error of the considered ADC arises due the iterative character of the output value setting. If the ADC output value is used before the transition process is over, then the result of conversion contains a dynamic error, which can be rather big. The consideration of this error is of great importance when the ADC is used in automated systems. The dynamic error can be found on the basis of the above analysis, mainly by using equations (8), (9), (11), (12), (12a), (14), (15), (15a), (17), (18) and (18a).

5. The analysis results generalization

Above for simplification it was assumed that $R_1 = R_2 = R_x = R$; $U_{O1} = |-U_{O2}| = U_O$; $U_1 = |-U_2| = U$; $E_1 = |-E_2| = E$. In a general case these equalities are not satisfied, which can be easily taken into account in all the obtained above expressions.

Thus, for example, if $R_1 \neq R_2 \neq R_x$, then the expression

$$B = \frac{U_x + U - E}{U_x - U - E} \cdot \frac{U_x - U + E}{U_x + U + E}$$

can be transformed to:

$$B = \frac{\frac{U_x}{R_x} + \frac{U}{R_1} - \frac{E}{R_2}}{\frac{U_x}{R_x} - \frac{U}{R_1} - \frac{E}{R_2}} \cdot \frac{\frac{U_x}{R_x} - \frac{U}{R_1} + \frac{E}{R_2}}{\frac{U_x}{R_x} + \frac{U}{R_1} + \frac{E}{R_2}};$$

expressions (19) and (20), as it was shown above, are transformed into (1) and (2), expression $U_x = \pm R_x \cdot \sqrt{U^2 + E^2}$ is changed to:

$$U_x = \pm R_x \cdot \sqrt{\frac{U^2}{R_1^2} + \frac{E^2}{R_2^2}}, \quad \text{etc.}$$

6. Simulation

The considered ADC was computer simulated using the results of the above analysis. It was found that the transition process of the ADC output value setting is practically over after 6-8 cycles. However the output value after the 1-st cycle differs from the settled value by about 20 - 40 % (!). Simulation simplified the study of the ADC with varying parameters and input voltage values.

7. Conclusions

As a result, of the analysis of an ADC a strict analytical description of it's functioning is obtained, as well as the conversion equation and expressions for errors calculation. It is shown that the process of the output value settling has an iterative character. The convergence of this process is studied. On the basis of the obtained equations the ADC was computer simulated, which simplified the ADC studying with varying parameters and input voltage values.

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S.I. Ilnytska (National Aviation University, Ukraine)
S.P. Borsuk (National Aviation University, Ukraine)

QUALITY ASSESSMENT CRITERIA OF ELECTRONIC CHARTS AND TECHNICAL MEANS OF THEIR VISUALIZATION

Electronic maps are widely used nowadays in many spheres of application as they introduce a lot of additional services in comparison with "traditional" paper maps. From the great variety of existent electronic maps it is necessary to define for user the most optimal one, and for this purpose it is necessary to define first quality assessment criteria of electronic charts.

Actuality of electronic charts construction is caused by increasing speeds of moving objects, necessity of tracing them (displaying them on chart) in real time. That's why special place among modern navigation means is occupied by navigation cartographic systems and electronic charts. As well due to high speed of technique and computational devices development electronic charts have become the parts of many other applications (ecology, agriculture, fire safety).

Special features of working with electronic aeronautical charts. In comparison with traditional paper maps electronic charts have a lot of advantages, which increase the navigation safety and make the task of orientation in current navigation situation easier.

- Possibility of plotting at map additional data from different sources (books of special signs, radio-navigation frequencies of airports and so on) in separate layers, thus it is possible to concentrate all data in one electronic chart;
- Possibility of navigation situation analysis performing in short terms, informing of pilot about potential dangerous;
- Possibility of any rote segment graphical representation with scaling;
- Possibility of fast objects' finding upon the address or names;
- Possibility of track planning between any points and estimation of flight time;
- Procedure of electronic chart correcting is much easier than correcting of traditional maps and could be performed directly before flight;
- Combined with outer navigation devices (like GPS) electronic charts provide the possibility of representation the navigation situation in real time, including current aircraft position.

Formats of electronic navigation charts representation. Basically electronic charts are subdivided on two big groups – raster and vector ones. The first ones are scanned paper maps – graphical in usual or special format, which navigation program "underlays" under the picture of necessary route. Data of such maps can provide some additional possibilities (for example, object finding upon the name), but in any case they are not perspective in future usage due to their big memory capacity, difficulties at scaling, lack of possibility of route planning and other problems. The future in navigation and cartography sphere belongs to vector electronic charts. They provide a lot of additional services. Vector format of charts is subdivided on the following sub-formats:

S-57 (Official vector format standard adopted by the International Hydrographic Organization), CM-93 (vector data is produced by C-Map), NTX (The Interchange (NTX) Format is a sequential format designed to hold hydrographic or topographic data. This format was one of the first available vector formats for Canadian Hydrographic Charts.), Geography Markup Language (GML) - XML based open standard (by OpenGIS) for GIS data exchange, DXF - Contour elevation plots in AutoCAD DXF format, Shapefile - ESRI's open, hybrid vector data format using SHP, SHX and DBF files, Simple Features - Open Geospatial Consortium specification for vector data, MapInfo TAB format - MapInfo's vector data format using TAB, DAT, ID and MAP files, National Transfer Format (NTF) - National Transfer Format (mostly used by the UK Ordnance Survey), TIGER - Topologically Integrated Geographic Encoding and Referencing, Cartesian coordinate system (XYZ) - Simple point cloud, Vector Product Format - National Imagery and Mapping Agency (NIMA)'s format of vectored data for large geographic databases, GeoMedia - Intergraph's Microsoft Access based format for spatial vector storage, ISFC - Intergraph's Microstation based CAD solution attaching vector elements to a relational Microsoft Access database

Main quality assessment criteria of electronic charts. For comparison of different charts quality it is necessary to define quality assessment criteria. First of all it is necessary to admit such important criterion as *clarity*. Chart clarity is defined as provided by chart possibility of visual space forms, dimensions and location perception [7]. It is proposed to introduce 10-point scale for estimation of quality assessment criteria. Therefore, 10 points (the highest grade) could be given for satellite maps (fig. 1), as they provide the clearest representation about objects.

Fig. 1 Satellite map of Kiev [1]

A little bit worse (8 poins) clearness of perception provide other vector maps (fig. 2, 4,5).

Fig. 2 Vector map of Kiev [2]

Map reliability is one more criterion of safe navigation with electronic charts. At this term is understood the correctness of information represented on map about some data. Unfortunately, there is no possibility to define the quantitative characteristic upon the given criterion.

One more criterion, **map accuracy *is similar to the previous one; it is the degree of correspondence of point's location at map to the objects' position in real world.***

Map details – are the map fullness by conventional signs and marks.

Map actuality – is a correspondence of map to current state of depicted objects.

Map readability – *distinguishability of elements and details of map.*

One more important criterion of electronic charts is *multi-layering*. At this term is understood the possibility of storage and representation of the same type objects in separate layer, which could be switched on or switched off [8]. Therefore, at presence of great amount of layers user can easily switch between the necessary information, not overloading display by unnecessary information. There are no common standards upon the given criterion, that's why it is proposed to adopt as the etalon one vector electronic map created by NRI of Geodesy and Cartography, where the quality of different information layers is 25 (tab. 1). As was defined earlier, 10 point is a highest grade; therefore, 10 point to this map.

Maps from Meta site provide 22 different layers of information, and the possibility of adding own user objects. It can be estimated as 9 points from 10.

Table 1

Layers of Kiev vector map NRI of Geodesy and Cartography [3]

To show on map					
v	Traumatology centre	v	Metro	v	Kindergartens
v	Schools	v	Adult education	v	Legal counseling
v	Pharmacies	v	Administration	v	Emergency service
v	Boarding schools	v	Users' pictures	v	Veterinary clinic
v	Universities	v	Stadiums	v	Vocational schools
v	Trams	v	Hospitals	v	Housing and communal services
v	Places of interest	v	Post	v	Churches
v	Emergency (medical)	v	Juridical offices	v	State organizations
v	Children hospitals				

Worse results show vector maps of Kiev from other sites [4, 5]. Only 12 layers of information (fig.3). Criterion of multi-layering can be estimated as 5 points from 10.

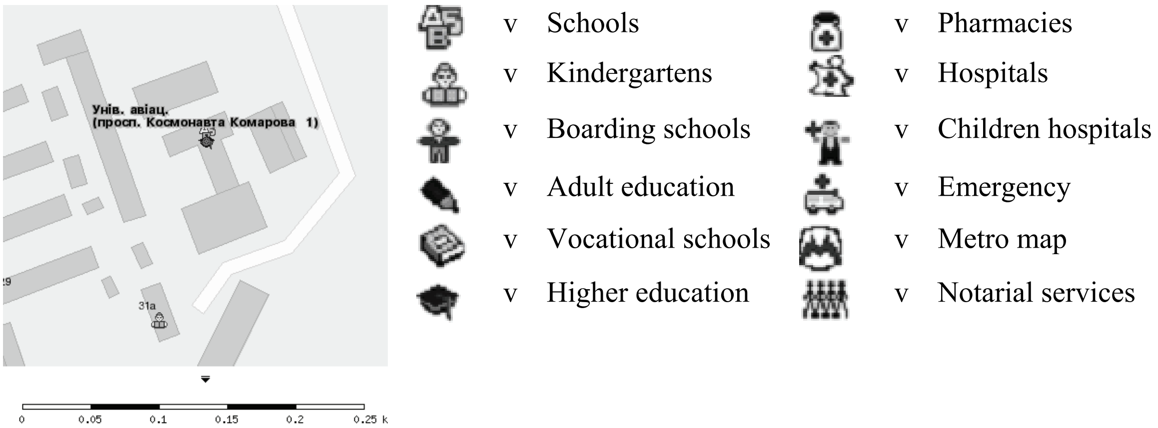

Fig. 3 Vector map of Kiev [4, 5]

Only 2 points for multi-layering can be given to Yandex maps [6], as they don't provide additional layers of information except the « Modes of transport » (fig. 4).

Fig. 4 Vector map of Kiev from Yandex-site [6]

One more important criterion is a *level of objects' detailing*, which in some kind of combination of multi-layering criterion and map details. Level of detailing at objects' depiction on map is provided mostly by the right choice of maps. For example, in navigation indicator can be installed detailed map of cities, with accuracy and detailed up to separate house (fig. 4, 5) and additional map of whole country with most important roads and objects. It should be noted as well that a lot of software provide the automatic choice of detailing level. Formally on detailing level it is possible to put only two restrictions – memory necessary for storage and map readability.

Table 2.

Comparison characteristics of electronic charts

Maps name	**Clarity**	**Multi-layering**	**Level of detailing**	**Place among considered maps**
Satellite map of Kiev	10	1	10	4
Vector map of Kiev from Meta-site	8	9	10	2
Vector map of Kiev from Yandex-site	8	2	10	5
Kiev vector map of NRI GC	8	10	10	1
Other vector maps	8	5	10	3

Technical means of visualization and functioning of electronic charts. When considering the possibilities of realization of optimal electronic charts it is necessary to define separately two main components: software and hardware (navigation indicators).

Software is one of the key elements of navigating system. Just the program defines representation of information from GPS-receiver, charts' data, variants of their usage and all additional possibilities of final product. Quality of software formally can be defined by the quantity of available functions, convenience of usage and other criteria. It is necessary to note that different kind of software can work only with definite types of maps. Therefore, one more criterion of software quality can be the quantity of different maps' formats supported by the given software. Now is widely used software for such platforms as Windows Mobile and Symbian, but some special-purpose navigation indicators use Linux. From this can be noted one more criterion of quality – possibility of easily software transportation from one platform to another. And definitely the most important criterion for software – is availability of qualitative maps for necessary region, which can be supported by program, because even the best program is nothing without good maps.

Main functions of navigation program.

- Graphic representation of any map region with scaling;
- Searching the objects by the address or nape;
- Planning the track between any points;
- Displaying of current position and track.

All these functions have a lot of parameters, upon the usage convenience of which depends the efficiency of program as the whole.

Hardware (navigating indicators). Besides the GPS-receivers navigating system should include some device for displaying and control of data. Nowadays are widely used special navigating indicators, pocket PC and smart-phones.

When choosing device for navigating system it is necessary to admit the following important criteria: cells work time (when using for walkers), size and brightness of screen, possibility of integration in car (aircraft), loudness of installed dynamic, presence of wireless interface, presence of slot for memory card, speed of objects plotting. Criteria at choosing the optimal navigating system depend on many factors, partially on the aria of application, price, presence of some parts of navigation system (PPC for example) already.

Conclusions. At given article have been detected main criteria of quality assessment of electronic maps, performed comparison characteristics of widely-used electronic maps in Ukraine. The proposed criteria for quality assessments of electronic maps can be used not only for road maps, but for aeronautical charts as well. Additionally have been defined main criteria of quality of navigation software and indicators.

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Filyashkin N.K., c.t.s., the proff. (National Aviation University, Ukraine)
Lukinova T.I., c.t.s. NAU (National Aviation University, Ukraine)

PARAMETRICAL IDENTIFICATION OF MODELS OF ERRORS OF INERTION SYSTEM OF NAVIGATION IN A MODE OF INTEGRATION WITH SATELLITE NAVIGATING SYSTEM

Ways of increase of accuracy of independent work of inertial navigation system (INS) are considered. Offered solutions allow increasing the accuracy of autonomous operation of INS by prediction its errors. Determination of predicted values of INS errors is based on procedures of identification of models parameters of its errors at INS integration with satellite navigating system. The results of mathematical modeling confirming expediency of such approach to increase the accuracy of autonomous operation of INS are given.

Urgency of researches. Formed in given period practice of creation and changing of navigation systems, based on usage integrated inertion navigation systems. Integration of inertion and satellite systems is realized by a way of complexation of two systems.

On decision of a problem of complex processing of the information in inertion navigation satellite systems the most attractive is, certainly, Kalman filtration. However, uses of Kalman filter meets certain difficulty at its practical realization aboard aircraft. In complexation there are estimated positions and speed of aircraft, and these data come not only to consumers, but also to contours of observation over a delay and a phase of receivers SNS. Communication of the of Kalman filter block with contours of SNS receiver is very rigid, therefore Kalman filter should be very high-speed, that is limited by characteristics of processors aboard CPU. Relative strapdown inertion navigating systems (SINS), usage Kalman filter meets additional difficulties. Particularly, in SINS the basic sources of errors – drifts of gyroscope transmitter and accelerometer, owing to nonstationarity of matrixes of transition from one system of coordinates connected with aircraft, to another - navigating, will be non-stationary casual processes even at stationarity casual processes which represent drifts of real sensor. This fact creates difficulties at aboard realization of this method of an optimum filtration.

Nowadays in modern aboard complexes, except algorithms of optimum estimation a condition vector (algorithms of the Kalman filtration), there are ways of processing of the homogeneous information, which have well recommended itself in practice. Particularly it is a way of mutual compensation. The suitability of usage of a method of compensation at information processing in inertion satellite systems of navigation tells, that in this case measurement of navigating parameters is carried out by measuring instruments which are based on different physical principles, and thus errors of these measuring instruments lay in different frequency ranges.

The basic advantage Kalman filtrations is, that at complexation SNS and SINS on output of Kalman filter, estimations of SINS error are restored (errors of zero shift of gyros and accelerometer, errors of scale factors etc.) which are used for correction inertion sensor. Therefore at breaks of receipt of data from receiver SNS received before an estimation of SINS errors and its measuring elements allow to improve accuracy characteristics of SINS in an independent mode.

But also at use of the scheme of indemnification there is a possibility to receive a predicted estimation of change of SINS errors for last period of teamwork of SNS and SINS, with certain duration which can be used for improvement of accuracy of definition of navigating parameters in autonomous work of SINS.

Statement or problem. The block scheme of realization of a method of compensation is presented in fig. 1. The algorithm of complex processing of the information which uses compensation method, has in comparison with optimum a Kalman filtration enough a simple look:

$$\hat{x} = x_{\mathrm{SINS}} - F(p)(x_{\mathrm{SINS}} - x_{\mathrm{SNS}})$$

where F(p) - the dynamic filter of the compensation scheme; x_{SINS}, x_{SNS} -navigating parameters (coordinates and speeds components) received from SINS and SNS; $\hat{x}$ - estimation of the given navigating parametre.

If choose filter $F(p)$ such that: it skip disturbance with minimal distortion ξ_1 and muffled a distortion ξ_2 then error of complex system will be minimum, that is the error $\hat{\xi}$ decreases depending on distinction in spectral characteristics of distortions ξ_1 and ξ_2. At considerable distinction in frequency characteristics of distortion on filter F(p) output (fig. 1 see) fully will be reconstructed the distortion ξ_1, that is SINS error.

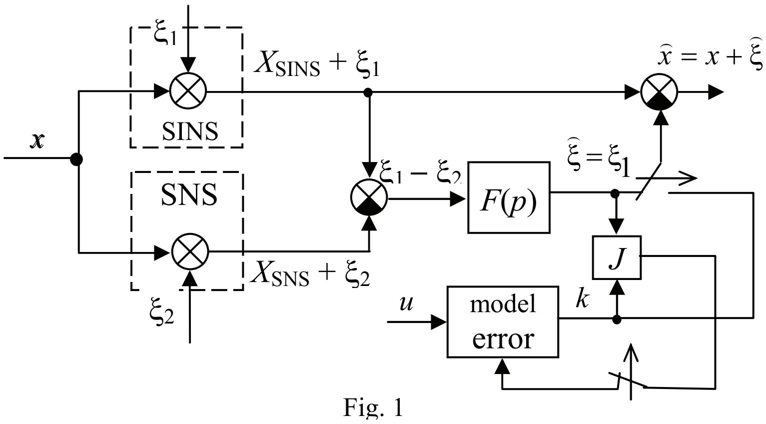

Fig. 1

Statement of problem can be formulated in a following way: being set of structure of mathematical model of SINS error and observing at complex processing of the information from SINS and SNS behind current SINS error, by identification corrected mathematical model of errors so that it as it is possible recreated replaceable in time current SINS error more precisely. The identification problem consists of search of such vector of parameters of mathematical model of errors that would minimise functional J for $p \in P$ where P - area of admissible values of parameters of Then in a mode of autonomous work the corrected mathematical model of error SINS can be used for improvement of accuracy of definition of navigating parameters.

Problem decisions. In connection with slow rate of character change of SINS errors it is offered to replace difficult model of SINS errors with more simple models in the form of linear regress with the further parametrical identification of factors of this model. Adjusting of model parameters is carried out during the discrete moments of time. Thus, lripus-kaetsja, that throughout one cycle of adjustment the identified parameters can be considered as constants.

Most the general approach to the decision of the formulated problem of identification consists in the following. For mathematical model of SINS errors (fig. 1)

$$\dot{k} = f(k(t), p, t), \qquad k(t_0) = k_0, \tag{1}$$

(Where f -function which depends on a vector of parameters p and time t as a measure of a deviation of settlement co-ordinates replaceable conditions from coordinates which are observed, accepted following integrated functional square-law of non-bridging:

$$J = \frac{1}{2}\int_0^{t_k} [z(\tau) - k(\tau)]^2 d\tau. \tag{2}$$

Here $z(t)$ - results of measurements of values replaceable system conditions on a time interval $0 \le t \le t_k$ and (in our case it ξ_1, that is SINS error).

The analysis of signals of an estimation filtered parameters $z(t) - k(t)$ (fig. 2 see) shows presence of casual variations of initial parameters. Therefore there was resolve a task averaging and filtrations of estimated parameters on separate intervals of time.

As criteria of affinity can be used:

- the maximum deviation $J = \max\limits_{k=1,2...,N} |z(\tau) - k(\tau)|$

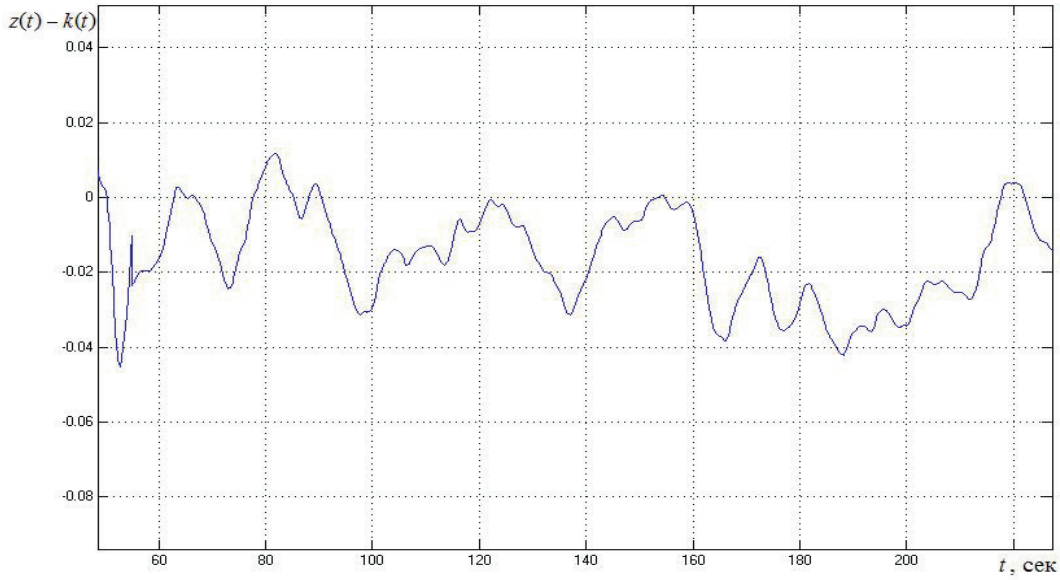

Fig. 2.

- average deviation $J = \frac{1}{N}\sum_{k=1}^{N}\left|z(\tau) - k(\tau)\right|$

- a standard or root-mean-square deviation $J = \sqrt{\frac{1}{N-1}\sum_{k=1}^{N}\left|z(\tau) - k(\tau)\right|^2}$

Parametrical identification of model of system which is observed, carried out for algorithms градlентноl identifications.

The algorithm gradient identifications consists in the following. We will be set by initial value p0 a vector of parameters and we will define size of non-bridging J_0, having solved the equation (1). Componenting revolting parameters on size h, we will find corresponding values non-bridging. Now j component of a vector - a gradient can receive as

$$\frac{\partial J}{\partial p_j^0} \approx \frac{J(p_1,...p_j + h,...p_n) - J^0(p^0)}{h}, \quad j = 1,n.$$

New approach for a vector of parameters we will define as

$$p^{i+1} = p^i - K^i \frac{\partial J}{\partial p^i} \tag{3}$$

Correlation (3) gives iterative process of improvement of estimations of parameters until will decrease functional of non-brodging. Depending on a way of a choice K i it is received different updatings of gradient procedures. Particularly , behind a method of the fastest descent K i gets out of a condition

$$\min J(p^i - K^i \frac{\partial J}{\partial p^i})$$

Thus, gradient method of identification is reduced to movement in spacious for the purpose $p \in P$ of search of the best in sense (2) parameters z.

As the elementary example at the first stage of researches the linear model of change of errors of calculation of SINS compound of speeds in view:

$$\dot{k} = p \cdot u, \qquad k(t_0) = k_0,$$

where u - a step entrance signal which revolted model of errors.

At researches the model three-componental SINS, model of satellite system of navigation, as standard, but the navigating system bent by white noise and model of the scheme which realizes indemnification method was used. An averaging and a filtration of estimated parameters on separate intervals of time was carried out behind a method of the least squares. Modeling was carried out with use of the program of visual modeling *Simulink*, which is a part universal mathematical package of programming *MATLAB*. On a graph (see fig. 3) there shown results of modeling of search, replaceable in time parametre p linear model of change of errors of calculation of speed.

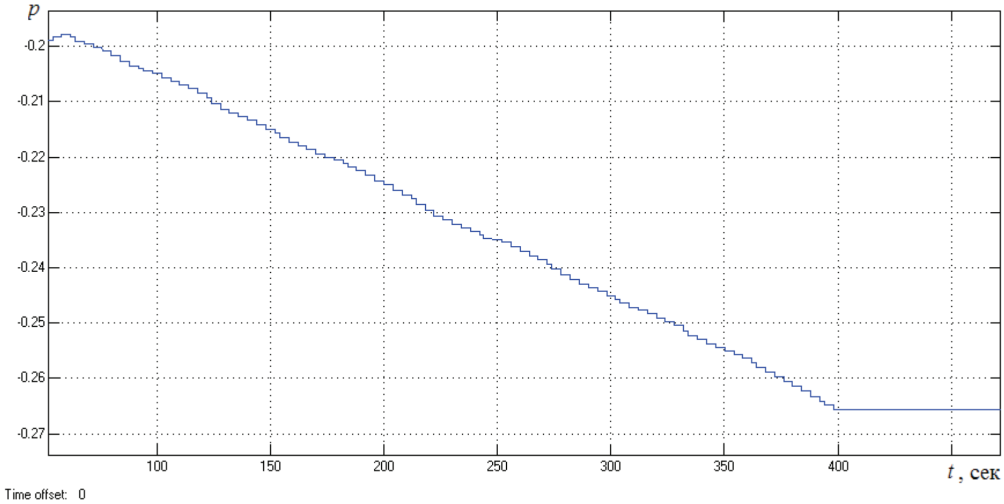

Fig. 3.

Constant change identified to parametre p testifies about rough enough approach of such model of SINS errors to the valid character of its behavior.

Therefore in work there was a carried out the statistical analysis of character of changes of SINS errors in time, by modeling of three-componental SINS under different initial conditions which more then all change character of errors, particulary: at different determinated compound errors of sensors of the primary information – accelerometers and sensors of angular speed; at different directions of flight (at different courses); at different widths (some results of modeling of changes of SINS errors in time presented on fig. 4). This analysis gives the bases to receive structure of hypothetical mathematical models of change of errors of calculation compound speeds on width and on a longitude. At reception of structure of model the analysis of known laws of change of errors of calculation of speed in time has been carried out. In particular that changes of errors of calculation compound occurs speeds on sinusoidal dependence to amplitude $A_{П}$, which depends on errors measurements of accelerations, and with frequency of fluctuations $\omega_{Ш}$ which is equaled to frequency of the Shculer, to be exact

$$\omega_{Ш} \approx \sqrt{\frac{a}{g_H(1-\frac{H}{a}-\frac{1}{2}e^2\sin^2 B)}} .$$

Where H - flight height; B - geographical latitude; a = 6378388; e = 0.0820365772.

$$g_H = -g\left(1+5{,}2884\cdot 10^{-3}\sin^2 B\right)\left[1-\frac{2H}{a}\left(1-e\sin^2 B\right)\right]$$

These parameters are reseived directly from algorithms of the decision kinematic equations of SINS.

And in addition in the presence of errors of measurement of angular speed, particularly, it concerns measurement of angular speed shift behind a phase takes place and is observed additional constantly increasing compound, which depending on a current rate more brightly shown in latitude, or longitudinal compound speed $\int_0^t L dt$.

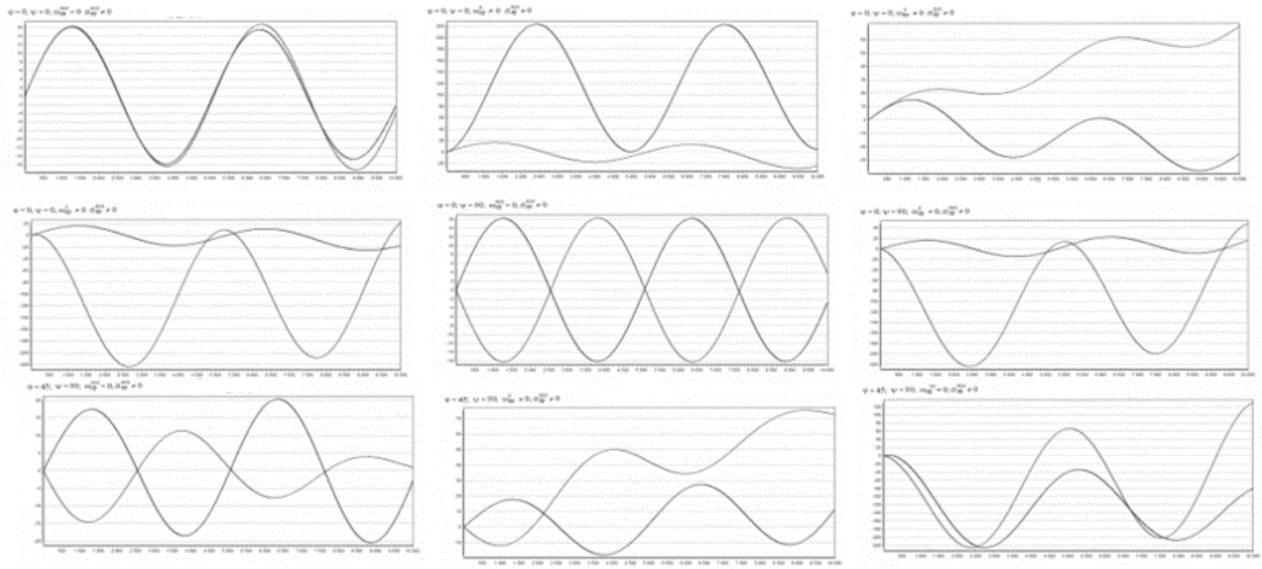

Fig. 4. SINS error

After all structure of hypothetical mathematical models of change of errors of calculation compound to speed can be presented in a way:

$$\Delta V = A_{\text{п}} \sin(\omega_{\text{ш}} t + \varphi) + \int_0^t L dt \tag{4}$$

Nevertheless at teamwork SINS and SNS there is a possibility of simultaneous supervision over errors of calculation not only compound speeds, and behind errors of latitudinal and longitudinal compounds of accelerations, and also, than an error.

Particularly the structure of hypothetical mathematical models of change of errors of calculation of latitude and a longitude can be presented in a way:

$$\Delta\dot{L} = \frac{\Delta V_E}{(R_2 + H)\cos B};$$

$$\Delta\dot{B} = \frac{\Delta V_N}{R_1 + H}.$$

Where $\Delta V_E,\ \Delta V_N$ - calculation of errors latitudinal and longitudinal compounds of speeds in a way (4);, $\frac{1}{(R_2 + H)\cos B}$, $\frac{1}{R_1 + H}$ - parameters which received directly from algorhythms of the decision of cinematic equations SINS.

Problem of parametrical identification of system which is observed, formulated thus: by results of supervision of initial replaceable models on errors of coordinates, speeds and accelerations there should be certain definite, optimum in some sense parameters of models: A_{Π}, L, φ. At parametre A_{Π} is defined in the block of supervision over errors of calculation compound accelerations, parametre φ - in the block of supervision over errors of calculation compound speeds, and parametre L - in the block of supervision over coordinates. The definite in separate blocks parameters are used other blocks that is the principle of "three blocks" - three definite parameters is realized.

The developed and investigated block of parametrical identification has been in details investigated on model singlearcomponent SINS, then entered into the developed model three-componental SINS. Results of modeling presented on fig. 5... 6.

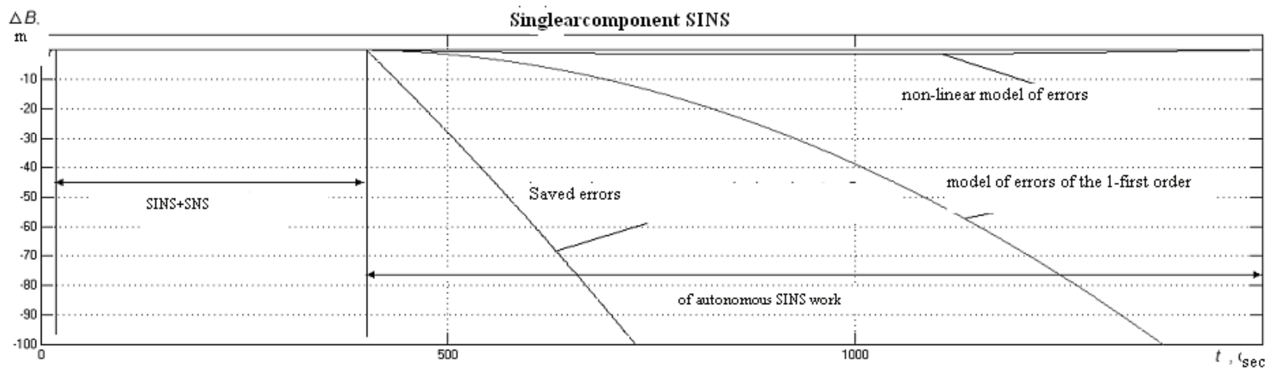

Fig. 5

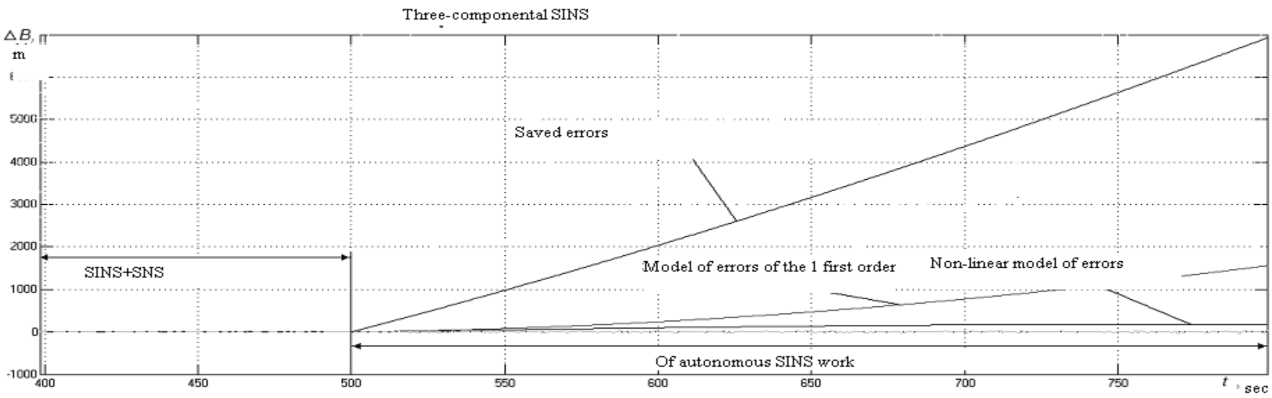

Fig. 6

Results of modeling testify about essential reduction of an error of autonomous SINS work. At autonomous work of latitudinal the channel of 3-componentual SINS model after scheme switching-off complexing with SNS for an interval of time 300s, is observed reduction of an error by 2 usages: about 7 km to 70 г, under the condition of use of rough sensors of the primary information.

Conclusions. Unlike Kalman filtrations the offered approach to complexing inertion satellite systems of navigation on the basis of the compensation scheme of more High-speed, noncritical to non-stationary casual processes which represent drifts of real sensors of primary information of SINS, and also can be easily enough realised in aboard processors TSVM. Developed for the scheme of indemnification a way of forecasting of an estimation of change of SINS errors on the basis of procedure of identification of parameters of hypothetical models of its errors at a stage of SINS complexing with satellite navigating system allows to reduce errors of autonomous SINS work essentially.

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M.P. Mukhina, PhD (National Aviation University)

ALGORITHM OF VISUAL TRACKING OF CONTRAST MOVING OBJECTS

The problem of visual tracking for moving object is considered. The analysis of image recognition methods is given together with its comparison of computer efficiency. The algorithm based on use of object contrast is presented. The speed of object center-of-mass is found by BLOB analysis in order to continue the tracking of object behind the obstacles. The results of algorithm use for different targets and qualities of video are presented.

Relevance.

The visual tracking of moving objects has various applications, starting from the robotic manipulation and landmark navigation and finishing by military purposes like guidance. The visual tracking may vary up to the way of tracking object detection: either it is set apriori (e.g. by operator) or must be found by searching the matching with some templates.

But once the object is detected the visual tracking itself starts. It includes the continuous locating of the selected object at the image.

Most algorithms for tracking objects in video consist of two components: a model of the dynamics of the object being tracked, and a model of its appearance. Often the appearance model is constructed before tracking, perhaps from training images, and then used. But for some real-time applications there is no possibility to train beforehand and the problem is to construct the object model simultaneously with tracking. Such a problem supposes the initial guidance on the object, determination of its features and their analyses.

Problem statement.

The tracked object is supposed to set by the operator as one of point that belongs to the object. The first problem is to detect all pixels of object $Z = \{p_1, p_2, \ldots p_n\}$ and construct the object model for further tracking. The next stage is to detect all objects on the video frames and identify the object with characteristics that do not sufficiently differ from the object characteristics on the previous frame.

The video consisting of frames 390×240 pixels is presented in the grayscale, fps is 25. Let's assume that for the very first frames the point that belongs to the object is given by the human operator.

The following constraints will be applied:

- the object proportions are not greater than 48×48 px;
- the object proportions are not less than 4×4 px;
- the object contrast is not less than 5% from the background intensity;
- the maximal speed of object center is not over 8 px/frame.

Review of approaches.

For solving the first problem (detecting the object) there is a variety of methods possible for use. They include:

- edge detection methods, where the most promising is Canny edge detection algorithm [1]
- threshold methods, especially Otsu's method [2] that has been proven as an efficient method in image segmentation.

Results of both methods are binary images, but the threshold methods give the pixels of object color and pixels of background color, while the edge detection methods give only contours of objects.

The determination of object features can be done with the help of methods of BLOB (Binary Large OBject) analysis [3]. It provides the finding of the following geometrical characteristics of object: area, center of mass, perimeter, orientation relatively image axes, etc.

As to the tracking of once detected object through video frames here the object characteristics will be in use. It is possible to assume that at least one of these characteristics cannot be changed instantaneously in sufficient value.

Proposed solution.

The object detection for the first frame is proposed to do with the help of threshold methods using Otsu's algorithm [2]. But based on a number of experiments (fig. 1) the thresholding must be done only for the region of interest (ROI), in the given case it will have the proportions 48×48.

a *b*

Fig. 1 Results of thresholding: a - for the full image, b - for cropped image

The cropping is done by selecting the point shown by operator as the center point of new image. Then the threshold value T is calculated and the cropped image is binarized.

The next step is BLOB analyses of cropped binary image that includes:

1) the determination of all closed objects (the color of object is considered to be the color of point set by the operator, the other color will be the background color). The results of this step in MATLAB is represented in the following form: label matrix **L** and the structure **B**. The matrix L has the same dimension as the cropped binary image (48×48), each element of matrix is the order number of objects in the image (0's correspond to the background, 1's to the first object, 2's to the second object and so on). The structure has N fields, where N is the number of image objects, and each field in turn contains indexes of pixels that belong to the current object. The example of label matrix and structure for the given image is represented in fig. 2.

1st object

2nd object

$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \qquad \mathbf{L} = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 2 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2 & 2 & 0 \\ 0 & 0 & 0 & 0 & 2 & 2 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \qquad \mathbf{B} = \left\{ \begin{bmatrix} 1,3 \\ 2,2 \\ 2,3 \\ 2,4 \\ 3,2 \\ 3,3 \\ 3,4 \end{bmatrix}, \begin{bmatrix} 2,7 \\ 3,7 \\ 4,6 \\ 4,7 \\ 5,5 \\ 5,6 \\ 5,7 \end{bmatrix} \right\}$$

Fig. 2 Resulting binary image and results of BLOB analyses **L**, **B**

2) the determination of selected object characteristics. They are area of object S and its center of mass X, Y (1).

$$S = \sum_{i=1} \sum_{j=1} p_{ij}, X = \frac{1}{S} \sum i_k, Y = \frac{1}{S} \sum j_m \tag{1}$$

where p_{ij} is the pixel belonging to the given object, i, j are indexes of these pixels.

The process of object detection is now finished. The object model consists of three main characteristics S, (X, Y), (V_X, V_Y); the last is assumed to be zero for the first frame.

To track the object through the video frames it is necessary to make the following assumption:

- the object speed is small enough to suppose that the center of mass determined for the previous frame will belong to the object in the next frame;

- in the case of object behind the obstacle its area is analyzed and the object is considered to be lost if it is decreased to zero values;
- the object speed is determined during the tracking and will be used in the case of object lost in order to predict its motion for the given permissible time.

The speed of object motion at i^{th} frame is determined as

$$V_X(i) = X(i) - X(i-1),\ V_Y(i) = Y(i) - Y(i-1).$$

In the case of object lost the coordinates of its center of mass are predicted according to the following expression (2):

$$X(i) = \frac{b_x}{N}\sum_{i=1}^{N} V_X(i) + X(i-1); Y(i) = \frac{b_y}{N}\sum_{i=1}^{N} V_Y(i) + Y(i-1), \quad (2)$$

where b_x and b_y are correction indexes.

Experimental results.

Analyses of contrast is performed. The minimal available contrast video frame is represented in the fig. 3. The white spot is the only possible for detection part of the object that is tracked through the video

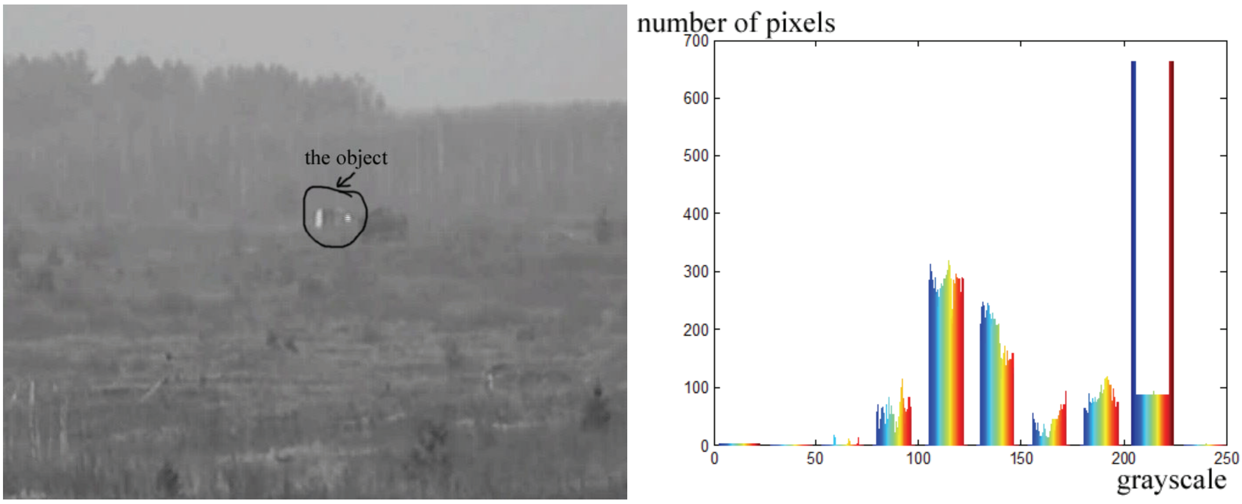

Fig. 3 First frame and its histogram

From the histogram it is seen that the white spot has the contrast level in 10% from the total level. During the tracking according to the proposed algorithm the object is gone behind the obstacle (dark spot in the image) and the motion of object is predicted. The graphs of center of mass speed and of area of object are shown in fig. 4.

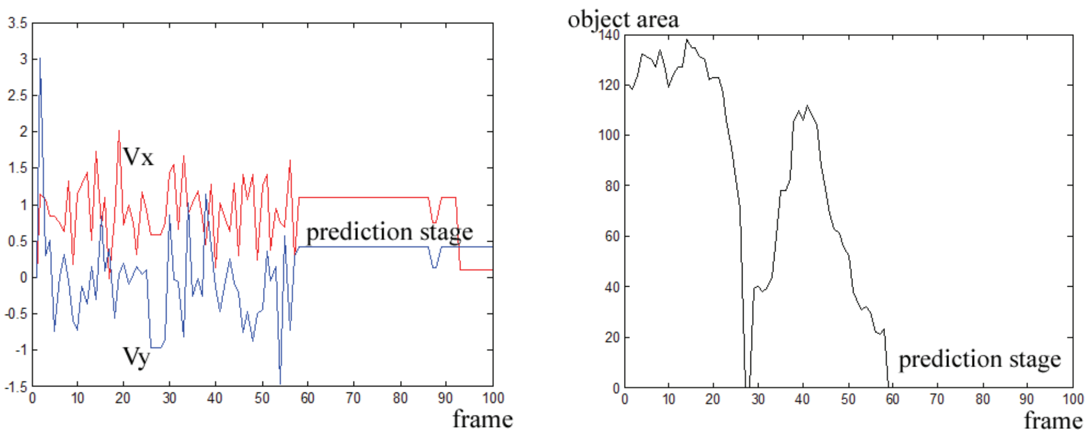

Fig. 4 Time dependencies of object speed and are in the stage of tracking and prediction

Conclusions.

The different in quality and contrast video files were analyzed and processed according to the given algorithm that was realized in MATLAB 2007a software. The speed of processing is about 24 frames per second, detection level is about 95% (5% of objects were undetectable from the very beginning either because of poor quality of video or bad contrast lower than 5%). The disadvantage of algorithm is in the object speed determination, since it required the correction index in the 50% of examples in order to capture the object after it appears from the obstacle.

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A. Ablesimov, professor (National aviation university, Ukraine)

TO THE MATTER ON SENSORS' SELECTION OF AUTOMATIC SYSTEMS

There was considered the technique of ACS speed sensors choice on the bases of their frequency characteristic analyses

The presence of speed sensors (SS) in the content of ACS provides the formation of damping component of stabilizing moment. The efficiency of control object antihunting is higher when the sensor's signal level is higher.

The influence of frequency oscillations of control object, the absolute angular speed of which is been measured, on the output signal SS, determines the alternating character of sensors' errors. That's why the strict agreement of speed sensors' parameters with the control object frequency characteristics is the necessary condition, on which the work quality of automated control systems depends.

Frequency characteristics of speed sensors are completely defined by parameters of 2 DOF's gyro with torsion, as the converters, of angular deviation into proportional electrical signals, are almost non-inertia and do not influence on the character of frequency dependence. That's why as the SS output signal the angle β_0 of relative frame turn is usually accepted.

The basic frequency characteristics of speed sensor are:

- amplitude-phase frequency characteristic (APFC)

$$W(j\text{щ}) = U(\text{щ}) + jV(\text{щ}) = A_m(\text{щ})e^{j\varphi(\text{щ})} = \frac{H\!/\!C_{\text{т}} \cdot \left[\left(1 - T_4^2\text{щ}^2\right) - jT_3\text{ɪ}\right]}{\left(1 - T_4^2\text{щ}^2\right)^2 + T_3^2\text{щ}^2}$$

- amplitude frequency characteristic (AFC)

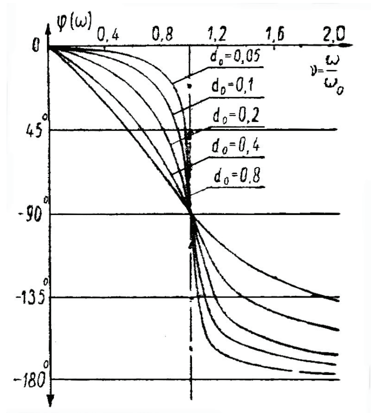
$$A_m(\text{щ}) = \frac{\text{в}_{0m}(\text{щ})}{\Omega_{0m}} = \sqrt{U^2(\text{щ}) + V^2(\text{щ})} = \frac{H\!/\!C_{\text{т}}}{\sqrt{\left(1 - T_4^2\text{щ}^2\right)^2 + T_3^2\text{щ}^2}};$$

- phase frequency characteristic (PFC)

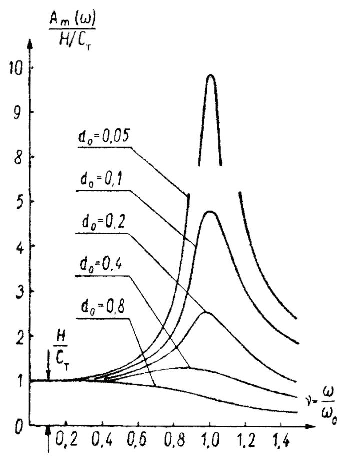
$$\varphi(\text{щ}) = \operatorname{arctg}\frac{V(\text{щ})}{U(\text{щ})} = -\operatorname{arctg}\frac{T_3\,\text{щ}}{\left(1 - T_4^2\text{щ}^2\right)}.$$

Characteristics, mentioned above, for the different values of damping coefficient $d_0 = \dfrac{T_3}{2T_4}$ are given at the pictures1-3. Characteristics are given for the case, when the input signal of sensor is the absolute speed of angular oscillations of it's base $\text{Щ}_0(t) = \text{Щ}_{0m}\sin\text{щ}t$.

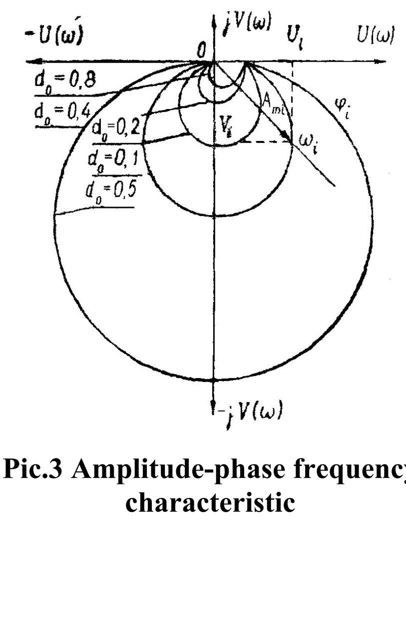
Frequency characteristics are received by substituting $p \to j\text{щ}$ into the transfer function of speed sensor



Pic.1 Phase frequency characteristic



Pic.2 Amplitude frequency characteristic



Pic.3 Amplitude-phase frequency characteristic

$W_{дс}(p) = \frac{в_0}{\Omega_0} = \frac{H/C_т}{T_4^2 p^2 + T_3 p + 1}$ and are constructed for "unit" gyro with transmission coefficient $\frac{H}{C_т} = 1$ in the function of relative frequency $н = \frac{щ}{щ_0} = щT_1$ at $d_0 = \frac{T_3}{2T_4} = 0{,}05;\ 0{,}1;\ 0{,}2;\ 0{,}4;\ 0{,}8.$

The given frequency characteristics show, that due to gyro frame persistence and friction in it's bearings forced precession oscillations of frame lag by phase from measured absolute angular speed of base (of control object), and phase angle $\varphi(щ)$ at frequency change from 0 to $+\infty$ changes from 0 to $-р$ (pic.1). The higher damping coefficient d_0 is, the greater is the phase lag of gyro frame oscillations. Relative amplitude of oscillations $A_m(щ) = \frac{в_{0m}(щ)}{\Omega_{0m}}$ at $d_0 < 1$ increases in frequency, reaching it's maximum value at $н = \sqrt{1 - 2d_0^2}$, and then decreases, asymptotically approaching to zero (pic.2). The smaller damping coefficient is, the more distinctive resonance peak will be. At $d_0 > 1$ resonance phenomena are absent, and amplitude, with the increase of frequency, monotonously decreases faster with the increase of damping coefficient.

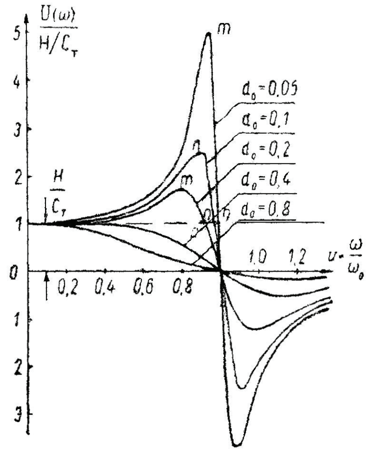
Thus, the measurement of absolute angular velocity is performed by the gyro sensor with the defined amplitude-phase errors, the values of which depends on both own gyro parameters and base frequency oscillations.

In accordance with amplitude-phase frequency characteristic (pic.3) forced gyro precession frame oscillations

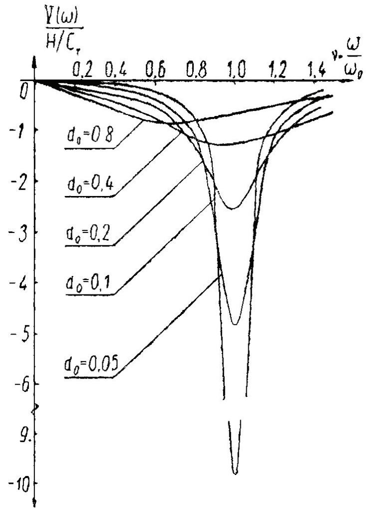
$$\beta_0(t) = \beta_{0m}(щ)\sin[щt + \varphi(щ)]$$

can be introduced as 2 components

$$\beta_0(t) = \beta_{0m}(щ)\cos\varphi(щ)\sin щt + \beta_{0m}(щ)\sin\varphi(щ)\cos щt.$$



Pic.4 Substantial frequency characteristic



Pic.5 Imaginary frequency characteristic

Taking into account, that amplitude of precession frame oscillations $\beta_{0m}(щ) = A_m(щ)\Omega_{0m}$, and change in time of base angular turn $б(t) = \Omega_0(t)dt = -\frac{\Omega_{0m}}{щ}\cos щt$, we will obtain

$$\beta_0(t) = A_m(щ)\cos\varphi(щ)\Omega_0(t) - щA_m(щ)\sin\varphi(\omega)\alpha(t) =$$
$$= U(щ)\Omega_0(t) - щV(щ)\alpha(t) = \beta_{0с}(t) + \beta_{0у}(t), \quad (1)$$

where $U(щ) = A_m(щ)\cos\varphi(щ)$ - substantial frequency characteristic, and $V(щ) = A_m(щ)\sin\varphi(щ)$ - imaginary gyro frequency characteristic (pic. 4,5).

Constituent $\beta_{0с}(t) = U(щ)\Omega_о(t)$ coincide by phase with absolute velocity of base and is useful output signal of sensor, and constituent $\beta_{0у}(t) = щV(щ)\alpha(t)$ - coincides by phase with the change of base turn angle, thus is a phase error of sensor.

Knowing the constituent amplitude $\beta_{0с}(t)$ we can determine the dependence of amplitude error of absolute velocity on frequency

$$\Delta\beta_{0m}(ш) = \beta_{0m}(ш) - \frac{H}{C_т}\Omega_{0m} = \left[U(ш) - \frac{H}{C_т}\right]\Omega_{0m}$$.

Thus, amplitude error is defined by substantial frequency characteristic of gyro speed sensor (pic.4). In the same way, the substantial frequency characteristic $U(щ)$, amplitude error is a non-linear function of frequency, and non-linearity character depends on the value of damping coefficient.

Characteristic analyses shows, that only at $\nu \leq 0{,}2...0{,}25$ in the first approach it is possible to consider $\Delta\beta_{0m}(ш) \approx 0$. If $d_0 < 0{,}707$, then the amplitude error rises at first, approaching at $\nu = \sqrt{1-2d_0}$ it's maximum value (points m at pic.4), and then decreases and at $\nu = \sqrt{1-4d_0}$ and changes it's sign.

Thus, having substantial gyro frequency characteristic of sensor and having it's damping coefficient, it is possible to determine the value of amplitude error for any of working frequencies.

By analogy can be determined phase error by imaginary frequency characteristic of gyro sensor (pic. 5). Imaginary frequency characteristic on the whole range of frequencies is negative. It's module non-linearly increases with increase in frequency, reaching it's maximum at $\nu = 1$. At the initial section ($\nu \leq 0{,}3$) it may be considered, that $V(щ)$ is proportional to the frequency.

It should be noted, that the dependence of output signal amplitude and it's constituents on the frequency of control object oscillations is one of disadvantages of gyro sensors, performed on the bases of 2 DOF's gyro with torsion.

During structural analyses of automated systems, the input signal of speed sensor is usually considered not the angular velocity of control object , but a correspondent turn angle. It is expedient as, firstly, angle is the output (regulated) coordinate system, secondly, the simplest is to measure frequency characteristics, changing the frequency of angular oscillations at constant amplitude, and thirdly, it is easier to perform the analyses and calculation of frequency characteristics relatively to the angle, than to the velocity.

If to consider angular oscillations of control object as the input signal $\alpha(t) = \alpha_m \sin щt$, then frequency characteristics are determined by substitution $p \to jщ$ into the transfer function

$$W_{дс}(p) = \frac{в_0}{б_0} = \frac{H/C_т \cdot p}{T_4^2 p^2 + T_3\, p + 1}$$.

It is easy to make sure, that in this case amplitude-phase frequency characteristics are circles with the coordinate centers $\left(\frac{H}{2C_т T_3};\ \mathrm{j}0\right)$ and diameter, equal to $\frac{H}{C_т T_3}$. Parametric equation of these circles is:

$$(U_\alpha - \frac{H}{2C_т T_3})^2 + V_\alpha^2 = (\frac{H}{2C_т T_3})^2$$.

Thus, amplitude-phase frequency characteristic may be constructed by one given or experimentally obtained point $U_\alpha(щ_i);\ jV_\alpha(щ_i)$. It is also simple to determine total damping coefficient $f_\Sigma = f_y + f_д$ and to calculate, for the chosen type of gyro, damping coefficient d_0.

Having substantial and imaginary characteristics, we can determine constituents $\beta_{0с}(t)$ and $\beta_{0у}(t)$ of the output signal of gyro speed sensor:

$$\beta_0^\alpha(t) = V_\alpha(ш)\Omega_0(t) + U_\alpha(ш)\alpha(t). \qquad (2)$$

It is easy to make sure, the equations (1) and (2) are equivalent.

Important advantage of received frequency characteristics is the possibility of their introduction in the Важным достоинством полученных частотных характеристик является возможность представления их в standardized form, which sufficiently simplifies all the calculations. Really, taking as a scale unit $A^{\alpha}_{\max} = \frac{H}{C_{т} T_{з}}$ we will receive, instead of family of amplitude-phase frequency characteristics, one circle of unit radius. If to choose a scale relatively to frequency $н = \frac{щ}{щ_0}$ so, that $\nu = 2$ correspondently $б^{\alpha}_{m\beta} = \frac{A^{\alpha}_{m\beta}}{A^{\alpha}_{\max}} = 1$, then all frequency characteristics may be united into one graph.

Further investigations of SS signals, reasoning from frequency operating range of control object, let us to optimize their parameters, to correct frequency characteristics for the quality improvements of automatic systems, determined by the technical conditions.

The application of standardized frequency characteristics during selection of automatic systems' sensors shortens the volume of calculations. If calculations are frequently performed, then it is expedient to use monogram with pre-constructed characteristics for the most possible values of damping coefficient. The construction of monograms is simplified by using packages of application programs.

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Klyuchko E.M. (National Aviation University, Ukraine)
Klyuchko Z. F. (National Aviation University, Ukraine)
Lizunova A. G. (National Aviation University, Ukraine)

BIOLOGICAL DATABASES AS CHAIN IN ALGORITHMS FOR ECOLOGICAL MONITORING OF FAUNA

In contemporary practice electronic biological databases are the chains in algorithms for ecological monitoring of environment fauna. Some examples of such problems solution during the creation of biological DB spread in global network are given as well as examples of results of many years monitoring of Noctuidae fauna in Striltsivsky steppe preserve (Ukraine, Lugansk Region).

Introduction. Electronic databases (DB) linked with the Internet with the information about living organisms are information systems (IS) constructed during last years. They were developed for few purposes: for academic purpose – maximal accumulation of the information about the groups of living organisms, for purposes of economy (including agriculture), needs of medicine (clinical diagnostic DB for computer analysis, etc.). Because such IS accumulates great massive of information that was digitalized and included into DB in different research and information centers – they all may be defined as DB that is spread in networks. Contemporary electronic DB with information distributed in Internet networks and mathematic simulation on the base of the data from such DB permit to study how different factors (geographic, ecological, environmental) influence on the area of spreading and number of organisms. So, such methods may be used for the protection of healthy human environment in contemporary conditions with intensive increase of technogenic influence that becomes the problem in whole world as well as in Ukraine. According to such formalization of problem the DB is the chain in algorithms of ecological monitoring of fauna. But this chain is considered as second one. The first chain is collecting of primary material in nature, registering of necessary characteristics and their digitalizing. As primary material for such work the authors have taken the data of own many years monitoring of Noctuidae fauna in preserve "Striltsivsky steppe" (Ukraine, Lugansk region).

During the DB development for ecology not only academic tasks are solved. Data from them further may be used for agriculture, during the construction of objects important for economy (airports, etc.), and for other important spheres [1, 2, 3]. Modern DB for biology were constructed during only the last 6 – 7 years [2, 3, 4] and we consider that any experience in this sphere may be useful for the realization of such projects in future.

Tasks and objectives. To ground the necessity of the construction of modern biological DB as component in ecological monitoring algorithms with the aim to defend the healthy environment for humans in contemporary conditions of technogenic influence increase.

Analysis of characteristics of some DB analogs with the information about biological organisms. Development of electronic DB with the information about the groups of living organisms is included into the projects «Network of Exellence» in European Union today. The tasks of nature conservation using of electronic DB and mathematic simulation on the base of these data ones tried to solve in different countries. Let's make the brief review of some of such tasks.

Task of integrated defense of the forests from pests. The concept of integrated defense of the forests from pests attracted scientist attention during long years but successfully it was realized only in last years after the construction of modern electronic systems for forest monitoring and electronic systems for decision making [5]. As prospective for today systems are considered ones that include models, control systems for DB, geographic information systems and expert systems. Such systems were started to develop in North America as systems for forest defense against some pests from Lepidoptera.

Task of defense from pests in agriculture. Another experience of defense from pests using electronic IS on the base of DB is known from agriculture [6]. There was described the system of relation DB control that was developed for nature monitoring and suggesting of recommendations to farmers about pests *Cydia pomonella* and *Psila rosae.* This system was developed using INFORMIX-SQL RDBMS Version 2.10.06 and installed on computers IBM XT model 286 with PC-DOS Version 3.30; it is in use since 1988. Farmers monitored insects; these data were transmitted to IS in research center. Experts on the base of received information about *Cydia pomonella* recommended different protective procedures to farmers.

Academic electronic DB with the information about the groups of living organisms. Due to such successes in IT as development of contemporary DB in global IS there are some projects included the information about taxonomy of organisms and their spreading. Such DB may be used for organism identification in future in case of high quality standards [7, 8]. Results of some project realizations permit to predict changes in biological specie numbers and their future spreading [9, 10]. Such tasks are rather important because of application for different problems solution like nature conservation, agriculture, etc.

As examples of such academic biological DB may be mentioned two important projects. Web- project «Tree of life» is a good electronic resource with the information about plant and animal variability [11]. Another web- resource of such type is a web- site of Institute of zoology (Russian Academy of Science) [11]. It represents review of scientific collections with the data about 60 000,000 species from fauna of Russia and other countries. These unique collections already have formed the ground for the initiation of numerical scientific projects about species variability, their evolution and ecological peculiarities.

Mathematic methods used for the solution of tasks with biological DB. For the solution of nature conservation tasks in some regions [12] was studied the possibility of usage of two mathematic methods for processing of museum electronic DB information and for the estimation of real number of species in region. Such methods were following: 1) phenomenological model based on saturation curve for the number of gathered insects; and 2) model that is based on the concept of species number increase according to normal logarithmic rule. There were demonstrated that mathematic method applications corrected previous imaginations about the places in nature that needed conservation, so, corrected significantly the practice of nature conservation.

For the data analysis and for the solution of some tasks in nature conservation were used Monte Carlo method [13] and methods of cluster analysis [14]. Cluster analysis methods and method of neuronal networks were also used for the simulation in ecology, for the studying of organisms spreading in different regions. Methods of regression also permit to predict the changes in spreading of organisms in different places and changes in species number [9, 10]. These methods may be applied in Ukraine also for the processing of ecological data like the data given below.

Results of fauna monitoring in Striltsivska steppe preserve. Fauna monitoring at the territory of Striltsivska steppe preserve was carried out during the period more then 40 years (1905 - 2007); at the beginning such researches were episodic. Only in last years such researches were carried out regularly [15 - 19]. Let’s observe some original data of such ecological monitoring for Noctuidae species that were gathered by authors.

Table 1

Noctuidae species content and changes in number of collected samples according to years in process of monitoring. Data reflect the dynamics of changes in numbers for each specie.

Name of specie	Number of collected samples according to year			
	1965	1996-2002	2006	2007
Phytometra viridaria Cl.	30	1	2	2
Lygephila lubrica L.	33	8	3	4

Table 1 (continue)

Name of specie	Number of collected samples according to year			
	1965	1996-2002	2006	2007
L. craccae F.	34		3	
Drasteria caucasica Kol.	28		2	1
Euclidia triquetra Den.& Schiff.	464	1	6	1
Catocala hymenaea Den.& Schiff.		1	56	26
Trichoplusia ni Hbn.	2		2	13
Macdunnoughia confusa Steph.	70	3	13	12
Diachrysia chrysitis L.	80	2	71	11
D. stenochrysis Warr.	70	3	82	12
Autographa gamma L.	122	4	5	13
Phyllophila obliterata Rbr.	100	2	1	6
Acontia lucida Hufn.	210	3	9	12
A. titania Esp.	70	2	17	14
A. trabealis Scop.	986	7	6	32
Oxycesta geographica F.	1397	5	28	86
Acronicta megacephala Den. & Schiff.	4	3	16	10
Mycteroplus puniceago Bsd.	104		14	
Tyta luctuosa Den. & Schiff.	210	5	88	79
Cucullia dracunculi Hbn.	14	4	6	4
Calophasia lunula Hufn.	94		5	16
Epimecia ustula Frr.	120		4	7
Schinia scutosa Den. & Schiff.	186	7	15	16
Heliothis viriplaca Hufn.	60	1	2	2
H. maritima Grasl.	143	5	5	22
Helicoverpa armigera Hbn.		2	8	9
Periphanes delphinii L.	3		29	
Pseudeustrotia candidula Den.&Schiff.	120	4	39	31
Caradrina wullschlegeli Pueng.	53			1
Hoplodrina octogenaria Goeze	15		1	9
H. blanda Den.& Schiff.	80	1	2	4
Athetis furvula Hbn.	21		1	8
Actinotia polyodon Cl.	1		52	6
Apamea ferrago Ev.	408		4	
Calamia tridens Hufn.	52	2	4	4
Archanara dissoluta Tr.	17	2	2	2
Episema glaucina Esp.	76		1	
Lacanobia w-latinum Hufn.	200	2	6	17
L. suasa Den. & Schiff.	120	5	4	16
Sideridis lampra Schaw.	1158	1		1
S. turbida Esp.	52		5	
S. egena Led.	27			2
S. rivularis F.		1	4	6
S. reticulata F.	409	4	5	22

Table 1 (continue)

Name of specie	Number of collected samples according to year			
	1965	1996-2002	2006	2007
Saragossa siccanorum Stgr.	30		1	
Conisania. luteago Den. & Schiff.	40	1	3	13
Hadena capsincola Den. & Schiff.	24		5	4
H. perplexa Den. & Schiff.	11		1	3
Mythimna alopecuri Bsd.	1467		2	1
M. ferrago F.	110		9	2
Agrotis bigramma Esp.	21		4	
A. ipsilon Hufn.	42		4	
Spaelotis ravida Den. & Schiff.	15			1
Xestia baja Den. & Schiff.				1

Conclusion. Monitoring of Noctuidae was carried out in Streltsivsky steppe preserve during more then 40 years (1965 -2007). During this study were registered 318 Noctuidae species from 144 genera. Taxonomic analysis revealed that majority of species belong to 17 genera: *Cucullia* (21 вид), *Hadena* (13), *Mithymna* (12), *Acronicta* (10), *Catocala* and *Apamea* (9 for each), *Xestia* (8), *Lacanobia, Euxoa* and *Agrotis* (7 for each), *Eublemma* and *Caradrina* (6 for each), *Lygephila, Amphipyra*, *Sideridis, Orthosia,* and *Noctua* (5 for each). Interesting characteristics of fauna is the large number of genera that are represented by 1-4 species (127 genera, or 88.2% of total number). Other peculiarity is that Noctuidae species content varies significantly in different years by the number of collected moth - 191 species on 1965 and 260 species on 2006-2007 (see table).

During the period of monitoring the number of meadow – forest species increased (90 or 28% of total number). This increasing was registered for the number of species as well as for the frequency of meeting of samples for collection during the season. Simultaneously increased the number of forest species (18 or 5.6% of total number), including species from generis *Catocala* (*C. fraxini L., C. pacta., C. elocata Esp., C. hymenaea Den. & Schiff.*), as well as *Amphipyra* and others (see table). Such changes are important characteristics of local fauna. This fact may be explained by the growing of squares covered by forest plants and bushes.

Such results of monitoring are rather important for nature protection in this area and for future development of economy in this region. We have to mention that in future for purposes of monitoring and analysis necessary to use more experience of world practice, contemporary IT methods, methods of regression for processing of great massive of monitoring data, for prediction of fauna changes, and for coupling of these DB with world information networks.

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Sitnik O.G., (National Aviation University, Ukraine)
Yurchenko O.S. (National Aviation University, Ukraine)

INTERCONNECTION OF EFFECTS OF PEAK AND LATITUDINAL IMPULSIVE MODULATION IN THE PROCESS OF DEEP PRINT AND HIS INFLUENCE ON QUALITY OF MAKING OF DOCUMENT IN CALS-TECHNOLOGY

Decision of problems of influencing of interconnection effects of peak and latitudinal impulsive modulation in the process of deep print for making of document in composition of CALS-technologies on quality of images needs explanation of many theoretical aspects. Interconnection of effects of amplitude and latitudinal impulsive modulation in the process of deep print for making of documentation in composition of CALS-technologies discovers itself as characteristic damages on the different areas of reproduction.

Introduction. The phenomenon of peak and latitudinal impulsive modulation in the process of deep print for making a documentation is known for specialists [1], somewise connected with a polygraphy, or making of technical document in composition of CALS-technologies for a civil aviation, treatment in the process of electronic-digital reproprinting of images (EDRI) or preparation to the printing. Actuality of the problem of such phenomenon learning as interconnection of effects of peak and latitudinal impulsive modulation in the process of deep print for making of document in composition of CALS-technologies, is known [2] because it in theory combines all types of images damages. Actuality of influence research of interconnection effects of peak and latitudinal impulsive modulation in the process of deep print for making a documentation in composition of CALS-technologies and quality of images, which are used in CALS-technologies for a civil aviation, is also known. This problem disturbs us in realization, at first sight, maximum simple task — recreation of high-quality reproduction by a polygraphy method for circulating of document [3].

From history of question. There is known [4] the simpler and the most laconic explanation of the origin reason of interconnection effects of peak and latitudinal impulsive modulation in the process of deep print for making document in composition of CALS-technologies. It is the dismemberment of stroke elements by a periodic raster, which causes defomation of maximum areas of strokes. Different researchers have offered measures, with the help of which strike line contours become even. Thus inside of a stroke the raster structure of not quadratic rejection is saved and s.o. That is why in a number of cases of ranging, for example, of imprints, printed on a different paper (tabl. 1), to objective and subjective estimations appeared weakly, that correlate mutually. Especially strongly such inconsistency showed up at comparison of the same type standards of printing paper. Experimental investigations, conducted by authors, showed, that principal reason of these failures became transformation of nonhomogeneity signet by frequency descriptions, which show rather considerable influence with the subjective estimation of printing imprints quality.

Analysis of the last researches, in which the problem decision of influence of interconnection effect of peak and latitudinal impulsive modulation in the deep print process for making document in composition of CALS-technologies on images quality [6] is founded, consists in that it seems impossible the decision of EDRI process practice problem by its programme-hardware facilities without the help of elaboration of modern positions of theory. Interesting to look, that these difficulties, which, for example, were tested in the Dutch institute of polygraphy researches [7] at comparison of subjective estimations and middling quadratic rejections of optical closeness of chaser die at control of the same paper type groups, were easily accountable, since frequency descriptions of paper acquire prevailing value exactly in the cases of control of the same paper type groups. Only, probably, with absence of necessary devices it is possible to explain that, doing a correct analogy between a printing imprint and photo image, only measurings of middling quadratic rejections limited to sizes by methods, accepted in a photo, but not in electronic images.

For the exactness analysis of transmission of microline areas of image different scientists [1] used methods for the estimation of granulation in passing or reflected light, and also original conceptions, based on statistical nature of the considered phenomenon with the purpose of picture development , but not electronic images, which have other specific. However and here estimations were limited to one size: or by the average value of gradient of optical black and white line closeness, or coefficient variations of reflection of elementary raster area were examined, which contains one raster point, or size of raster elements (RE) area. Offered and tested different and very useful methods (templates, photomicrographs, photo-electric and other) measuring of RE area on a form and imprint owing to the force of circumstances also could not be the basis for the complete objective estimation of image transfer exactness in EDRI for making of the high-quality technical document.

Raising of a problem in a general view and its connection with important scientific tasks lies in research of influencing of interconnection effects of peak and latitudinal impulsive modulation in the process of deep print on quality of document making in composition of CALS-technologies, which can be caused a number of reasons, beginning from the wrong mode of EDRI, their improper treatment and ending with incongruous tuning on the stage of forms making and by the printing process and its influencing to images quality. The special attention is deserved by consideration of question about the degree of accordance of peak-impulse modulation and real observed on a practice mechanisms of forming of image in the deep print process. Obviously, that if we were limited to the only idealizing picture of presentation of image on imprints, had gotten by the method of deep print, as infinity number of discrete elements, which have an identical form, but differ one from one only by intensity, then principle difficultly accoutable within the framework of this idealization contradiction would arise up.

A research purpose is making of high-quality colordistriduted forms on a tape, or on a paper subject to the influence on quality of effect interconnection images of peak and latitudinal impulsive modulation in the process of deep print for making a documentation in composition of CALS-technologies. The features of display of effects interconnection of peak and latitudinal impulsive modulation in the deep print process investigated for making a documentation in composition of CALS-technologies because they stipulate for impossibility the problem decisions of optimal process of reproduction programme hard-ware facilities without the help of new positions of theory and modern technology using.

New approach for the decision of problems is expounded in a hypothesis [3] and consists in next. Possibly in an experiment, that the point is that even at very high intensities of colourful layer the maximal, in theory possible value of integtal raster optical solidity I_n in peak-impulse system ha integral of Other at the amplitude impulsive system must be considerabs to be much lower than similar description in autonomic system. It is set that depending on porosity of impulses in the peak-impulse system a specific area RE makes 0,4 – 0,7 at that time as in the autonomic system its maximal quantity equals unit. Influence of specific area of RE size on a size is sufficiently strong and that is why within the framework of the resulted idealization of process which was investigated in an interval ΔI_n. he had to be insignificant enough $\Delta I_n \approx 0,3 - 0,5$.

Scientific result , which is got on the basis of application of the developed elements of theory and scientifically methodical device expounded in [5] and consists in the following. In actual fact interval of optical solidity of images, that by the method of deep print reproduce not less, but more than at the use of the peak systems and reaches 1,4 – 1,6 units of optical closeness in despite of that on the printing forms cells sizes are little enough change (within the limits of 20% for areas) in dependence at their depths and practically in all of interval remains permanent on reproduction, and on printing imprints obviously there is an peak effect, that expansion of RE up to even filling by the paint of all area in shades of image. In shades due to this effect a raster structure disappears in general, and dark areas obtain character of continuous chaser die. In this case by reason of change of RE area on an imprint there is a specific of printing process in which viscid easily fluid printing-inks based on organic solvents are used.

Exposition of basic research material with the complete argumentation of received scientific results, it is done in [5]. It is suggested to use in the model of process some modern looks for the estimation of influence of the phenomenon, which is examined on images quality by descriptions and analytical calculations. Formal, effect of RE area change on the imprints of deep print depends on the depth of raster cells on a printing form, it means that we can examine the expansion of impulses depending on their amplitude as influence of filter of lower frequencies on periodic sequence of equal wide impulses. For the gradation description of deep print process looked like enough smooth curve, the original balancing of simultaneous influence is needed on the quantity of raster optical closeness of peak-impulsive effects and latitudinal impulsive modulation. With the purpose of estimation of these phenomena we convert the known formula [6] to the kind, comfortable for an analysis process

$$D_r = \lg \frac{1}{1 - S_{ef} \cdot (D_r) \cdot (1 - 10^{-ef})} \text{ if } S_{ef}<1 \tag{1}$$

where $D_r = D_e$ if S_{ef}=1. $S_{ef}\ (D_e)$ – an effective quantity of specific RE area, numeral equal to the specific area of screened image with set values D_e and D_r.

Minimum value of S_{ef} corresponds the specific area of raster cells of printed form, that determined by porosity of raster structure. A maximal value is determined at at the uniform ceiling of area in the process of EDRI. At the uniform ceiling of intervals between impulses the quantity of raster optical solidity is equal to optical closeness of raster element D_e. The uniform ceiling of impulses can take a place before, than maximal value of optical closeness of copy reaches, that is at some value D_p. Appropriately to assume that during linear low frequency filtration the change of RE width is proportionally to the size of their peaks of D_e, and the change of specific RE area is proportionally to the square $D_є$

$$S_{ef}(D_e) \approx S_o + k\ {}^{2}_{ef}$$

Numeral value of coefficient to D_o is possible to define from condition

$$S_{ef}(D_n)=1 \tag{2}$$

$$k=(1 - S_o)/ D_n^{2} \tag{3}$$

Quantity k reflects in maximum measure the property of print process, as filter of lower frequencies. The greater k, then the less effective width of a strip of passing process frequencies, the more raster structure on a documentation during printing suffers frequency twisting. Analysis of experimental information, received on different devices, інтуїтивно confirms enough supposition, that quantity k depends on viscosity of printing-ink, growing with diminishing of viscosity during another equal conditions.

Consider that quantity k must depend on the regimes of realization of print process at CALS-technology and printing-technical properties of paper for a technical documentation.. Unfortunately, in works, devoted the experimental investigation process of deep print [7], these very important characteristic on our opinion didn't determined. It is rather expedient to think that for the filter influence control we use the process of deep printing on the frequency spectrum of the image of special continuous scale of halftones and next visual finding of ceiling RE area on an imprint with the objective dimension of optical solidity of lower boundary of this area D_p . In the area of action of quadratic specific RE area dependence from their amplitude, probably next relation must be right.

$$D_r = \lg 1 / 1 - [S_o + (1 - S_o)(D_e / D_p)^2\ ](1 - 10^{ef}) \tag{4}$$

Correlation (4) is one of modifications of the known formula (1) in relation to the case of deep print. It can be used for an estimation of dependence of raster optical closeness on De, So and Dp . Certainly, as the initial formula, this relation is right just on condition of ignoring the quantity of optical paper solidity for a tekhnich document and the known effects of EDRI.

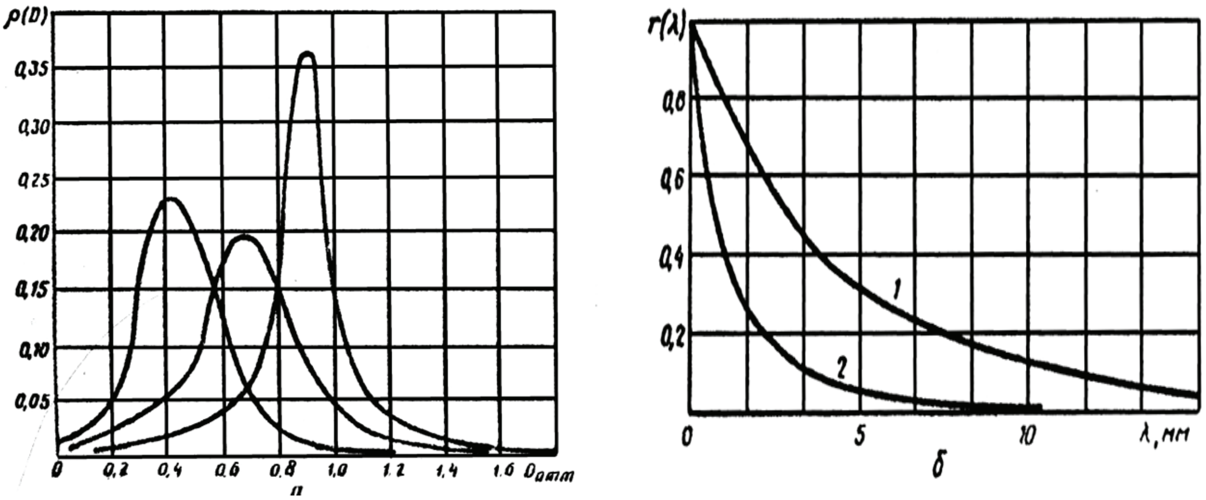
The hypothesis of decision of existent problems [3] consists in the following. The phenomenon of RE size instability on printing imprints in high light images presents some interest for general research of process. Because of the small depth of raster cells in this area obviously there are considerable variations of enough large RE area aside its diminishing to complete RE non printing. Not stoping on reasons of these phenomena, which are connected with physical essence of EDRI, and dynamics of deep print process, and depends on many technological factors, we will denote the fact of presence of printing process instability area in high lights of images. In an integral aspect, that is in character of influence on the quantity of Dr , these phenomena are equivalent, to some measure, to the peak and latitudinal impulsive modulation. That is why the upper boundary of print process is reasonably to accept such value of Dr, at which size of RE area with the sufficient degree of probability corresponds the area of raster cells on a printing form. Thus, it is suggested to break up the interval of deep print process on three areas: not about RE seals, areas of peak effects action and area of complete disappearance of raster structure.

Confirmation of justice of assertions in a work is an analysis additional researches parameters , which were used for a design. Consider that the formal reason of size RE instability in high lights of image is too less depth of cells on a printing form. That is why possibility of increase of printing process stability is connected with an intentional increase of exactly this parameter. For that however general amount of paint in high image light was much less, than in the middle area of process, rational would be to realize the controlled effect of peak, that is regulated change of the raster cells area on the print form exactly in the area of high lights.

Position of modern science [2]is used in developments of elements of theory, what totally confirms fact, that from other side, in high shades of image the classical method of deep print due to adjusting of cells depth allows to reach greater magnitudes of D_r, than in another ways. Such increase of depth of raster cells is rationally only to the some border, because in the range of 30–40 mkm satiations effect advances, that is the amount of paint which passed to the imprint stops to depend on the raster cell depth. The observing effect of satiation is well explained by the theory of fragile break of paint layers in a printing process and determined sizes by specific energy of interaction between a paper and paint and superficial tension of paint on the boundary with air.

The personal membership dues of authors consists in the following. After numeral mathematical transformations we'll get results of design of process for the decision of problem of images quality increase through creation of modern theory of effects interconnection of peak and latitudinal impulsive modulation in the process of deep print for making technical document in composition of CALS-technologies, which discovers itself as characteristic damages on the different areas of reproduction. Thus, the process of forming of deep print image is not adequate to simple peak-impulsive modulation by rectangular impulses at screening. Effects of latitudinal impulsive modulation, filtration and peak limitation are quite obviously observed. Reverse effects of low frequency filtration are observed in the area of instability of printing process, that is the action of above enumerated links has a lower level of limitation. A study and accounting of action of all these factors will allow in future to open completely possibilities of reproduction of images using the method of deep print.

The special problems arise at the recreation of stroke images in EDRI (including the text of deep print). A deep print (it belongs to stenciled also) has the worst possibilities of recreation in it relations in comparison with another ways of seal (high and offset). Because of specific features of this method we have to screen seal stroke and text images using other methods. As well as at researches of other authors [1], it was experimentally set on a designing complex EDRI, which includes a laser formed automat (LFA) and a device "FAKEL", that variations of magnitude of optical solidity of chaser dies have a normal division with the sufficient degree of authenticity (after a criterion x_i-square) (pic. 1a). In addition, unlike previous researches, their auto correlation (pic. 1б) and power descriptions were experimentally determined.

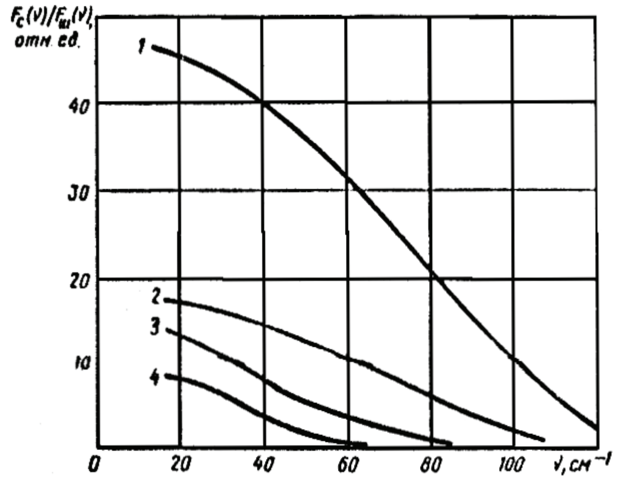


Pic. 1. Solidity of division of optical closeness of different on a thickness printing imprints (chaser die) – (a) and the coefficient of autocorrelation of optical closeness of printing imprints (chaser die) of visual satisfactory (I) and unsatisfactory quality (2) – (б).

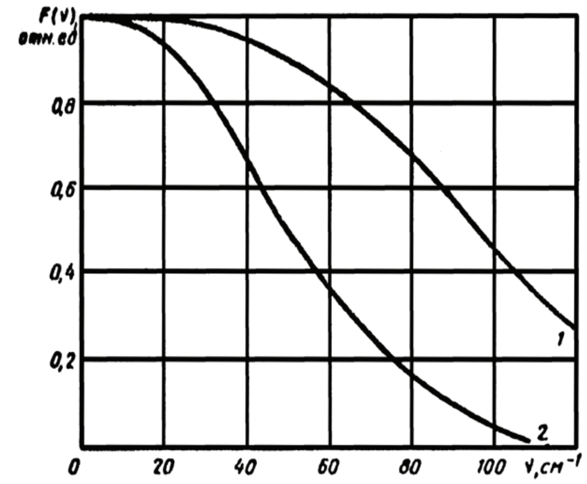
The analysis of autocorrelation functions showed that on it's look they are very close to exponents. In exceptional cases, in particular for a paper for a technical document, in the power spectrum obvious resonance lances and descriptions appeared. Thus, experimental researches showed that variations of optical closeness on the equal printing imprints (chaser die) fields can be well enough described as a two spaced process or, that is exactly the same, as normal noise, which got through an inertia link. In a statistical content the characteristics of variations of optical chaser die closeness are analogical to the proper descriptions of a semitone image in EDRI. It is possible to assume (it will be shown bellow) that a printing process on the frequency descriptions is analogical the filter of lower frequencies. The basic parameter of this filter (effective strip of admission or interval of auto correlation) depends on a method (high) and terms of seal (pressure, thickness of colourful layer and other) and properties of printing paper for a technical document. As it was foreseen before, auto correlation (frequency) descriptions of printing imprints (chaser die) influence on a observer's subjective estimation of a seal heterogeneity parameter.

By analogy with a semitone image, it would seem, it costs to analyse passing in the printing process of test-object cosinity and to get frequency contrasting description. For printing processes it is impracticable, because all basic methods except of phototyped can not realize a direct semitone image transfer. That is why the attempt of indirect determination of peak frequency description of raster printing process was begun. As an analogue of cosine signal, the peak of the first accordion of radial micro stroke measure, which has porosity 0,5, was measured.

Noise in experiments identified with the effective value of fluctuation of peak of the first accordion of radial measure signal. For comparison experimental information for the processes of the high printing on the high-quality chalky paper are given on (pic. 2). Information about noise for the case of the high-quality high printing is presented (pic.3), since it was within the limits of error of measuring and it was taken by us conditionally as equal to one relative unit in all of range of the probed frequencies. In the case of analysis of noises in a newspaper high printing it was made clear, that noises are enough considerable. Even in law frequency part of spectrum their specific weight makes 10-14% of the quantity of basic signal.



Pic. 2. Dependence of signal/noise to frequency for the processes of high printing on the chalky (1), natural vanished #1(2) and on the #2 (3) grades of paper and paper for newspaper printing (4).



Pic.3. Comparison of frequency characteristics of processes of offset (1) and high printing (2) one kind of paper (by a facility mechanism #1 for high printing).

The choice of extreme cases (high-quality and newspaper paper) for making of high-quality technical document was done intentionally in an experiment for inclusion providing of all realized possibilities of high printing, which are shown in table1.

Table 1

Description of high printing processesnon the different types of paper

Paper name for producing document	Ratio of the signal/noise in the range 0–20 , cm	Effective strip of frequencies (on tyhe level *0,7*) Y_{ef}, cm	Maximum process frequency cm	Specific information capacity V_{pr}. un./ cm^2
Chalky	45	60	125	$15\cdot10^4$
Vanished #1 for high printing	16–20	50	125	$8{,}4\cdot10^4$
Vanished #2 for high printing	13–18	35	110	$4{,}5\cdot10^4$
Newspaper	6–10	30	100	$2{,}2\cdot10^4$

Conclusions and prospects of subsequent researches in scientific subdirection of images treatment consist in that first untraditional approach is offered, which will help to solve problems using creation of theory modern elements . It allows to do more exact calculations at constructing of the systems and complexes, and also at using of maximum possibilities of EDRI, for the increase of quality of technical document. Offered new theory refreshes by fundamental researches and by calculation information which was used in work, for confirmation of the got results in the design process.

In a conclusion it should be noted that all these experimental results were got during work on LFA or on a device „FAKEL" with the use of the same paints, that provided their comparableness. Naturally, that in the real printing processes on aviation indicated above quantities can endure considerable changes depending on the concrete modes of seal, type of printing equipment, parameters of printing-ink and paper for a technical document.

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Sitnik A.G. (National Aviation University, Ukraine)
Sitnianskikh L.M. (National Aviation University, Ukraine)

INFLUENTIAL DEVELOPMENT PRINCIPLES AND CHARACTERISTICS OF THE CONTROLLERS ON THE INFORMATION VISUALIZATION SYSTEMS IN COCKPIT OF THE PLANE IN ORDER TO INCREASE THE LEVEL OF FLIGHT SAFETY

To connect the devices and equipments in to the onboard computer (БПЭВМ), its necessary to have the appropriate developed high-quality controllers, which has been adapted with these requirements.

It is known from the literature [1], what important technical functions carry out during the process of visualization, used in practice, of the analysis and synthesis of the images and its introduction in processes of the information. All basic ideas and the rules, which define the initial positions of information theory of visualization systems functioning of the civil aircraft (CA), determine actions of the developers, which arm with their necessary common theorem by an arsenal.

The purpose of research. consideration in a complex influence of principles of development and characteristics of the controllers on visualization system of the information in a cabin of the plane to increase the level of safety of flights.

The base of the task consists of a general view and its connection with the important scientific tasks in research of a way of the decision of an interrelation problem, interdependence and influence of principles of development and characteristics of the controllers on the information visualization system in a cabin of the plane to increase the level of flight safeties.

The basic part Is offered to use in model of the controller some modern sights for an estimation of results of experiments, for example, for the characteristic of a information effectiveness of visualization system on the basis of new development principles of of the controllers.. Necessary given for the description L (|s |) it turn out or experimentally, or with attraction of the appropriate mathematical models. In particular, for strongly disseminating optical of thick layers .

$$L(|s|) = \frac{1}{\pi}\frac{\ln 10}{k}10^{-2|s|/k}, \qquad (1)$$

where k - parameter which determines erode(degradation), caused dispersion of light large extreme.

Let the dot source gets the process, but it can be (pixel) or bitmap element, which is in a point $x = 0, y=0$ and which intensity is equal J. Then $f(x, y)=J\delta(x, y)$. Using results (1) and , that $x_o = 0, y_o = 0$, , we find mathematical expression of researched process .

$$R(s,\varphi) = J\delta(s). \qquad (2)$$

From (2) follows, that the source during processing draws on the carrier a line s = 0. Really owing to obligatory dispersion of radiation in a material substance of the carrier not an ideal line will be registered, and some distributed mathematical image, which, is described by function L (|s |). It means, that instead of (2) we shall have really

$$R_и(s,\varphi) = JL(|s|) \qquad (3)$$

Properties of a material of the information carrier results that the function (2) is only average value of some stochastic function (3). Then, if õ - factor describing sensitivity of a material, for an average of distortions in structure of the carrier we have

$$\overline{n} = \chi \int_0^{\pi} d\varphi \int_{-a}^{a} R_u(s,\varphi)\, ds . \qquad (4)$$

<u>The offered solutions of problem</u> . Let's make the assumption that the size of area of the processed information on the carrier and is much more than parameter, determining width of function. Then the limits of integration on s can be put equal to infinity, and we get

$$\overline{x} = \chi\pi \quad J \tag{5}$$

from comparing (4) and (5), we see, what at the made assumptions? χ $R_и$ *(s,φ)* is equal $J_c(s,\varphi)$ and consequently under the formula we find

$$\overline{f_B(x,y)} = \frac{x}{\pi}\int_0^{\pi} d\varphi \int_{-a}^{a} R_u(s,\varphi) q_\alpha (x\cos\varphi + y\sin\varphi - s) ds \tag{6}$$

Let's substitute (4) and (5) in (6) and find the integration. Then

$$\overline{f_B(x,y)} = \chi J 2\pi \int_0^{\infty} d\omega \int_{-a}^{a} \omega W_\alpha(|\omega|) L|s| \exp(-i2\pi\omega s) J_0(2\pi\omega\sqrt{x^2+y^2}) ds \tag{7}$$

then condidering $k\langle\langle a$ the (7) limits of integration on *s*-equal to infinity and entering $L_Ф(\omega)$A spectrum of function degradation of a line on the carrier of the information, we have

$$\overline{f_B(x,y)} = 2\overline{n}\int_0^{\infty} \omega W_\alpha(|\omega|) L_\phi(\omega) J_0(2\pi\omega\sqrt{x^2+y^2}) d\omega \tag{8}$$

The personal contribution of the authors consists in disclosing essence of processing the images in the controller. The equality (10) and (11) allow to compare among themselves importance of parameters regulations α And degradation *k* from the point of view of their influence on width of the processed dot image. So, if $d_k \rangle\rangle\, d_\alpha$, for degradation of the processed dot image the phenomenon "degradation", available on a material of the carrier of the information is responsible(crucial), at a return inequality - the presence the phenomenon degradation is responsible(crucial). As the procedure of processing of the images is during modeling principles of development of the controller linear, that, having considered dot object, we have received the simultaneously necessary information on pulse reaction of all visual information processing system . Therefore preliminary conclusion about relative influence of function degradation and regulation of function on quality of processing of the images in the controller in an equal measure concerns both to a dot source, and to object of the any form as pixels of a various configuration, or screen of elements depending on researched process of processing and model of the controller.

For definiteness we shall assume, that they are in points {x=Xo, *y=0), {x=*x_0*, y=0}* and have identical intensity 7/2. Then, we have

$$R(s,\varphi) = \frac{J}{2}[\delta(s + x_0\cos\varphi) + \delta(s - x_0\cos\varphi)] \tag{12}$$

Owing to degradation, drawing, accompanying process, of the information on the carrier, factor releasing in experiment will be described on the average by function

$$R_u(s,\varphi) = \frac{J}{2}[L(|s + x_0\cos\varphi|) + L(|s - x_0\cos\varphi|)] \tag{13}$$

Because of non-uniformity of a carrier information covering of material and occurrence of distortions the concrete realization is set in (13). to find the average value of processable function it is necessary to make it with the help of mathematical substitution and transformation, then we are convinced, that in this case

$$\overline{f_B(x,y)} = \frac{1}{2}\left|\overline{f_{B1}(x + x_0, y)}\right| + \left|\overline{f_{B1}(x - x_0, y)}\right|, \tag{14}$$

where $\overline{f_B(x,y)}$ - Is defined by expression from (13).

To account dispersive function in the processed image we use the formula (14). Let's substitute in it $J_c(s, ф) = \chi R_H(S, Ф)$, where $R_H(S, Ф)$ is set in view of process , and we shall take into account, that n_0=0, $\overline{\beta^2}$ =1. Then

$$\sigma_B^2(x,y) = \frac{\chi J}{2\pi^2}\int_0^{\pi} d\varphi \int_{-a}^{a} [L(|s + x_0\cos\varphi|) + L(|s - x_0\cos\varphi|)] q^2(x\cos\varphi + y\sin\varphi - s) ds \tag{15}$$

Analysis of resolution needs value σ_B^2 = (0, 0). considering, that X = 0, У=0, then we have

$$\sigma_B^2(0,0) = \frac{\chi J}{2}\int_0^{\pi} d\varphi \int_{-a}^{a} ds \int_{-\infty}^{\infty} d\omega_1 \int_{-\infty}^{\infty} |\omega_1||\omega_2| W_\alpha(|\omega_1|) W_\alpha(|\omega_2|)[L(|s + x_0 \cos\varphi|) + \tag{16}$$
$$+ L(|s - x_0 \cos\varphi|)] \exp[-i2\pi(\omega_1 + \omega_2)s] d\omega_2$$

Considering similarly previous $a = \infty$, we see, that the integration of the sum of functions degradation on *s* results in function $2L_\Phi(\omega_1 + \omega_2)\cos[2\pi(\omega_1 + \omega_2)x_0 \cos\varphi]$. The subsequent integration от φ Gives:

$$\sigma_B^2(0,0) = \int_{-\infty}^{\infty} d\omega_1 \int_{-\infty}^{\infty} d\omega_2 |\omega_1||\omega_2| W_\alpha(|\omega_1|) W_\alpha(|\omega_2|)[L_\Phi(\omega_1 + \omega_2) J_0[2\pi x_0(\omega_1 + \omega_2)] \tag{17}$$

where $\bar{n}$ Is defined in (17).

The received results of researches. The gotten expressions allow to concretize (17) and to take into account the requirements to the controller, which performance provides the order about $2x_0$. These inequalities have the form

$$\int_0^{\infty} \omega W_\alpha(|\omega|) L_\Phi(\omega)\{1 + J_0(4\pi x_0\omega) - 2{,}46 J_0(2\pi x_0\omega)\} d\omega > 0 \quad , \tag{18}$$

$$0{,}19 \int_0^{\infty} \omega W_\alpha(|\omega|) L_\Phi(\omega)[1 + J_0(4\pi x_0\omega)] d\omega >$$
$$\sqrt{\frac{\gamma}{\bar{n}} \int_{-\infty}^{\infty} d\omega_1 \int_{-\infty}^{\infty} |\omega_1||\omega_2| W_\alpha(|\omega_1|) W_\alpha(|\omega_2|) L_\Phi(\omega_1 + \omega_2) J_0[2\pi x_0(\omega_1 + \omega_2)] d\omega_2} \tag{19}$$

Let L (|s |) is defined for value $W_\alpha(|\omega|)$. Let's substitute these functions and make replacement variable $t = x_0\omega$ and set a condition, whatγ=1.

$$\int_0^{\infty} t \exp(-\frac{\alpha^2}{2x_0^2} t^2)[1 + (\frac{\pi}{\ln 10} \frac{k}{x_0})^2 t^2]^{-1}\{1 + J_0(4\pi t)] - 2{,}46 J_0(2\pi t)\}] dt > 0 \quad , \tag{20}$$

$$0{,}19 \int_0^{\infty} t[1 + (\frac{\pi}{\ln 10} \frac{k}{x_0})^2 t^2]^{-1} \exp(-\frac{\alpha^2}{2x_0^2} t^2)[1 + J_0(4\pi t)] dt >$$
$$\{\frac{1}{\pi \bar{n}} \int_{-\infty}^{\infty} dt_1 \int_{-\infty}^{\infty} |t_t||t_2| \exp(-\frac{\alpha^2}{2x_0^2}[t_1^2 + t_2^2])[[1 + (\frac{\pi}{\ln 10} \frac{k}{x_0})^2 (t_t + t_2)^2]^{-1} J_0[2\pi(t_t + t_2)]^{1/2} dt_2$$

Let's choose parameters *k* and *a* so that $d_K = d_a = d$. The performance of the given condition means, that the appropriate values of parameters *k* and *a* result in their equivalent influence on spread of the dot image. We find *k*=2*d*ln10, *α =2πd.*

Then at the analysis of process it is visible, that there is some boundary value d_o, such, that at the given relation d_o/x_o begins to be carried out an inequality (20) and (21). Analytically integral which is included in (21), does not undertake. its calculation which has been carried out on БПЭВМ during the result analysis of process modeling , gives the value $d_o/x_o \approx 0{,}52$. For this relation d/x_0— $d_0/x_0 = 0{,}52$ we find that minimal value $\bar{n} = \bar{n}_0$, for which begins to be carried out an inequality. The appropriate calculations on БПЭВМ of modeling results of process give $\bar{n}_0 \approx$ 350.

At the given value *Xo* for performance of a condition of experiment it is not necessary to require $d = d_K = d_a$. Let, for example, after the carried out count it appears, that is possible to choose such material of the carrier of the information, for which the value *dk* appears less found d_0. Then, having substituted value k, which corresponds given *dk*, we define new value *a*. Such situation is more favourable at the analysis of process, as to the greater value of parameter Regulater corresponds large noise immunity of processing algorithm of the images.

Conclusions. Thus, the application of the mathematical device of researches to the received results of experimental data of modeling process of the images allows to formulate the joint requirements of parameters a, k, to and intensity of information radiation by development of the controllers. It will allow to consider influence not only internal and external factors of influence on principles of development of the controllers, but also on their parameters and characteristics, and also their interaction with system of information visualization in the cabin of the plane to increase the level of flight safety . The researches can be similarly carried out in view of other characteristics of recording environment. It is offered to take into account effects connected to nonlinearity of the sensitive material characteristic of the information carrier: Whether it will be the display, panels of visualization, indicators or solid-state carriers for the engineering specifications, which also render influence through system of visualization on flight safeties.

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V. Apostolyuk, Ph.D. (National Aviation University, Ukraine)

EVOLUTIONARY OPTIMAL CONTROL

Evolutionary approach to the numerical solving of multi-dimensional procedural optimal control problems with respect to arbitrary representation of plant model and constraints is considered in this paper. New genetic algorithm with variable control programs length is proposed and its characteristics are investigated while solving the test problem.

Introduction. Simulated natural evolution being applied to the multi-parameter and multi-objective global optimisation problems have already resulted in a well established group of so-called evolutionary algorithms [1, 2]. At the same time, constantly increasing computational power of the microprocessors significantly widens areas of application for such algorithms. In recent years, genetic algorithms have been successfully applied to several control problems, such as non-linear model structural identification [3], system identification [4], and controller parameters optimization [5]. Apart from that, application of conventional genetic algorithms to predictive control with fixed prediction horizon (PH) has been in active development during the last decade [6, 7]. Conventional genetic algorithm being applied to the model prediction based direct control utilizes encoding of optimisation parameters into a fixed length binary representation, which naturally fixes the PH distance and results in fundamentally sub-optimal control functions. In addition to that, using fixed PH it is impossible to detect in advance the case of non-existing solution. In order to overcome the mentioned above problems, new variable length genetic algorithm (VLGA) is proposed and studied in this paper, which could be applied to the direct procedural control, thus delivering fundamentally optimal solutions. Such an application requires both proper control functions encoding and specially developed fitness functions formulations, which will successfully solve multi-objective optimisation of the procedural direct control.

Goals and motivations. Taking into considerations model and constraints complexity level, possible applications of the procedural optimal control approach can be represented in a form of a "bubble diagram" shown in the figure 1. The darker area in the diagram reflects higher efficiency of the approach in solving corresponding problems. One should also note that the classic control approaches as well as fuzzy logic don't deliver fundamentally optimal control in terms of a given criterion. The main goal of the research is to develop and study algorithms able to solve the optimal control problems with respect to the arbitrary complexity level of both process model and constraints representation, thus overcoming limitations of the conventional control methodologies.

At the same time, considering the exponential growth of the computational power of modern processors some novel and pure algorithmic approaches are reckoned to be feasible and highly efficient in solving the optimal control problems even under conditions of real-world applications. Such algorithms must apparently have certain features that would make them advantageous in comparison with the existing methods in system optimal control:

- The only requirement to the mathematical model is that it must be able to adequately predict the system state with respect to the given control functions. No special constraints in terms of its linearity or mathematical simplicity are required whatsoever.
- Control algorithms must be able to efficiently readjust to system parameters variations.
- More control functions are considered as admissible that could lead to more optimal results.
- Straightforward treatment of optimization criteria and control constraints that could be given in an arbitrary form.

The latter would also allow the control algorithm to explicitly solve the path-planning problem with respect to the plant dynamics and arbitrary obstacle configuration. There are two major groups of algorithms that could be used either separately or combined to solve the optimal control problems:

- States traversing techniques

- Evolutionary programming.

First group includes Dijkstra's algorithm [8] and A-star with all of its modifications [9-10]. The second one refers mainly to the genetic algorithms both with fixed and variable "chromosome" length [11]. The latter variable length genetic algorithm has several specific features that make it advantageous in solving optimal direct control problems.

Optimal control problem. Formulation of general optimal control problem is well known and here we shall give emphasis only to the aspects that are essential to the subject. Let the state of the system at time t be a vector $\vec{x}(t) = \{x_1(t),...,x_n(t)\}$ in an n-dimensional Euclidean space which we shall call the state space X. The steering device or control we model as an m-dimensional vector function of time $\vec{u}(t) = \{u_1(t),...,u_m(t)\}$. The components of $\vec{u}(t)$ are allowed to be piecewise continuous and the values they can take are bounded so that at any time t, $\vec{u}(t)$ lies in some bounded region U of the control space. Without loss of generality we impose the restriction $|u_i| \le 1$, $i = 1,...,m$. Such controls are deemed admissible in terms of the considered algorithms. We shall study systems whose behaviour can be modelled by the most general state transfer function F that calculates state of the system given its current state and control vectors:

$$\vec{x}(t + \Delta t) = F(\vec{x}(t), \vec{u}(t)). \tag{1}$$

Function F here is assumed to be defined for all $\vec{x} \in X$ and all admissible $\vec{u}$.

This approach to system representation significantly expands number of systems that could be successfully controlled compared to the conventional systems representation via systems of either ordinary or non-linear differential equations. We now wish to control the system from the initial state $\vec{x}(t_0)$ to the given final state $\vec{x}(t_1)$ while minimizing some cost function. This function could be also given in a form of a conventional cost functional

$$J(\vec{x}_0 \to \vec{x}_1) = \int_{t_0}^{t_1} f_0(\vec{x}(t), \vec{u}(t))dt. \tag{2}$$

We are, of course, assuming that there are admissible controls that transfer the system from $\vec{x}(t_0)$ to $\vec{x}(t_1)$ and we are looking amongst this subset of admissible controls for a control that minimizes cost function J. Although the cost function (2) is given in a conventional form of a functional, it is not required by the nature of control algorithms under consideration. In fact, any cost function perfectly suits the most of the algorithms.

System transition in state-space. Let us assume that every component of the control vector $\vec{u}(t) = \{u_1(t),...,u_m(t)\}$ can take a value only from the given set of constant values:

$$\vec{u}^0 = \{u_1^0,...,u_p^0\}. \tag{3}$$

In this case control vector $\vec{u}(t)$ has $s = m^p$ different possible constant values $\vec{u}(t) \in \vec{u}_1^0,...,\vec{u}_s^0$. Application of the piecewise constant control $\vec{u}_i = \vec{u}(t_i)$ to the system at the current state $\vec{x}_i = \vec{x}(t_i)$ can result therefore in s new states at the every subsequent instant of time $t_{i+1} = t_i + \Delta t$. In terms of the optimal control problem formulated earlier, we are searching for the finite sequence of v control inputs $\vec{u}_i(t)$ that transfers the system from its initial state $\vec{x}_0$ to the goal state $\vec{x}_g$. Each of the control $\vec{u}_i$ is assumed to be acting on the system and remained constant within the time interval Δt. Such a limitation causes the found solution to be a sub-optimal rather than optimal, to which it tends when $\Delta t \to 0$.

Control function encoding. There are many forms of solution representation that could be successfully used control algorithms. The simplest one is an array, where each component is an integer index of a particular component of the control values vector $\vec{u}^0 = \{u_1^0,...,u_p^0\}$:

$$B = \{b_1,\ldots,b_v\}, \ b_i \in [1,\ldots,p], \tag{4}$$

where p is the number of possible values for the control, v is the number of subsequent constant control inputs to the system. Here and after this controls array is referred to as *control program*, since each component of the array (4) can be considered as an instruction from the given instruction set (3). For the multidimensional control (m>1), instructions for every component of the control vector $\vec{u}(t) = \{u_1(t),...,u_m(t)\}$ are taken from the program (4) consecutively. If the number v is not a multiplier of m, some predefined default instruction is used. In case of the control program (4), the system is subjected to the piecewise constant control input completely defined by application of a control program

$$u_i(k \cdot \Delta t) = u^0_{b_k}, \quad k \in [1, \ldots, v], \tag{5}$$

during the period of time $v \cdot \Delta t$. One should note that the piecewise constant control (5) is the simplest but not the only possible interpretation of a control program instructions. Both higher order function approximation and Boolean controls can be successfully parameterised using the integer values from the array (4) as well.

Algorithms operation. In a sense, the algorithmic optimal control is the form of a model predictive control, since it uses the model of a process or a plant to predict the effect of the suggested control function. Generalised schematic representation of the algorithms operation as a part of the control system is shown in the figure 2.

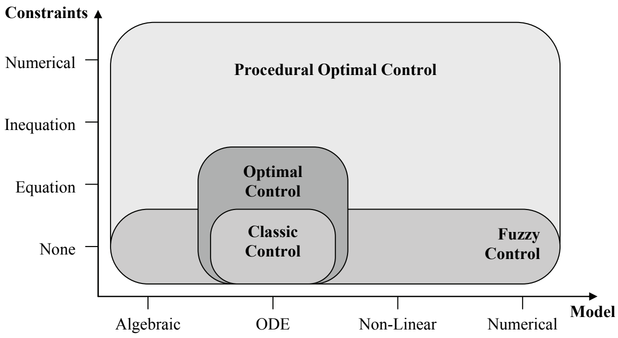


Fig. 1. Procedural control fields of application

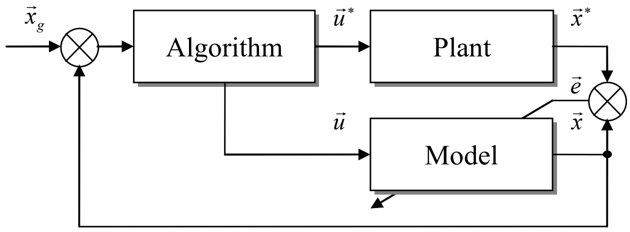


Fig. 2. Algorithms operation scheme

Here $\vec{x}_g$ is the goal state of the plant, $\vec{x}$ is the state, which is predicted by the model, $\vec{x}^*$ is the actually measured stated of the plant, $\vec{u}$ and $\vec{u}^*$ are the suggested and the best found controls respectively. System representation error $\vec{e}$ is used to adjust the model accordingly. The algorithm heavily uses the model to predict the plant state while searching for the acceptable control that would transfer it to the desired goal state $\vec{x}_g$. As soon as an acceptable control function is found, it is used to control the plant, while adjusting the model parameters comparing the predicted and its actual state. For some algorithms the searching process can continue and would most probably result in improved control function, which could be then used instead of the one found earlier.

There are three clearly distinctive modes for the algorithms operation as follows:

- Search for the control function (off-line operation, no control applied to the system).
- Application the control function to the system (on-line operation, system is under control, model is verified, control function is improving).
- Readjustments of the control function if the operation results are not acceptable.

Control function readjustment could be required due to the different reasons, including system parameters variations detected in the second mode, when the model verification is performed. For some control algorithms, as well as for others in some extreme cases, readjustment means that the search process for the acceptable control function must be started again with no acceptable control function available. As a result, the algorithm goes back into the first mode instead of the third one, which is supposedly more efficient in terms of solution time and required computational power. One should also note that it is not necessary to use the same algorithm in all modes of operation. Proper combination of different algorithms will deliver better results since it allows using the most appropriate algorithm for the task.

Evolutionary control algorithms. Evolutionary algorithms are widely used to solve multi-parametric and multi-objective optimisation problems. In conventional evolutionary algorithms, which also could be referred to as genetic algorithms, the search process is stopped as soon as the acceptable solution is found. However, in order to implement the ongoing optimal control for a dynamic system, the searching process should not be interrupted while the best acceptable solution is taken to be applied to the system. Such a modification is represented by a flowchart in the figure 3. In a sense, the evolutionary control algorithm above has no explicit ending. However, it is terminated as soon as the system has been successfully transferred to the goal state. Reaching the goal is checked all the time no matter whether the better control has been found or not (it is reflected in the figure 3 by the dotted line). Generating of controls requires additional adjustment of all of the controls in the current set with respect to the updated time of the system, which is referred to as time trimming. Although the "evolutionary" nature of the algorithms is not obvious from the flowcharts above, it becomes apparent when all of the stages are given in greater details. Let us now study in greater details major blocks that form the evolutionary algorithm with respect to its control application. During the initialization stage, predefined number N of control programs in the form (4) is generated randomly. This initial set can be either evenly distributed across the search space ("uneducated search") or having higher density in vicinity of suggested solution ("educated search"). The latter could be efficiently used especially in the control readjustment mode. During the control programs evaluation stage, every program from the current set is decoded into a control function using the instruction set (3). This function is then evaluated in terms of its capability to solve the control problem (transfer the system to the goal state) with respect to the optimisation criteria and constraints. After evaluation, the acceptable control function could be selected and then used to control the system. Moreover, based on the results of the controls evaluation, every control program in the current set of programs is assigned a "fitness" value, which defines the probability for this program to be later used to produce the next generation of programs. With or without the acceptable control program found, the evolution of the control programs is continued, and new set of control programs is generated. The process of the new controls generating is shown as a flowchart in the figure 4. In order to generate new set of programs, two encoded control programs from the current set are selected randomly using the fitness defined probabilities (the higher fitness value, the higher probability for the program to be selected). After that, application of so called genetic operations results in a new control program, which is placed to the new set. This solution generation process is repeated until N new control programs are generated, and old set can be finally discarded.

Genetic operations. There are four genetic operations that can be applied to the selected functions: crossover, mutation, inversion, and length modification. The latter operation defines the difference between the conventional genetic algorithms and VLGA. During the crossover, for each of the two selected control programs B_1 and B_2 a random index $n \in (1, \min(v1, v2))$ is generated that splits the corresponding program into two sub-programs:

$$B_1 = \{b_{11}, \dots, b_{n-1}, b_n, \dots, b_{v1}\},$$
$$B_2 = \{b_{12}, \dots, b_{n-1}, b_n, \dots, b_{v2}\}.$$

After that, two new control programs are produced by exchanging the obtained earlier sub-programs:

$$B_1^* = \{b_{11}, \dots, b_{n1-1}\} \cup \{b_{n2}, \dots, b_{v2}\},$$
$$B_2^* = \{b_{12}, \dots, b_{n2-1}\} \cup \{b_{n1}, \dots, b_{v1}\}. \tag{6}$$

Finally, only one of the resulting control programs (6) is randomly selected for the further processing. Application of the mutation operation means increasing or decreasing randomly selected instruction within the selected control program:

$$B = \{b_1, \dots, b_n, \dots, b_v\} \to B^* = \{b_1, \dots, b_n \pm 1, \dots, b_v\}. \tag{7}$$

Needless to say, that the boundary condition $b_n \in [1, \dots, p]$ must be checked and corresponding adjustments must be applied if necessary. Next genetic operation, which is inversion, is applied with relatively small occurrence probability, and is used to provide necessary global optimum search capability for the algorithm.

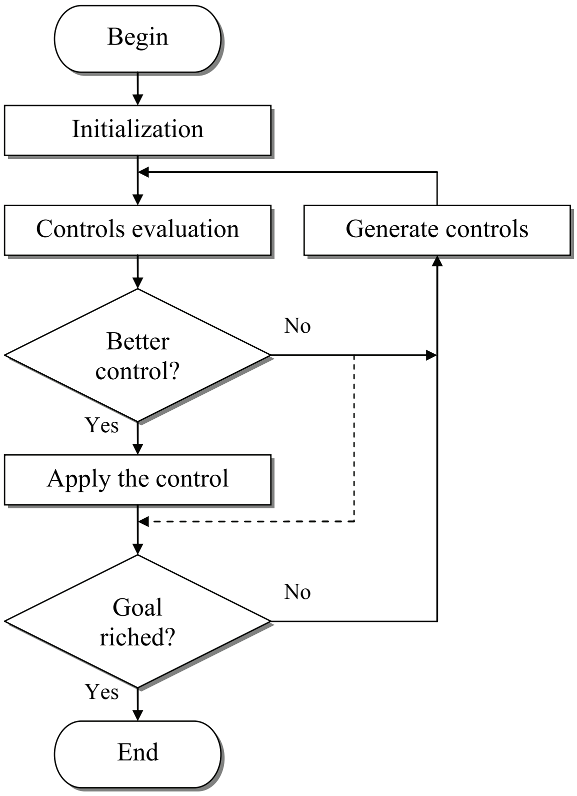


Fig. 3. Evolutionary control algorithm

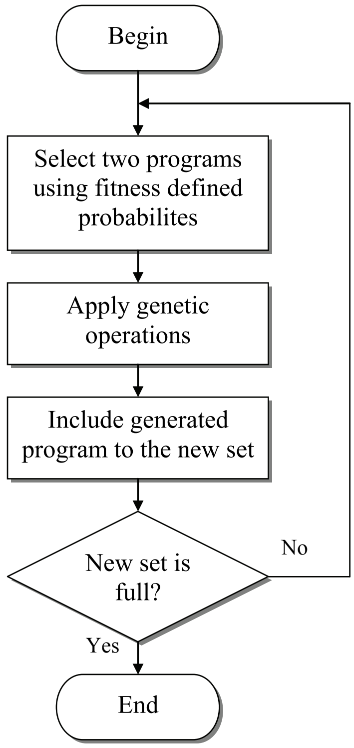


Fig. 4. New controls generating process

First random index is generated for the selected control program, thus dividing it into two sub-programs. After that, new control program is produced by exchanging the order of the sub-programs:

$$B = \{b_1, \ldots, b_{n-1}, b_n, \ldots, b_v\} \to B^* = \{b_n, \ldots, b_v, b_1, \ldots, b_{n-1}\}. \quad (8)$$

One should note that contrary to the crossover operation (6), mutation (7) and inversion (8) do not modify length of the subjected control program. Additional variation of the control program length is done by means of the modification operation

$$B = \{b_1, \ldots, b_v\} \to B^* = \{b_1, \ldots, b_{v*}\},\ v^* = v \pm n. \quad (9)$$

Here n is the number of instructions either added to or subtracted from the control program. In case of length increasing modification, added instructions are randomly selected from the instruction set. Each of the described above genetic operation is applied using its own application probability.

Fitness function. One of the problems related to the application of evolutionary algorithms to the procedural optimal control is a proper choice of the used fitness function. In a sense, finding the optimal control function requires solving a multi-objective optimisation problem. Successful fitness function must adequately represent not only control accuracy, based on which the acceptable control program can be identified, but the optimisation criterion and problem constraints as well. The simplest linear aggregation of the mentioned quantities is given by the following expression:

$$f(B) = w_C \cdot \{w_D \cdot D(\vec{x}_v, \vec{x}_g) + w_J \cdot J(\vec{x}_0 \to \vec{x}_v)\}. \quad (10)$$

Here w_C, w_D, and w_J are the weight coefficients for the constraints violation penalty, Euclidean distance in the state space between the final state $\vec{x}_v$ after control program execution and the goal state $\vec{x}_g$, and cost function correspondingly. In this case, fitness function is inversely proportional to the expression (10). One should note, that as soon as the successful program able to control the system to the desired state is found, which means $D(\vec{x}_v, \vec{x}_g) \to 0$, fitness value solely depends on the cost function (2). The latter provides smooth transition of the algorithm operation from the searching for any acceptable solution to the searching for the optimal one. In general, proper choice of the fitness function providing the best algorithm operation in terms of its accuracy and reliability is certainly subject for further research.

Algorithm testing. The benchmarking testing case is the control of a linear system that is defined by simple ordinary differential equations

$$\frac{d}{dt}\begin{bmatrix} X \\ V \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -0.5 \end{bmatrix} \cdot \begin{bmatrix} X \\ V \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} \cdot U, \tag{11}$$

from the state $\vec{x}_0 = \{1,1\}$ to the state $\vec{x}_g = \{0,0\}$ with respect to either minimal time or shortest trajectory in the state-space. Although the system (11) is simple and linear, it will be presented to the algorithm as a purely numerical model. The system (11) will be controlled with and without presence of constraints. Constraints are given by the following system of inequations, defined in the state space:

$$\begin{cases} (X-1.5)^2 + (V-0.5)^2 > 0.625, \\ (X-1)^2 + (V+0.25)^2 > 0.625. \end{cases} \tag{12}$$

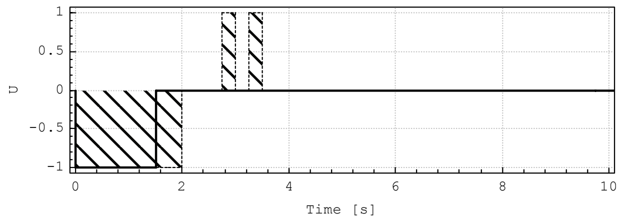
The controls are allowed to have only three admissible values $\vec{u}^0 = \{-1,0,1\}$, and the control time step is $\Delta t = 0.25$ s. Algorithm performance is suggested to be evaluated in terms of *sims*. One "sims" corresponds to a single estimation (prediction) of the system state after time Δt.

The following parameters were used for the algorithm: number of programs in the generation N = 100, initial program length $v_0 = 16$, mutation probability – 0.1, crossover probability – 0.9, modification probability – 0.1, and inversion has been disabled. Simulations results are given in the table 1 and shown in the figures from 5 to 8. In the figures 7-10 the dashed line corresponds to the first found acceptable solution and the solid line corresponds to the best found optimal solution. Transitional states are shown by means of black and white circles for the acceptable and optimal solutions correspondingly.

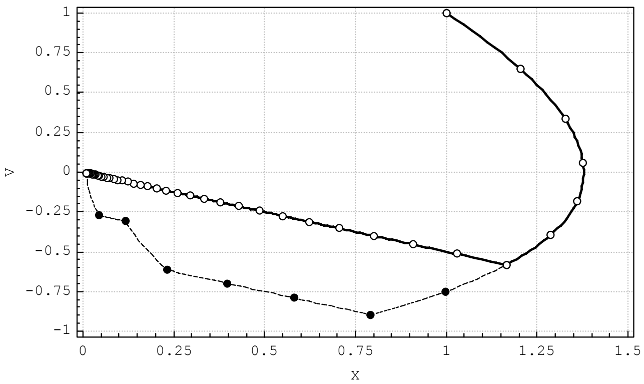
Parallelisation of the algorithm. Analysing the shown above results one should note that finding the optimal solution to the given problem using VLGA may require significant amount of simulations to be done, which results in increased solution finding time. On the other hand, real-time applications of the algorithm require the solution to be found as soon as possible. One of the approaches to this problem is to use parallelisation during the "controls evaluation" stage . In this case, every control program B_i (9) from the set of N programs is evaluated at the separate processing unit PU$_i$, which performs system simulation with respect to the given control function and calculates quality function (10). The best performance is achieved when number of PUs equals to the number of the control programs N. Using this kind of parallelisation, evaluation time of the whole set of programs equals the time of the longest program evaluation. At the same time, by increasing the number N of the control programs and corresponding PUs, the solution could be found within smaller number of iterations, while keeping the evaluation time constant.

Conclusions. From the presented in this paper results, one can see that the variable length genetic algorithm is perfectly capable of solving the procedural optimal control problem even for the numerically defined system model and constraints. At the same time, sub-optimal but acceptable control solution could be also found prior to the optimal one after significantly less number of iterations.

Although the algorithm allows its parallelisation, the following approaches to its improvement in terms of performance and quality of the obtained solution are yet to be investigated: other forms of multi-objective fitness functions, fitness weight coefficients optimisation, adaptive time step, and so on. Algorithm readjustment performances in case of varying system parameters and stochastic disturbances must be properly studied as well.

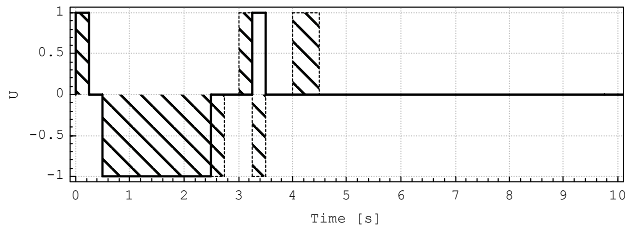


a) Control functions

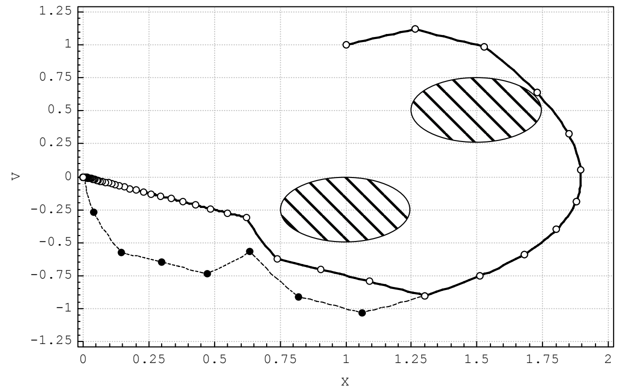


b) State-space trajectories

Fig. 5. Unconstrained minimizing trajectory length

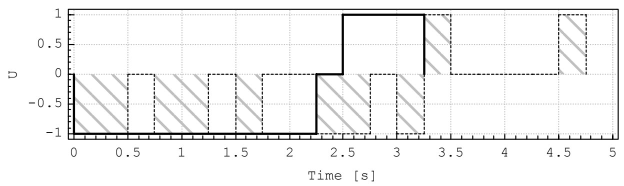


a) Control functions

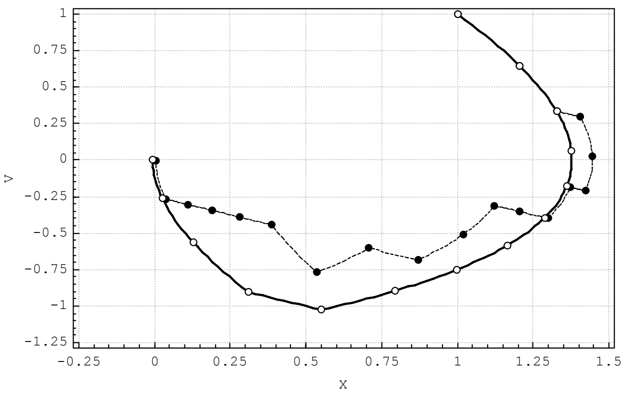


b) State-space trajectories

Fig. 6. Constrained minimizing trajectory length

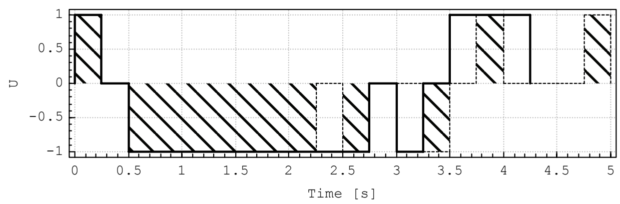


a) Control functions

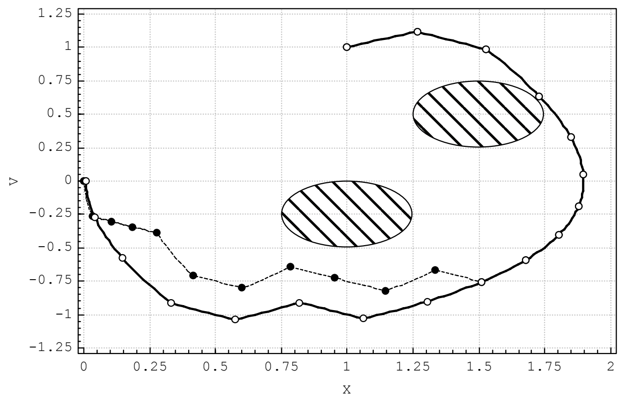


b) State-space trajectories

Fig. 7. Unconstrained control minimizing time



a) Control functions



b) State-space trajectories

Fig. 8. Constrained control minimizing time

Table 1

Algorithm performances

Problem and type of solution	**Iterations**	**Sims**	**Cost**
Minimal trajectory length			
Unconstrained acceptable	14	24 198	3.51
Unconstrained optimal	510	1 202 969	3.01
Constrained acceptable	99	141 693	4.90
Constrained optimal	8741	21 464 704	4.43
Minimal time			
Unconstrained acceptable	14	25 337	4.75
Unconstrained optimal	110	181 347	3.25
Constrained acceptable	223	305 420	5.00
Constrained optimal	3711	5 269 306	4.25

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Zemlyanskyi V.M. (National Aviation University, Ukraine)
Chudesov O.P. (National Aviation University, Ukraine)

PHASE FILTER SYNTHESIS FOR COHERENTLY OPTICAL TRANSFORMER

In general case for a differential COT block diagram [1], in which reception of dissipated radiation carried out in some arbitrary direction in the limited domain of reception, which is Doppler signal phase constituent signal on output of photo-receiver is determined by the effects of dispersion, depends on parameters of particles $q = \frac{\pi d}{\lambda}$ and *m* (*d* is a diameter of a particle, λ - is a wave-length, *m* - refraction index) also parameters of optical block diagram: angle between γ bunches, direction of reception, size and form of receiving aperture, and also from the polarizations state of probe bunches.

For a differential block diagram of COT two types of symmetric reception are specific, which are forming phase conjugate Doppler signals formation [1, 2]. A block diagram of COT corresponds to the first type of symmetric reception, whereas for two directions of reception which are symmetric to the plane of symmetry of OXZ block diagram (Fig.1 in [2]) Doppler signals are phase conjugate if the probe bunches have the following polarizations: a) line-matched with direction of electric vectors which are perpendicular to the planes of bunches (OYZ); b) linear polarizations with direction of electric vectors in the plane of bunches; c) one bunch has right-circulation (left-circulation) and other left-circulation (right-circulation) polarizations respectively; d) linear polarizations which are equal by the module, but opposite by azimuths. A block diagram corresponds to the second type of symmetric reception COT, in which elliptic polarizations have bunches with identical azimuths and ellipse, including a circle and linear ones. In this case the phase conjugated Doppler signals are formed during radiation received in two directions which are non-central in relation to the optical axis of COT block diagram (OZ axis, see the Fig.1 in [2]).

Let the COT will be realized by the first type of symmetric reception (Fig.1). We will designate complex amplitude of Doppler signal, which is formed on the output of photo-receiver radiation perception within the limits of some spatial domain of A1 (by the part of circular ring limited for example, see Fig.1a) using $J_{A1} = J_1 e^{-i\Phi d}{}_1$ where Φ_{d1} is a phase of Doppler signal, determined by the effects of dispersion, the value of which is in limits of

$-\frac{\pi}{2} < \Phi_{d1} < \frac{\pi}{2}$ (the phase of signal is determined by the moment of particle introduction time in the estimation domain $\Phi=0$). Thus Doppler signal which is formed by radiation perception within the limits of some spatial domain of A_1 (by the part of circular ring limited within the limits of domain of $Б_1$ of equal to the size domain of A_1 and located symmetrically to OXZ planes of symmetry, it is possible to note [2] $J_{Б1} = J_1 e^{-i\Phi d}{}_1$. A total Doppler signal, which is formed by radiation perception over the domains A_1 and $Б_1$ and is equal to

$i_1 = 2J_1 cos\Phi_{d1} cosw_d t$, i.e. has a phase equal to zero $\Phi=0$. It is possible to select two identical domains of A_2 and $Б_2$, located symmetrically (Fig.1a), for which $J_{A2} = J_2 e^{-i\Phi d}{}_2$ and $J_{Б2} = J_2 e^{-i\Phi d}{}_2$ also phases of these Doppler signals are in limits of $\frac{\pi}{2} < \Phi_{d2} < \frac{3\pi}{2}$. In this case Doppler signal A_2 and $Б_2$ domains is equal to $i_2 = -2|J_2 \cos\Phi_{d2}| \cos w_d t$ and situated in counter phase in relation to the i_1 signal from the A_1 and $Б_1$ domains. If the radiation will be perceived simultaneously over the domains of A_1, $Б_1$, A_2 and $Б_2$ (Fig.1) then

$$i_{12} = i_1 + i_2 = 2(J_1 \cos\Phi_{d1} - |J_2 \cos\Phi_{d2}|) \cos w_d t$$

and phase of this signal can accept only two values:

$\Phi_d = 0$ if $J_1\cos\Phi_{d1} > |J_2\cos\Phi_{d2}|$ and $\Phi_d = 180^\circ$ if $|J_2\cos\Phi_{d2}| > J_1\cos\Phi_{d1}$..

If correlation $\frac{J_1}{J_2} = \frac{|\cos \Phi d_2|}{\cos \Phi d_1}$ is done then Doppler's signal components are observed, $i_1 = -i_2$. An analogical situation can be observed during realization of the second type of symmetric reception (Fig.1b) of the dissipated radiation within the limits of some spatial domains of $A_1 - D_1$ and $Б_1$- C_1.

Let us consider dependence of Doppler phase signal dependence on change of angular receiving aperture. Let, for example, in COT bunches are utilized on a wave-length I = 0,488 mkm, having powers equal to P = 50 Wt and linear coordinated polarizations are intersect in a measuring volume in angle γ = 11,25°, through which the stream of water moves with the particles of polystyrene with the diameter of d_r = 3,1 mkm. In addition, in KOT block diagram the first type of symmetric reception of the radiation dissipated back is carried out and the center of round receiving diaphragm coincides with the axis of block diagram.

The analysis of results of numeral experiments shows that phase of signal $\Phi_d = f_7(\alpha)$, (see Fig.2) is equal to Φ_d = 180°, if angular aperture is 3,5° < α < 9°, and at other values of apertures $\Phi_d = 0$. With respect to dependence of phase of elementary constituent of Doppler signal, which is formed by receiving of dissipated radiation within the limits of ring-shaped form opening of small thickness from observation direction $\Phi_{di} = f_8(\alpha_i)$ so that phase suffers leaps on 180° (fig.2). At α_i corresponds to a maximum of Doppler signal (fig.3), for example, α_i = 2,25°; 6,5°; 11,5° and 16° or to a minimum of signal if at this value α_i there is no phase leaps Φ_d on 180°, for example, if α_i= 12,25°. Such change of dependence of $\Phi_d = f_7(\alpha)$ and $\Phi_{di} = f_8(\alpha_i)$ could be explained on the basis of phase spatial symmetries of Doppler signal properties [1]. First leap phase of Φ_{di} on 180° at α_i = 2,25° is explained by means of Φ_{dAi} growth phase of signal Φ_{dAi}, which is formed by a radiation reception on the right half plane of OXZ (A domain) is increased also, but situated in limits of $\frac{\pi}{2} < \Phi_{dAi} < \frac{\pi}{2}$, and by values of 2,25° ≤ $\alpha_i \leq$ 6,5° phase of signal passes to the $\frac{\pi}{2} < \Phi_{dAi} < \frac{3\pi}{2}$ domain. Thus, constituent of Doppler signal i_1 from the reception of $0 < \alpha_i < 2{,}25°$ domain is in counter-phase with i_1 signal from the perception domain of $2{,}25° < \alpha_i < 6{,}5°$. Therefore, at α_i=3,5° a total Doppler signal tends to zero. In addition, at α_i=3,5° there is a phase leap of Φ_d on 180° could be explained that at $3{,}5° < \alpha_i < 9°$ amplitude of signal constituent with phase of Φ_d = 180° is more than the amplitude of signal constituent if with $\Phi_d = 0$.

The second phase leap of Φ_{di} on 180° at α_i= 6,5° is explained by the fact while increasing α_i, in 6,5°<α< 11,5° domain phase of signal from the domain of reception A is in limits of- $\frac{\pi}{2} < \Phi_{dAi} < \frac{\pi}{2}$. It is also depicted on amplitude measurements specification and phase of Doppler signal Φ_d (Fig.2 and 3). In estimation domain 3,5° ≤ $\alpha_i \leq 6{,}5°$ signal raises as the phase of signal in the given domain remains constant Φ_{di} = 180°. As long as α_i is increased to 9° the signal tends to minimum while decreasing (coefficient of phase harmonization [1] if α_i = 9° is equal to K_Φ = 0,006) because α_i = 9° the signal component i_1 in perception domain 0 ≤ $\alpha_i \leq 2{,}25°$ and 6,5° ≤ $\alpha_i \leq 9°$ nearly compensate signal component i_2 from the reception domain 2,25° ≤ $\alpha_i \leq 6{,}5°$. Similarly future phase leaps Φ_{di} could be explained and signal variation while α_i increases.

On the basis of the executed theoretical researches the complex of the application programs of synthesis of phase antiphase symmetric spatial filters (ASSF) is designed for COT differential block diagram by means of the first or second type of symmetric reception at the different states of polarization of two probe bunches. Some results of phase ASSF synthesis for double channel COT block diagram at different view between probes bunches are presented in Fig. 4.

In a double channel COT block diagram on the way of the dissipated bunches before the second and first photo-receivers according phase ASSF 1 and ASSF2 are installed (fig.4). At the serve of output photo-receivers signals on a differential amplifier, on the output effective high-frequency signal is formed on Doppler frequency (for the block diagram of LDA), or on frequency of double frequency interferometer (for the block diagram of coherently-optical meter of micromarticles (COMM)). In the first and in the second cases the use of phase ASSF is provided by achieving signal/noise relation on the output of coherently-optical sensor on an order and more in compare with already known block diagrams. It allows increasing measuring speed accuracy substantially by LDA, or size of microparticles by the coherent meter of microparticles sizes.

The block diagram of practical realization of phase optical filtration by ASSF1 and ASSF2 could be applied to the task of size and concentration measurements of spherical microparticles are represented in Fig.5. In this block diagram synthesized phase ASSF1 and ASSF2 (seeFig.4) provide optimum optical filtration of effective signals and, in addition, suppression of low-frequency disturbances on the output of amplifier *19*. A high-frequency effective signal enters to the particles size analyzer after filtration.

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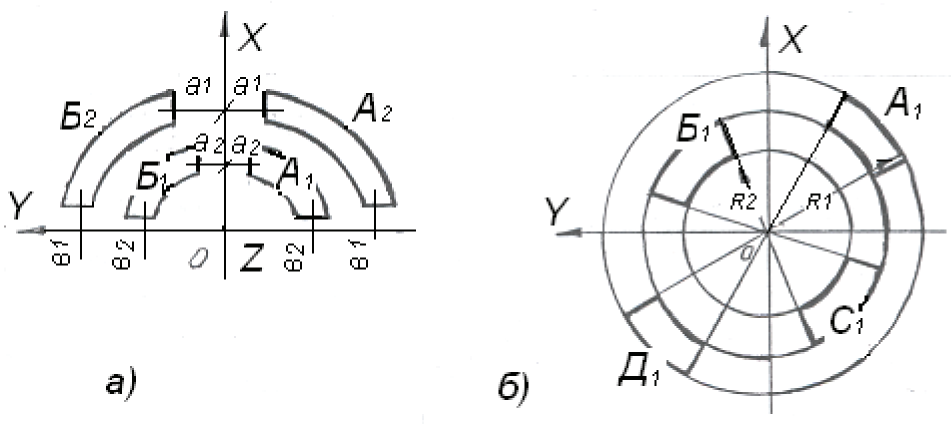


Fig.1. Types of symmetric reception of the dissipated radiation, which provides forming of the phase conjugated signals: a) the first type of symmetric reception relatively to OXZ; b)the second type of symmetric reception relatively to the OZ axis .

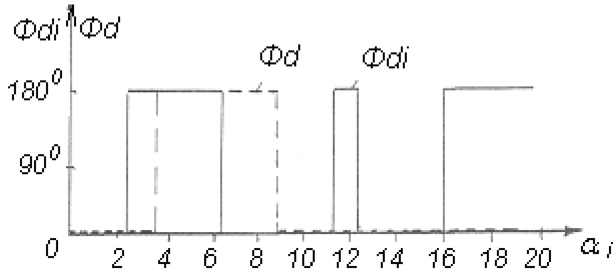


Fig.2. Dependence Doppler phase signal dependence with respect to the angular aperture $\Phi_d = f_7(\alpha)$ and perception direction $\Phi_{di} = f_8(\alpha_i)$.

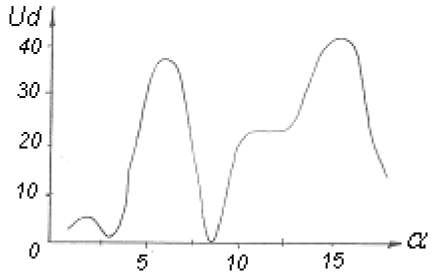


Fig.3. Dependence of amplitude of Doppler signal on an angular receiving aperture.

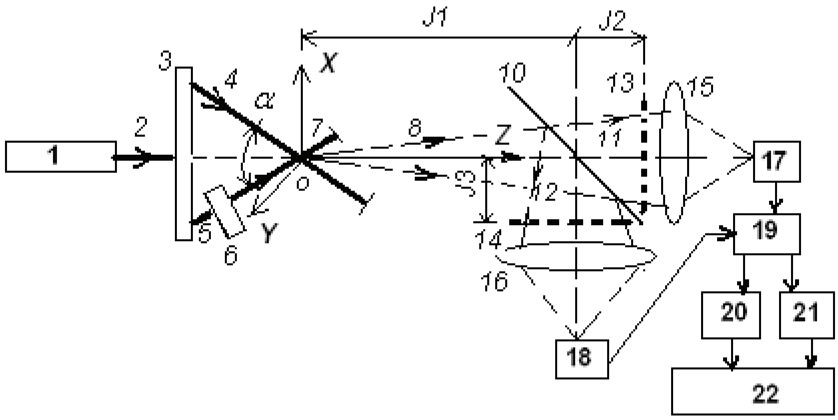
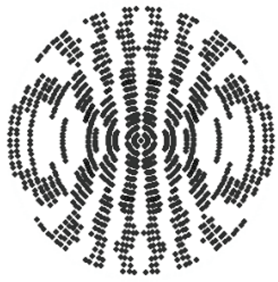
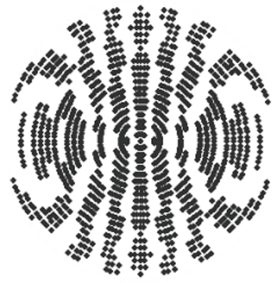


Fig.5. Bloch diagram COMM, which realizes the method of phase optical filtration

1-laser; *3*-replicator; *6*-phase shift device; *7*-zone of microparticle measurements ; 8- dissipation radiation; 10- beam splitter; *13*-ASSF1; *14*-ASSF2; *15*,16-lenses; *17*,*18*-photo-receivers; *19*-differential amplifier; *20*-high-frequency filter; *21*-low frequency filter; *22*-particles analyzer.





Angle between rays $\gamma = 20^\circ$

angle $\theta_0 = 170^\circ$

Angle between rays $\gamma = 20^\circ$,

angle $\theta_0 = 20^\circ$ and -40°

Angle between rays $\gamma = 90^\circ$,

angle $\theta_0 = -45^\circ$

Angle between rays $\gamma = 90^\circ$,

angle $\theta_0 = -225^\circ$

Fig.4. Results of optically coordinated phase filters' synthesis of ASSF for double channel reception block diagram of COT (diameter of particle d =2e-005m; wave-length radiation of laser λ =6.328e-007m; receiving aperture α = 5 ; linear coordinated polarizations).

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V.M. Zemlyanskii, d. of sci, prof. (National Aviation Universyty, Ukraine)

METHODS OF ANTIPHASE SYMMETRIC SPACE FILTRATION (ASSF) OF LASER DOPPLER ANEMOMETER (LDA)

The classification of the first developed methods of antiphase symmetric space filtration is given, principles of design and peculiarities of realization of these methods in the coherent-optical converters (COC) based on set properties of space symmetry of Doppler signal parameters and phase-polarized effects are considered, inherent to the differential scheme of laser Doppler anemometer (LDA) [1] in application to a variety of compensational LDA, used as either monodispersal or polydispersal fluxes light-propagated particles, examples of realization of LDA are given, implementing ASSF method.

Introduction and problem formulation. The action principle of antiphase symmetric space filtration (ASSF) is based on set properties of space symmetry of Doppler signal parameters under for different beams polarizations [1], and also on common laws of constituent phase of Doppler signal change, that is determined by spread effect depending on geometry of beams and parameters of differential LDA scheme, considered at [2].

Investigations show that for the given geometry of beams and parameters of particles, it is always possible to choose such polarization of that beams for which implementing one of types of symmetric reception and it is possible to mark two space regions of reception, for which the antiphase Doppler signals are observed [2]. This antiphase symmetric space filtration first of all gives the possibility in the case of antiphase signals summation to provide the cross noises reduction that occurs in multicomponent LDA. Secondly, it gives the possibility to obtain the maximum of Doppler signal and increase signal/noise ratio by means of phase agreement of these signals in case of transmitting it after high-frequency filtration into the device of subtraction. At third, for the case of antiphase Doppler signals and low-frequency component signals of photo receptors equality it gives the possibility to achieve the mode of low-frequency stand compensation, while subtracting these signals and the useful signal is rising simultaneously (thus providing the compensational mode of LDA work). Compensational LDA, that are based on balanced receive method [3], first were considered in works [4] and [5]. The disadvantage of considered there LDA is that they can efficiently work only while receiving the emission in the space domain, in limits of which the polarization agreement coefficient K_{nu} = 1. This essential limitation doesn't spread on LDA schemes, considered in this work.

ASSF method, depending on the type of symmetric reception could be divided into two groups: of symmetric reception of phase-conjugate signals and of symmetric reception of antiphase signals (see Fig.1)

The first group of ASSF method could be implemented in LDA, varying the fluxes speed while introducing the monodispersal particles. The distinctive feature of these methods is such a symmetric reception type usage, for which the phase-conjugate signals generation is observed.

For the differential LDA scheme two types of symmetric reception for different beams polarization are set up, in the case of which the formation of phase-conjugate Doppler signals is observed. To the first type of symmetric reception the LDA scheme is related, in which for two directions of reception, symmetrical relative to the plane, Doppler signals are phase-conjugate, if beams posses the next polarization states: a) linear agreed; b) linear, with direction of electrical vectors in the beams plane; c) one beam has left-circular (right-circular), while the other one has right-circular (left-circular) polarization; d) linear polarizations with equal by absolute value, but different by sign azimuths. To the second type of symmetrical reception the LDA scheme is corresponded, in which if the beams have either elliptic polarizations with equal azimuths and ellipticity, or left-circular (right-circular) polarizations, then phase-conjugated Doppler signals are formed during the reception of radiation in two directions, symmetrical relative to axis of LDA scheme.

It is shown that if in the measuring volume two beam couples of the same intensity are intersected with the same angle, and they are not coherent relative to each other and posses linear mutually orthogonal polarizations, rotated on the angle of 90 degrees between them, then the Doppler signal from one couple of beams, observed in some random direction, is phase-conjugated relative to Doppler signal of the other pair of beams, observed in the direction that is symmetrical to the first one relative to the plane passing trough the axis of scheme and oriented perpendicularly to the plane of beams.

The domain of application of the second ASSF group of methods is distributed on polydispersal particles. Implementation of these methods suppose the use of LDA beams with mutually orthogonal polarizations and realization depending on the type of beams geometry ($\gamma \le 1^\circ, \gamma >> 0$ and $\gamma = 180^\circ$, look Fig.1) of one of types of symmetrical reception, for which the formation of antiphase Doppler signals is observed. For the second group of methods the antiphase signals formation is not affected by the variations of LDA scheme or particles parameters, in other words – the transfer function configuration principle may be arbitrary, but with the obligatory satisfaction of corresponding condition of symmetry of reception for this type of LDA scheme.

For differential scheme of LDA with linear mutually orthogonal polarizations of probing beams it was set that for two directions of reception, symmetrical relative the plane of beams, Doppler signals, independently of beams intensity, are equal by their amplitude and are in the antiphase.

This gives the possibility to create two space conjugated transfer functions, the method of calculation of which depending on the particles size (Fig.1), or based on the theory of dispersion Mi (particles of small size) [1], or on the diffraction theory of Fraungofer (large particles) [6], or using two-wave LDA scheme to choose for the given size of particles such parameters of beams geometry and reception aperture, for which Doppler signals, created during reception of radiation on different wave lengths are in the antiphase. For the first group of methods the following case is typical: the configuration and size of transfer function, by means of which the antiphase filtration is carried out, depend on parameters of LDA scheme and particles.

Let it be required to provide the control of technological process of designing non-transparent in optical range spherical monodispersal particles of given size d_{r1} and speed of their movement.

In the Fig.2 one of LDA cases is represented, implementing the ASSF method. The beam *5* passes through the frequency shifting device *6.* The controlled particles are entered the measurement zone *11* with the help of particles generator *12*. The reflecting surface of mirror *15* is designed to be optically agreed with the defined above size of particles. To design such a mirror, the sample spherical particle of diameter d_{r1} is putted to the centre of measurement zone “o”. Rotating slightly the half-wave plate *8*, the combination of axis of symmetry of interference picture maximum with the particle centre is achieved. Then, in stead of mirror *15* the photo plate is set with the angle β relative to the OZ axis, on which the exposure of summed diffracted field of radiation is provided (large particle, small angle γ, see Fig.1). In the regions of photo plate, where maximums of interference picture resulted due to superposition of two diffracted fields of radiation are received, the mirror coverage is putted, and in the regions of plate, where minimums of interference picture were observed, the holes are designed. Created in such a way mirror *15* (or synthesized on computer) is set in strictly the same place, but with the angle β relative to the scheme axis OZ, where previously the photo plate was set.

Use of the mirror *15* is equivalent to the application of two optical agreed ASSF, set correspondingly before photoreceivers *22* and *23*.The offered LDA gives the possibility of high accuracy, sensitivity and noise immunity of appropriate control of designing the monodispersal spherical particles with the simultaneous measurement of their speed. In the LDA scheme noise compensation is provided. With the help of proposed LDA scheme the control of holes in non-transparent screen (of Fraungofer defraction) is also possible. Monodispersal spherical particles of different materials are widely used in radiotechnical, chemical, food and other types of production, while creating sample sizes of particles, and also for Metrologic attestation and calibration of various measurement devices by the principle of action and particles analyzers.

Conclusions. The classification of developed methods of antiphase symmetric filtration (ASSF), based on phase and polarization effects of spread, which depending on used in LDA type of symmetric reception are divided into two groups of methods: of symmetric reception of phase-conjugated signals and of symmetric reception of antiphase signals is proposed. The first group of ASSF methods, in the basis of which lies the use of one of types of symmetric reception, for which the formation of phase-conjugated signals is observed, and corresponding antiphase space filtration could be implemented in LDA with entering into the flux of monodispersal particles. The domain of application of the second ASSF methods group is spread on fluxes with polydispersal particles. Implementation of these methods in LDA supposes the usage of probe beams with mutually orthogonal polarizations and providing one of types of symmetric reception (depending on the beam geometry), for which the formation of antiphase Doppler signals is observed.

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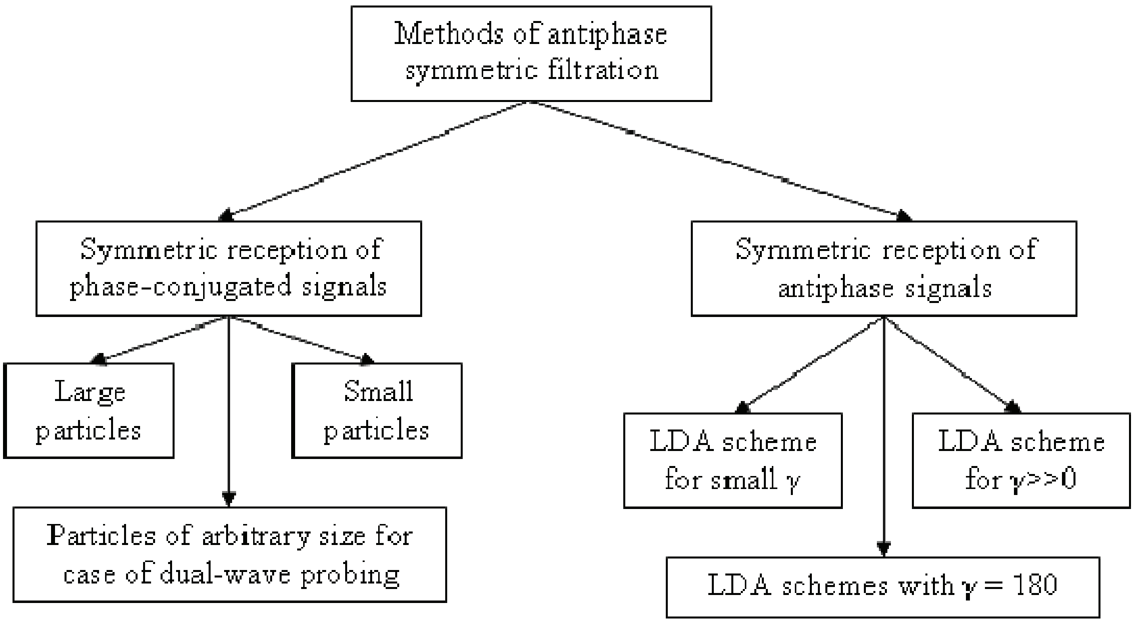

Fig.1 Classification of antiphase symmetric filtration methods.

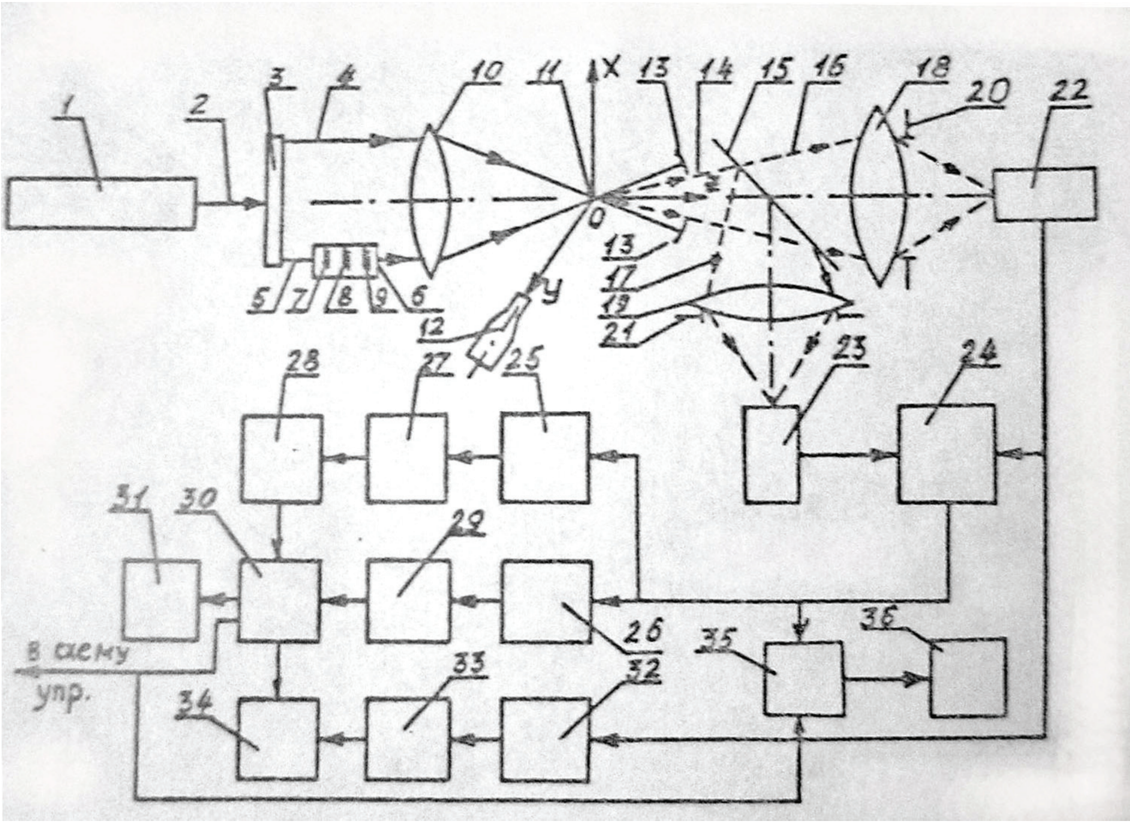

Fig.2 Compensational LDA scheme for the purpose of large particles with predefined size speed measurement: *1* – laser; *2*, *4* and *5* – laser beams; *3* – replicator; *6* – frequency shifting device, consisted of quadruple-wave plates *7* and *9* and of rotating half-wave *8*; *10*, *18* and *19* – lenses; *11* – measuring zone; *12* – particles generator; *13* – traps of radiation; *14*,*16* and *17* – spread beams; *15* – mirror, reflecting surface of which is agreed with particles size; *20* and *21* – diaphragms; *22* and *23* – photoreceivers; *24* – differential amplifier; *25* – upper frequencies filter; *26* – lower frequencies filter; *27*, *32* – detectors; *28*, *29*, *33* – threshold devices; *30* – comparison scheme; 31 – counter; *34* – digital device of evaluation of impulses quantity ratio; *35* – key; *36* – Doppler processor.

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V. Azarskov, doctor of technical sciences (National Aviation University)
S. Polishchuk, candidate of technical sciences (National Aviation University)
S. Fatyeyeva, candidate of philological sciences (National Aviation University)

ERGATIC CONTROL SYSTEM WITH STABILIZATION CIRCUIT OF BIOLOGICAL COMPONENT

Structural and information representation of operator organism as a biological control object in the control circuit of ergatic system is given. The increase of control efficiency in the system with such an approach can be achieved by the stabilization of biological control object parameters

Introduction. Progress of society during last decades is characterized by automation of person's activity in various fields due to using computer science and computer technologies. In most cases from the point of view of information theory the technical realizations with human in control circuit can be considered as automated control systems (ACS).

The analysis of existing variety of ACS allows us to make an essential general conclusion – the presence of a biological object (human) in the control circuit. Over a long time problems of ACS synthesis and analysis were being solved differentiating technical and biological components as they relate to various fields of knowledge. On the one hand these fields are mathematics, physics, automation, telemechanics, electronics, and on the other hand – biology, anatomy, physiology, medicine.

Complex approach to analysis and synthesis problems of ACS has been suggested by such well-known scientists as V. Glushkov, V. Novoseltsev, N. Amosov, V. Ashutin. Their investigation has led to creation of the theory of biotechnical systems (BTS). According to BTS definition they are the special class of large systems representing biological and technical components in a single control circuit for the achievement of efficiency function.

The common character of various BTS types is not quite formal. The main conditions of their optimum functioning are the principle of adequacy, i.e. the optimization of control characteristics of both technical and biological components, and the principle of information environmental identification, demanding the optimization of information streams between all BTS components. In other words, for the achievement of maximum control efficiency BTS should structurally and functionally correspond to morphological and physiological features of biological and technical components of the system.

Regardless of BTS purposes (control of technological process; air traffic control, railway transportation control; maintenance of vital functions of human organism, etc.), cybernetic resources of the human organism are integrated into the control circuit for optimizing the achievement of efficiency function. In this case ACS can be considered as an ergatic system (ES).

Statement of the problem. The analysis of anthropogenic accidents and disasters shows the considerable influence of human factor on the causes of their occurrence, i.e. the violation of fundamental principles of BTS theory is present. In other words, the biological component (operator) can't provide efficient control influence on keeping the system in permissible state limits.

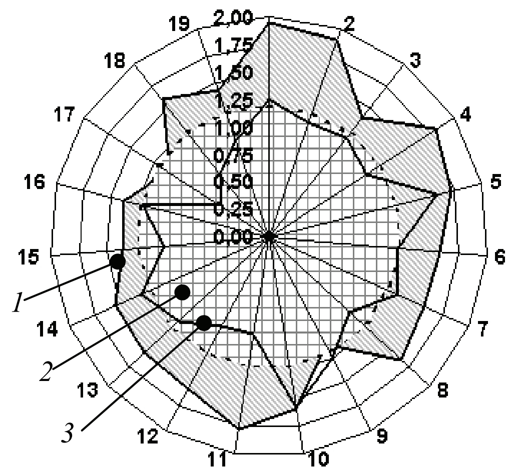

Fig. 1. Efficiency of control in hemodialysis system: **0-2,00** – hemodialysis doze index (Kt/V); **2-19** – number of patients; *1* – Kt/V calculation values; *2* – Kt/V limit value *3* – Kt/V real received values

Efficiency investigation of extracorporeal replacement of the kidney function in Ukrainian hemodialysis departments in 2000–2006 years indicates the low physician's ability to optimize the replacement process (Fig.1). In its turn, the low control efficiency the hemodialysis system shortens patient's lifetime [1].

"Sprut" experiment on board the International Space Station in 2005 demonstrated the possibility of flight failure, due to decreasing the total liquid volume in the cosmonaut organism (Fig.2) [2].

Return of American astronaut Stefanyshyn-Piper Heidemarie aboard "Atlantis" spaceship from International Space Station to the Earth is also a striking example of the loss control in the system. Though, there was no information about worsening her health she lost consciousness at celebration ceremony. It is clear that such a situation is not admissible in the open space, because aftereffects could be fatal.

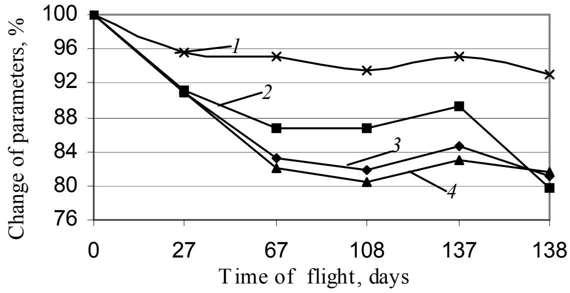

Fig. 2. Change of cosmonaut's body mass and liquid compartment state during the orbital flight: *1* – total body mass; *2* – extracellular liquid volume; *3* – total liquid volume; *4* – intracellular liquid volume

In addition, in the modern flying vehicle (FV) from the point of view of BTS theory, the principles of information environment identification are broken. This infringement is caused by the fact that in a mode of manual control of FV there is no quantitative information about the state of the biological object (pilot), which at the moment acts as an optimizing part in a circuit of feedback [3]. While to both airborne recorders of FV and to flight control center the information on condition of technical devices comes from tens of sensors, physical condition of the crew is fixed only at a level of radiotalks. This makes impossible to authentically identity the degree of crew influence on creating the emergency situation, the efficiency of crew actions in case of emergency, the anticipatory actions of crew to stabilize the system operation at all stages of control process.

Thus, the goal of the research is detailing the theoretical aspects of the problem of biological component integration in the ES control circuit for the purpose of increasing integral system efficiency.

Solution of the problem. The mathematical description of any control system generally looks like:

$$y_i = f_i(x_1, x_2, \ldots, x_j, \ldots, x_s, z_1, z_2, \ldots, z_k, \ldots, z_u, t), \quad i = 1, 2, \ldots, r \qquad (1)$$

where y_i – output values; x_i – input values; z_k – perturbation vector; t – time.

General structural scheme of such a control system is shown in Fig. 3. Depending on the output parameters deflection of y from the given x, the feedback device forms error signal $\varepsilon = f\,(x,\ \mu)$, which changes control vector parameters ω to achieve the control function maximal value.

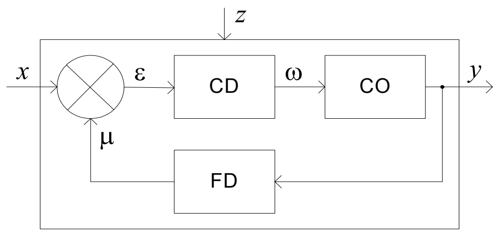

Fig. 3. Ergatic control system structure: CD – control device; CO – control object; FD – feedback device

Limitation of the input variables x and the disturbances z is the necessary condition of normal functioning of such system:

$$x_{j_{\min}} \le x_j \le x_{j_{\max}} \qquad (2)$$

$$z_{k_{\min}} \le z_k \le z_{k_{\max}} \qquad (3)$$

If we have an ergatic system in which the biological and technical components are interconnected in a single control circuit, the expression (1) looks like:

$$y_i = f_i(x_1, x_2, \ldots, x_j, \ldots, x_s, \text{б}_1, \text{б}_2, \ldots, \text{б}_l, \ldots, \text{б}_p, z_1, z_2, \ldots, z_k, \ldots, z_u, t) \qquad (4)$$

where α_i – variables, which characterize the biological control object (BCO) as an open system [4]. Besides limitations (2) and (3) the limitation for space of BCO parameters state also is imposed:

$$\sigma_{l_{\min}} \le \sigma_l \le \sigma_{l_{\max}} . \quad (5)$$

In this case BCO is a constituent part of the feedback circuit and parameter $\mu = f(\alpha)$. If the theoretical aspects of analysis and synthesis of classical control system (1) – (3) are considered in detail, the situation changes when biological components are introduced in the system by means of equations (4) and (5).

Let us consider BCO in ES control counter as a system, which tends to the accessibility of control efficiency function Ψ. So we can affirm that the algorithm of Ψ function accessibility is kept in the central nervous system, the position in space and time is provided by receptors, the moving in space is performed by effectors, and the energy support is provided by the metabolic system. Thus, it can be formulized as

$$\Theta(t) = \underset{\Psi}{\Phi}\{ДE, I, RE\}, \quad (6)$$

where $\Theta(t)$ – state space of BCO; Φ – functional of control law in the system; ΔE – parameters of energy balance of biological system, I – quantitative information processed in BOC; RE – factor of integrity for functioning receptor-effector organs and systems.

Proceeding from the principles of human physiology and the definition of BCO by means of formula (6), we can represent the structure of the human organism in the following way (Fig. 4).

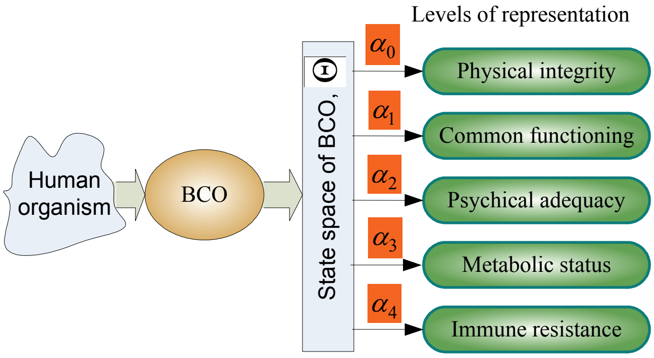

Fig. 4. Levels of representation of human organism for his integration into circuit of automated control system

Possible state space of BCO Θ can be written as a sum of sets of vectors α_l which carry information about the corresponding level of BOC structural organization

$$\Theta \in \{ \alpha_0 \cup \alpha_1 \cup \alpha_2 \cup \alpha_3 \cup \alpha_4 \ldots \cup \alpha_n \}, \quad (7)$$

where α_0 – level of physical integrity; α_1 – level of common functioning; α_2 – level of psychical adequacy; α_3 – level of metabolic status; α_4 – level of immune resistance.

The accessibility of maximal value of control efficiency function $\Psi_{\max}$ always takes place with the destabilizing factor of outdoor environment (DFOE) – z. The influence of DFOE results in the shift of BCO parameters α_l from the steady position (homeostasis disbalance). The general solution of this problem can be written as

$$\alpha_{l\,\min} \le \alpha_{l\,\mathrm{opt}}\Big|_{z_{\min} \le z \le z_{\max}} \le \alpha_{l\,\max}, \quad (8)$$

where $z_{\min}$, $z_{\max}$ – minimum, maximum accepted values of DFOE parameters for particular BCO respectively.

So we can say that the control efficiency function in ES will achieve maximum value $\Psi \to \Psi_{\max}$ if the system has the control circuit for stabilization of parameters α_l. Subject to the equation (6) and (8) the given condition can be written as [5]:

$$\alpha_l(t)_{\mathrm{opt}} = \underset{\Psi \to \Psi_{\max}}{\Phi} \begin{cases} \Delta E = 0 \\ I = I_{\Sigma} \\ RE = RE_{\max} \end{cases} \quad (9)$$

where $\alpha_l(t)_{\mathrm{opt}}$ – optimal values of BCO homeostasis borders; I_{Σ} – information capacity of BCO; $RE_{\max}$ – maximum possible characteristics of receptor-effector organs and systems.

In this case one of the basic problems, which arises concerning control in ES is keeping homeostasis parameters within the allowed value limits. Hence, the structural scheme of ES realizing equation (9) is shown in Fig. 5 [6].

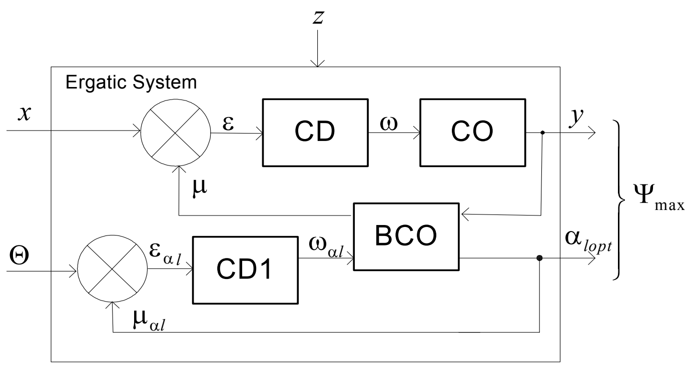

Fig. 5. Ergatic control system with circuit stabilization of parameters of biological control object

At present there are some technical applications in which the similar approach is partially used. An example may be a system for medicobiological provision of manned orbital flight. The stabilization circuit of BCO parameters is based on supporting the energy balance ΔE and the estimation parameters $б_0$, $б_1$ in the on-line mode. In the case of orbital flight they are quite enough to solve the problem. But in the interplanetary flight with the maximum degree of isolation and the flight duration for some years the on-line monitoring of all levels $б_0 - б_4$ of BCO representation will be necessary. Only with such approach it will be possible to form prognostic information about BCO states and to create anticipatory impacts for keeping parameters Θ within the required limits.

Conclusion

The configuration of modern ergatic systems has limitations related to estimation of human organism state. The deficiency of quantitative information on the human organism state in the control circuit can lead to the decrease of control efficiency of the automated control system.

The proposed method of human organism representation as a biological control object gives the possibility to provide mathematical approach to the problem of biological component for the purpose of constructing the ergatic system with the prognostication in space and time of man's functional state.

The introduced structural scheme of the system with the stabilization circuit of biological object parameters enables to forecast human state in extremal conditions and eo ipso increase general reliability and safety of automated control system.

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Hohlov E.M. (National Aviation University, Ukraine)
Grishchenko Y.V. (National Aviation University, Ukraine)

THE ANALYTICS OF FLIGHTS AS THE PROCESSES OF THE INTERACTION BETWEEN A HUMAN AND A MACHINE FROM THE POINT OF VIEW OF NEW DISCOVERIES

Now the basic method of the analysis of the processes of a flight is the consideration of problem situations or negative events at the complication of flight conditions. The example of such analytical approach is the methods of the express-analysis used in onboard or ground systems of the objective control. At that tens of so-called “sure events” of a flight, which contain the information about the failures or deviations in the technical equipment of piloting during the certain time moments (passing marker beacons, deviation from the beginning of a glidepath, etc.) are registered.

Such approach at the estimation of the interaction processes " flight crew - aircraft " in a flight is insufficient as does not describe the nature and mechanisms of these processes and, the most important, does not allow to change the growth trend of the accident rate under the human factor (crew), that exist more than 50 years . If in the beginning of the 50-60s years of the 20s century the share parameters of crews were 40-50 %, by 2007 year the share of the accident rate and catastrophe because of crews and other air personnel had been 85-90 % according to ICAO, border state aviation committee (MAK). At that trends do not decrease.

Other and the newest approaches to the solving of this problem, directed on the achievement of zero accident rate on human factor (HF) in regional and global scales [1, 2, 3, 4, 5, 6, 7], are essentially necessary.

At the application of the process approach and the general process theory to the analysis of flights as the extremely complex productions, as it is known the East Europe qualifiers of intellectual products (IP) [7, 8] are used.

The typical qualifier contains not less than 20-25 positions, describing various types of such products. The major IP type is potentially possible and registered scientific discoveries.

"The establishment of unknown earlier objectively existing laws, properties and phenomena of the material world, that bring basic changes at the level of knowledge" are usually defined as a scientific discovery. The similar definition of a discovery is in the new civil code of Ukraine. At the process approach the material world is understood as the world as process (set of processes) in two forms - the nature and material activity of a human being.

Therefore the analysis of the flight processes at taking the accident rate and catastrophe on HF can be carried out from the position of discoveries - unknown before phenomena, instead of just as simple events or situations.

Work on studying of such phenomena during the last 20 years is shown in tables 1 and 2.

Table 1

The area of application of the found phenomena during the flight at the analysis of the crew activity under the conditions of suddenness and unexpectedness

№	The name of the found phenomenon	The areas of application in aviation	Authors
1	2	3	4
1.	The phenomenon of factorial transitions (PFT) [1, 2]	At the analysis of the transition of a normal flight to an emergency or catastrophic flight	Hohlov E.M., 1985.
2.	The phenomenon of the amplification of the dynamic stereotype of pilots (PADS) [3, 4]	The analysis of the flight handwriting of pilots under special flight conditions and cases	Grishchenko Y.V., 1986.

Table 1 (continue)

1	2	3	4
3.	The phenomenon of factorial resonance [5, 6]	The analysis of occurrence mechanisms of areas ("points on ICAO") inevitability at aviation incidents	Korneev S.V., Polozhevets A.A., 1985, 2004.
4.	The phenomenon the toroidal* rotations of the information in two-sided processes [7]	At the substantiation of the nature of occurrence of two most emergency stages of flights - take-off and landing	Hohlov E.M., Jankova S.A., 2000.
5.	The phenomenon of compression of the information and information zero at the action of improbable multiplicative factorial overlay of cooperating factors [7]	At substantiation of the nature of information processes when pilots operate in the conditions of suddenness and unexpectedness	Hohlov E.M., Grishchenko J.V., Gulenko V.D., Polozhevets A.A., Jankova S.A., Kozhohina E.V., 2000.

- toroidal from the word toroid

Table 2

Formulae PFT ЯФП and PADS ЯУДС on the standard methodology of the registration of discoveries

	The known phenomenon	The unknown phenomenon	The formula of a discovery [8]
	The phenomenon of the action of factors	PFT	“This phenomenon in bioproductions assumes the mechanisms not only the analysis of known scientific position - the phenomena of the action of factors, but also the analysis of mechanisms of interaction of factors, terminal interaction of factors, lead to that terminal interaction through the entropy of factorial transition becomes the causa finales of any negative changes in these processes ˝ [1].
	The phenomenon of the dynamic stereotype	PADS	During interaction "human - machine" (HM) assumes this phenomenon the mechanisms not only formation of steady stereotyped connections (handwriting of an operator), but also their amplitude-frequency amplification when the HM system is in conditions of absolute suddenness and unexpectedness [3-4].

According to existing methodology at the substantiation of the facts of existence of the new phenomena it is necessary to carry out theoretical and practical proofs.

Theoretical proofs are reduced to that all these phenomena have entropy character and connected with uncertainty which is shown at the analysis of the moments of transitions during interaction "human - machine".

Therefore at the mathematical substantiation not only known measures of the information and the formula entropy Shennona, Hartly, Wiener, Kolmogorov, and also new measures of entropy created at the analysis of such processes were applied:

- The generalized formula of entropy:

$M \cdot \log M$ (entropy Hohlov-Grishchenko), where M - any mathematical measure or transformation (the formula, function, functional, etc.) (fig. 1);

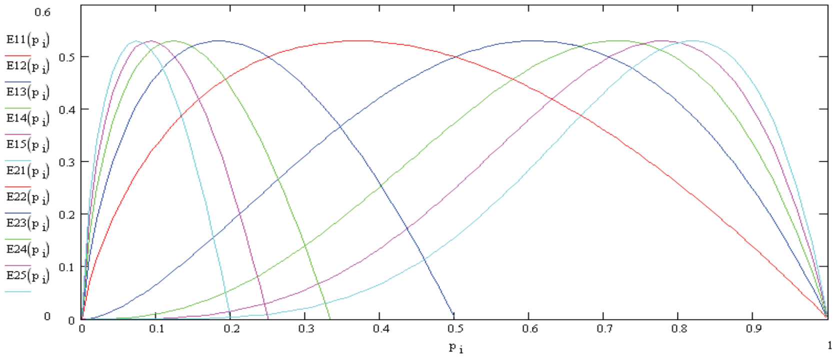

Fig.1. Nomogram of effects on $M \cdot \log_2 M$

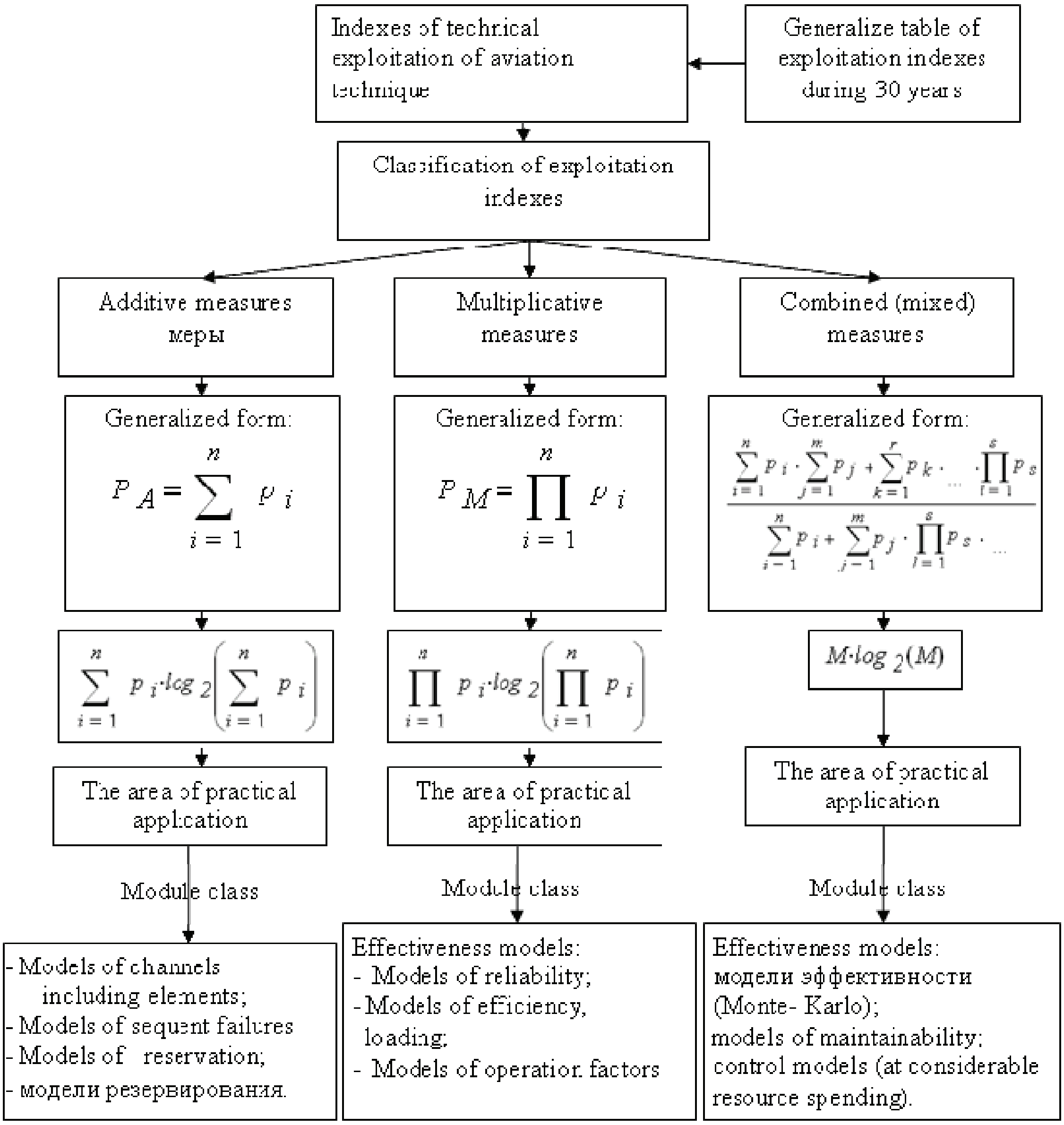

Fig. 2. The classification of parameters of technical operation of aviation techniques and engineering psychology as complex polycomponental probability measures and their entropies

Additive and multiplicative formulae of entropies:

$\sum_i p_i \cdot \log \sum_i p_i$ и $\prod_i p_i \cdot \log \prod_i p_i$ (Hohlov entropy, 1970 entropy of factorial transitions).

Thus for each kind of entropy has been made special factorial nomogram, allowing to analyze character of factorial overlays during a flight depending on conditions improbablility, polyfactorial, interactions of factors, etc.

The generalized formula of entropy was used as for calculation of scopes probability parameters and various type of mathematical models (fig. 2).

At engineering - psychological substantiation of the given phenomena the theory of action and counteraction I.M.Sechenova determining a role of amplified processes in conditions of suddenness and unexpectedness (Setchenov's amplified reflexes) [9] were applied for the first time.

In 1986 the analysis of the reasons of emergency not design process on CAES was carried out in view of these phenomena as mechanisms of such phenomena we see not only in flights as extremely complex processes, but also in anyone negative, engineering processes - failures and accidents [1].

At carrying out of experiments the complex simulators of planes equipped with systems of the objective control (SOC), and also decoding SOC of real flights in various conditions were used. During 1985-2005 . tt was investigated about 7000 flights in airlines of the countries of participants of the agreement on use of air space.

Rather important are as practical results of the analysis of air incidents taking into account of processes factorial resounding (A.A.Polozhevets's works [6]). It was proved, that " points of inevitability " (term ICAO) in AE represent the areas factorial resounding and they can be removed by definition of first attributes of occurrence of the factorial resonance on special maps the head of a flight .

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V.M. Azarskov, Dr. Sci. (Eng), (National Aviation University, Ukraine)
L.S. Zhiteckij, Cand. Sci. (Eng), (National Aviation University, Ukraine)
O.A. Sushchenko, Cand. Sci. (Eng), (National Aviation University, Ukraine)

ADAPTIVE DIGITAL FEEDFORWARD/FEEDBACK CONTROL CONCEPT APPLIED TO DESIGNING AN AIRCRAFT AUTOTRACKING RADAR

The problem of designing a perfect adaptive control algorithm for controlling the nonminimum phase discrete-time tracking system which represents an aircraft autotracking radar obtained by sampling a continuous-time system is addressed in this paper. A new adaptive controller consisting of the adaptive feedback in conjunction with adaptive indirect feedforward circuits is developed.

Introduction

The objective of tracking control is to follow a prescribed trajectory so that the tracking error must be minimized. An aircraft autotracking radar belongs to this class of control system. However, its input signal is the angular tracking error [1, chapt. 6] whereas the command reference signal plays the role of such an input signal for the classical tracking system. This feature of autotracking radar is essential.

Modern motion control systems require accurate high speed tracking capabilities [2]. To achieve this goal, feedforward techniques in conjunction with a feedback design have been before proposed by many researches. In order to realize a feedforward scheme, explicit knowledge of the system dynamics is needed. Namely, for compensating a dynamic lag in the feedback circuit, the ideal feedforward controller is the dynamic inverse of a plant to be controlled. Thereby, this controller becomes unsuitable if the plant is nonminimum phase.

Since the modern controllers are implemented digitally in almost all practical applications, sampling a continuous-time system is often necessary [1,2]. To implement the digital of the autotracking radar, the continuous-time tracking error $e(t)$ that is the current difference between the angular displacement of the moving aircraft and the angular displacement of the axis of the tracking antenna needs to be sampled as shown in Fig. 1.

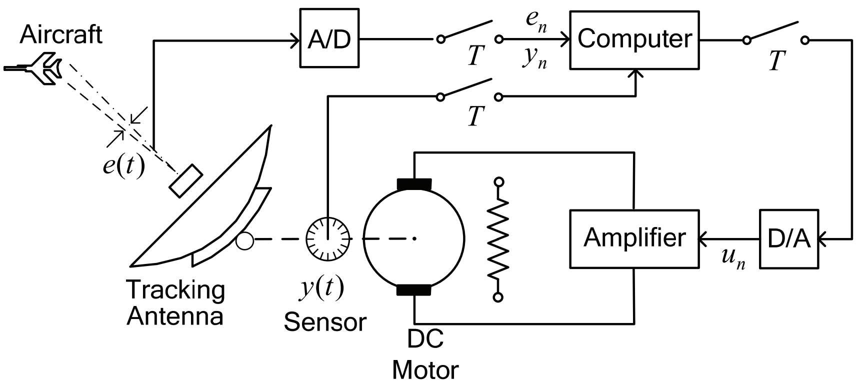


Fig. 1. Aircraft autotracking radar together with digital control circuits

Unfortunately, the sampling effect may lead to the appearance of the nonminimum phase properties of the plant described in the terms of the discrete time when it is sampled with sufficiently fast sampling rate while its continuous-time counterpart is indeed minimum phase. Such a property that is not desirable has been first observed by one of the authors [3] who dealt with a third-order system. This fact is strictly confirmed by Astrom and his colleagues [4] proving that a continuous-time system whose pole excess is larger than 2 will always produce a pulse transfer function having nonminimum phase zero (zeros) if the sampling interval is sufficiently short.

To cope with unstable zeros arising in discrete-time systems, a number of feedforward approaches has been advanced. Among these is the feedforward methodology devised independently in [5,6] and also in [7, p. 14 – 16]. Their methodology exploits the fact that a noncausal expansion of partial unstable inverse dynamics converges in a region of the complex plane encompassing the unit circle. Although such a tool is approximate because of truncated Laurent series expansion, the approximation error can be made arbitrarily small when there is no noise and future reference trajectory information is available, one must know plant parameters to implement this methodology as in the ideal case. In practice however it is hard to derive explicit knowledge of these parameters. In this case, an adaptive control concept seems to be appropriate.

Stabilization of plants using adaptive control strategy is known to be an important preliminary step toward achieving good performance for this class of control systems. Contrary to the minimum phase case, the development of stable adaptive control scheme for nonminimum phase plants is hampered by the singularity that may occur when the identification algorithm leads to appearing uncontrollable estimated plant description [8]. For overcoming this intrinsic difficulty, two different approaches were advanced by several researches. One of them suggests the introduction an excitation probing signal. A drawback of this approach is that one may not be desirable in various practical applications. The alternative approach is based on suitable modification of the parameter estimates to put them away from the singularity surface in the parameter space. To date, there are only two ways to modifying the estimation procedure. One is to hypothesize the existence of a known convex compact region in which no pole-zero cancellation of estimated model occurs [9,10]. The other exploits some observable properties of either least squares [8,10] or gradient-type algorithms [11]. Although the first way requires *a priori* knowledge of a region onto which parameter estimates must be projected, however, it is essentially simpler than the second way.

In contrast to the adaptive control of discrete-time minimum phase system which causes its output to asymptotically follow a desired reference sequence without tracking error when there is no noise, the tracking error is intrinsic for the adaptive control of nonminimum phase system [7,8]. Meanwhile, the existing adaptive controllers contain no feedforward circuits to compensate this error. Probably, this reflects the fact that adaptive identification algorithms do not guarantee the convergence of parameter estimates to their true values when persistence of excitation is absent, in general. Nevertheless, some authors tried utilize here the truncated Laurent series expansion technique for this [7, 11]. However, their results have been remained somewhat uncompleted.

The present paper deals with improving a tracking performance index of adaptive discrete-time nonminimum phase system obtained by sampling a continuous-time system. Based on the feedforward/feedback control methodology, a new adaptive control scheme containing the adaptive feedforward control loop in conjunction with the feedback controller is developed. The key idea is that the adaptive feedforward control scheme is now neither inverse of the plant model to be estimated nor its approximation. An attractive feature of this scheme is that its parameter converges to the corresponding true value, while the similar convergence of the plant parameter estimates is not guaranteed. The main effort is focused on establishing the stability of the designed system that is not obvious and also on studying its ultimate behavior.

Problem statement

The continuous part of an aircraft autotracking radar containing the amplifier together with the DC motor in series (see Fig. 1) is assumed to be a third-order plant whose transfer function is given by

$$W_0(s) = \frac{k}{s(\tau_1 s + 1)(\tau_2 s + 1)}, \tag{1}$$

where k denotes its gain and τ_1 and τ_2 are the time constants. It is assumed that $\tau_1 \neq \tau_2$. Without loss of generality, let $\tau_1 > \tau_2$, i.e., $\eta = \tau_1 / \tau_2 > 1$. The following basic assumptions on (1) are made.

A1) The parameters k, τ_1 and τ_2 are exactly unknown, but one knows *a priori* intervals

$$0 < k_{\min} \leq k \leq k_{\max} < \infty, \tag{2}$$

$$0 < \tau_{1,\min} \leq \tau_1 \leq \tau_{1,\max} < \infty, \tag{3}$$

$$0 < \tau_{2,\min} \leq \tau_2 \leq \tau_{2,\max} < \infty. \tag{4}$$

to which k, τ_1 and τ_2 belong.

A2) The condition $\hat{\eta} = \hat{\tau}_1 / \hat{\tau}_2 > 1$ is valid for any estimate vector $\hat{\tau}$ from known convex compact region $T_\tau = [\tau_{1,\min}, \tau_{1,\max}] \times [\tau_{2,\min}, \tau_{2,\max}] \subset \mathbf{R}^2$ containing the unknown vector $\tau = [\tau_1, \tau_2]^{\mathrm{T}}$.

Since the continuous-time part needs to be sampled with a sampling period T, the discrete-time model of a system composed of the zero-order hold, this part and a sampler in series is further considered. The corresponding pulse transfer function in z^{-1} is obtained as

$$W_0(z^{-1}) = \frac{\mu B'(z^{-1})}{(1 - z^{-1})A'(z^{-1})} \tag{5}$$

with $\mu = kT_0$ and the polynomials $A'(z^{-1}) = 1 + a_1' z^{-1} + a_2' z^{-2}$ and $B'(z^{-1}) = b_1' z^{-1} + b_2' z^{-2} + b_3' z^{-3}$ whose coefficients are defined in [3]. Note that they have the following observable property:

$$b_i' > 0 \;\; (i = 1,2,3) \quad \text{for all } \eta = \beta_2 / \beta_1, \; k \in (0, \infty). \tag{6}$$

Let y_n^0 represent a command reference input signal at the time instant $t = nT$ $(n = 0, 1, 2, \ldots)$. Then the discrete-time tracking error will be determined as

$$e_n = y_n^0 - y_n, \tag{7}$$

where y_n denotes the output measured signal formed by the sensor (see Fig. 1).

The following assumption about the first difference $\Delta y_n^0 := y_n^0 - y_{n-1}^0$ is required.

A3) The sequence $\{\Delta y_n^0\}$ is upper bounded. This implies that its l_∞-norm satisfies

$$\| \Delta y^0 \|_\infty := \sup_{0 \le n < \infty} | \Delta y_n^0 | < \infty.$$

The aim of this paper is as follows. It is required to design a digital autotracking radar containing the continuous-time plant described by transfer function (1) together with the zero-order hold and with a simple adaptive controller such that the discrete-time closed-loop control system will be stable in the sense that, under assumption A3), the tracking error $\{e_n\}$ and also the control $\{u_n\}$ sequences remain bounded uniformly in n for any sampling period T, and y_n follows y_n^0 as closely as possible for all sufficiently large n. More certainty, it is necessary to achieve the second-order astaticism of tracking control system, i.e., the component of the error e_n proportional to Δy_n^0 should go to zero as n tends to infinity.

Preliminaries

Fix a sampling period T and define

$$\mu_{\min} = k_{\min} T, \;\; \mu_{\max} = k_{\max} T,$$

$$\beta_{1,\min} = T / \tau_{1,\max}, \;\; \beta_{1,\max} = T / \tau_{1,\min}, \;\; \beta_{2,\min} = T / \tau_{2,\max}, \;\; \beta_{2,\max} = T / \tau_{2,\min}.$$

In view of (2) – (4)

$$\Omega = [\mu_{\min}, \mu_{\max}] \times [\beta_{1,\min}, \beta_{1,\max}] \times [\beta_{2,\min}, \beta_{2,\max}]$$

will be the set of the vectors $\hat{c} = [\hat{\mu}, \hat{\beta}_1, \hat{\beta}_2]^{\mathrm{T}}$ mapping the membership set $[k_{\min}, k_{\max}] \times T_\tau$ of the original parameters. This yields $c \in \Omega$, where $c = [\mu, \beta_1, \beta_2]^{\mathrm{T}}$.

Let $A(z^{-1}) = 1 + a_1 z^{-1} + a_2 z^{-2} + a_3 z^{-3}$ and $B(z^{-1}) = b_1 z^{-1} + b_2 z^{-2} + b_3 z^{-3}$ be the polynomials given by $A(z^{-1}) = (1 - z^{-1}) A'(z^{-1})$ and $B(z^{-1}) = \mu B'(z^{-1})$. Now, define the maps $\Omega \to \Xi \subset \mathbf{R}^5$ and $\Omega \to \Xi^0 \subset \mathbf{R}^6$ in which Ξ and Ξ^0 represent the sets of the vectors $\hat{\theta} = [\hat{a}_1', \hat{a}_2', \hat{b}_1, \hat{b}_2, \hat{b}_3]^{\mathrm{T}}$ and $\hat{\theta}^0 = [\hat{a}_1, \hat{a}_2, \hat{a}_3, \hat{b}_1, \hat{b}_2, \hat{b}_3]^{\mathrm{T}}$, respectively, induced by $\hat{c} \in \Omega$. Assumptions A1) and A2) give that Ξ and Ξ^0 are compact. This means the existence of finite

$$a_{i,\min}' = \min_{\hat{c} \in \Omega} \hat{a}_i', \;\; a_{i,\max}' = \max_{\hat{c} \in \Omega} \hat{a}_i' \quad (i = 1, 2),$$

$$a_{i,\min} = \min_{\hat{c} \in \Omega} \hat{a}_i, \;\; a_{i,\max} = \max_{\hat{c} \in \Omega} \hat{a}_i \quad (i = 1, 2, 3),$$

$$b_{i,\min} = \min_{\tilde{\theta}\in\Omega} \tilde{b}_i,\; b_{i,\max} = \max_{\tilde{\theta}\in\Omega} \tilde{b}_i \quad (i = 1, 2, 3).$$

Define the convex compact regions

$$\Xi^+ = [a'_{1,\min},\; a'_{1,\max}] \times [a'_{2,\min},\; a'_{2,\max}] \times [b_{1,\min},\; b_{1,\max}] \times [b_{2,\min},\; b_{2,\max}] \times [b_{3,\min},\; b_{3,\max}],$$

$$\Xi^* = [a_{1,\min},\; a_{1,\max}] \times \ldots \times [a_{3,\min},\; a_{3,\max}] \times [b_{1,\min},\; b_{1,\max}] \times \ldots \times [b_{3,\min},\; b_{3,\max}].$$

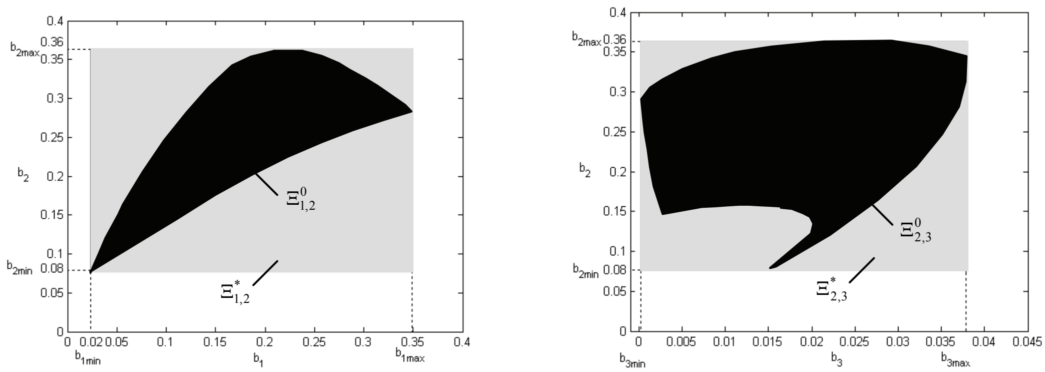
From (6) and these definitions we can derive

$$b_{i,\min} > 0 \qquad (i = 1, 2, 3) \tag{8}$$

and

$$\Xi^* \supset \Xi^0. \tag{9}$$

To illustrate inclusion (9) together with (8), the projections Ξ^0 and Ξ^* onto the planes $\{\tilde{b}_1, \tilde{b}_2\}$ and $\{\tilde{b}_2, \tilde{b}_3\}$ denoted as $\Xi^0_{1,2}$ and $\Xi^*_{2,3}$, respectively, are depicted in Figures 2 (a) and (b). They were calculated for the numerical example setting $0.14 \le \tilde{\alpha} \le 0.22$, $0.3 \le \tilde{\beta}_1 \le 1.0$, $1.1 \le \tilde{\beta}_2 \le 30.0$.



(a) (b)

Fig. 2. Geometric interpretation of (8) and (10) as applied to a numerical example

Let

$$\tilde{W}_0(z^{-1}) = \frac{\tilde{B}(z^{-1})}{\tilde{A}(z^{-1})} \tag{10}$$

be an arbitrary pulse transfer function with $\tilde{A}(z^{-1})$ and $\tilde{B}(z^{-1})$ induced by some fixed $\tilde{\theta}^0$. Introduce the Sylvester resultant matrix

$$M(\tilde{\theta}^0) = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ \tilde{a}_1 & 1 & 0 & \tilde{b}_1 & 0 & 0 \\ \tilde{a}_2 & \tilde{a}_1 & 1 & \tilde{b}_2 & \tilde{b}_1 & 0 \\ \tilde{a}_3 & \tilde{a}_2 & \tilde{a}_1 & \tilde{b}_3 & \tilde{b}_2 & \tilde{b}_1 \\ 0 & \tilde{a}_3 & \tilde{a}_2 & 0 & \tilde{b}_3 & \tilde{b}_2 \\ 0 & 0 & \tilde{a}_3 & 0 & 0 & \tilde{b}_3 \end{bmatrix}$$

associated with $\tilde{\theta}^0$. The absolute value of its determinant plays the role of a measure of the controllability of plant (10) [9, chapt. 7]. In fact, $\tilde{B}(z^{-1})$ and $\tilde{A}(z^{-1})$ will be coprime iff

$$|\det M(\tilde{\theta}^0)| > 0. \tag{11}$$

It is known that (11) is satisfied for any $\tilde{\theta}^0 \in \Xi^0$. Calculations performed for the numerical example shows that (11) may take place even for all $\tilde{\theta}^0$ from Ξ^* covering Ξ^0. Motivated by this observation, one can make the following crucial assumption.

A4) $\tilde{A}(z^{-1})$ and $\tilde{B}(z^{-1})$ are coprime for all $\tilde{\theta}^0 \in \Xi^*$.

Adaptive control algorithm

Following to [11], the control input u_n will be chosen as the sum

$$u_n = u_n^{(s)} + u_n^{(c)}, \tag{12}$$

where $u_n^{(s)}$ denotes the output signal of a stabilizing feedback controller and $u_n^{(c)}$ represents the signal generated by a compensating indirect feedforward controller (see Fig. 3).

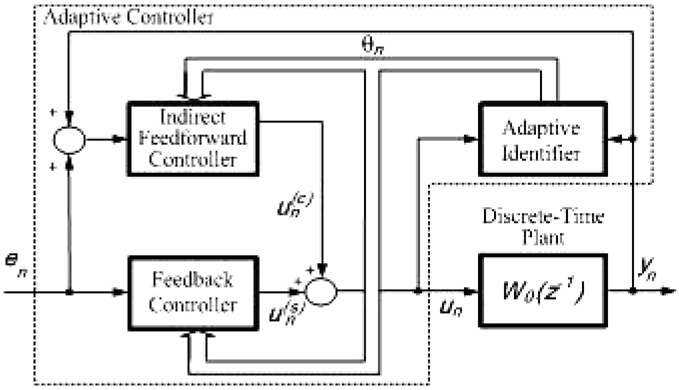


Fig. 3. Structure of the adaptive tracking system

The parameter estimator is a basic one used to establish earlier global convergence results [8] subject to parameter projection. As in [9, chapt. 7], we use (9) to design the gradient constrained parameter estimation algorithm with the dead zone of the form

$$\theta_n = P_{\Xi^+}\left\{\theta_{n-1} - \frac{f(\tilde{e}_n, \eta)}{\|\varphi_{n-1}\|^2}\varphi_{n-1}\right\}. \tag{13}$$

In this equation, $f(\tilde{e}, \eta)$ represents the dead zone utilized in [8] and defined as

$$f(\tilde{e}, \eta) = \begin{cases} \tilde{e} - \eta & \text{if} \quad \tilde{e} > \eta, \\ 0 & \text{if} \quad |e| \le \eta, \\ \tilde{e} + \eta & \text{if} \quad \tilde{e} < -\eta, \end{cases}$$

where $\eta > 0$ is a constant P_{Ξ^+} is the projection operator necessary to ensure $\theta_n \in \Xi^+$, $\varphi_{n-1} = [-\Delta y_{n-1}, -\Delta y_{n-2}, u_{n-1}, u_{n-2}, u_{n-3}]^T$ denotes the state vector and $\tilde{e}_n$ defines the estimation error given by

$$\tilde{e}_n = \Delta y_n - \theta_{n-1}^{\mathrm{T}}\varphi_{n-1}. \tag{14}$$

Utilizing the pole assignment strategy of [10], the control signal $u_n^{(s)}$ can be determined as

$$F_{n-1}(z^{-1})u_n^{(s)} = G_{n-1}(z^{-1})e_n \tag{15}$$

In this control law,

$$F_n(z^{-1}) = 1 + f_1(n)z^{-1} + f_2(n)z^{-2} + f_3(n)z^{-3},$$

$$G_n(z^{-1}) = g_0(n) + g_1(n)z^{-1} + g_2(n)z^{-2} + g_3(n)z^{-3}$$

satisfy the Bezout polynomial identity

$$(1 - z^{-1})A_n'(z^{-1})F_n(z^{-1}) + B_n(z^{-1})G_n(z^{-1}) = 1 \tag{16}$$

with the polynomials $A_n'(z^{-1})$, $B_n(z^{-1})$ whose coefficients are the components of the estimate vector θ_n updated via (13), (14).

The operation $P_{\Xi^+}\{\cdot\}$ in (13) together with assumption A4) ensure the solvability of (16) for all n.

It is known that in the absence of any noise and plant uncertainty, the control signal

$$u_n^{(c)} = \mu^{-1}\Delta y_n^0 \tag{17}$$

generated by the feedforward controller allows to achieve the second-order astaticism of the tracking system. However, control law (17) cannot be realized because μ is unknown. Again, Δy_n^0 remains here unmeasured. Therefore, these variables must be replaced by the suitable estimates μ_n. It turns out that the estimate can be found by utilizing the relation

$$b_1 + b_2 + b_3 = \mu(1 + a_1' + a_2') \tag{18}$$

derived from (4). This leads to choosing

$$u_n^{(c)} = \mu_n^{-1}(\Delta e_n + \Delta y_n) \tag{19}$$

where

$$\mu_n = [b_1(n) + b_2(n) + b_3(n)]/[(1 + a_1'(n) + a_2'(n)]$$

is obtained after replacing in (18) the unknown coefficients by their estimates and Δy_n^0 by $\Delta e_n + \Delta y_n$ that is valid due to (7).

Since $b_i(n) > 0$ $(i = 1,2,3)$, it follows from the expression of μ_n that one is bounded away from zero. It is essential to avoid the singularity in (19).

Main result

The basic convergence result is summarized in the following lemma.

Lemma 1. Under assumptions A1), A2) and A4, the adaptation algorithm defined in equations (13) and (14) is convergent in the sense that the estimate vector θ_n converges to a constant vector θ_∞ for any initial $\theta_0 \in \Xi^+$.

Proof. The proof is based on proving the fact that $V_n = \|\theta - \theta_n\|^2$ is the Lyapunov function.

The stability properties of the proposed adaptive control algorithm are explored in the next theorem.

Theorem 1. Subject to assumptions A1) – A4; the adaptive control system which comprises plant (5), estimator (13) together with (14) and controllers described by equations (12), (15), (16), (19) is stable in the sense that the tracking error e_n and the control signal u_n remain bounded for all time.

Proof. The proof follows the ideas given in [10, section 4] and in [8, lemma 12.2.1].

With the convergence properties established in lemma 1, the following theorem can be stated.

Theorem 2. Let assumptions A1) A4) be valid. If y_n^0 is a signal linear in n and there is no noise, μ_n converges to its true value μ.

Proof. The proof is omitted because of space limitation.

Comment. Note that $\mu = \lim_{n\to\infty} \mu_n$ is achieved without requiring the convergence θ_n to θ if y_n^0 is linear and $v_n \equiv 0$. Nevertheless, numerical simulations show that this property is observed for not necessarily linear y_n^0. However, the question of why this important property takes place remains unresolved, as yet. For any case, the convergence μ_n to μ implies that the second-order astaticism is achieved.

Conclusion

The main contribution of this paper is a new adaptive controller applicable to controlling a nonminimum phase discrete-time tracking system. It contains a novel adaptive feedforward loop in addition to the usual adaptive feedback loop. This allows to achieve effecting perfect tracking. The proposed adaptation law is simple enough for its practical implementation.

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Shevchuk D.O., PhD (National Aviation University)

CREATED CONTROL RULES "KNOWLEDGE BASE" INTELLECTUAL SYSTEM FOR INCREASING PLANE CONTROLLABILITY IN TYPICAL DAMAGES CONDITION ON THE FLIGHT

Method of creating control rules "knowledge base" intellectual system for increasing plane controllability in typical damages condition on the flight is considered.

Recently, much attention has been paid to the application of knowledge-based control techniques for flight control and especially in special satiation such as damage of the plane on the flight. It shows that techniques like neural fuzzy systems can provide appropriate tools for nonlinear identification, control of high performance aircraft, helicopters, flight control reconfiguration and advisory systems. Fuzzy systems are used as supervisory, expert systems. Previous positive experience crews' actions in similar situation are formalized to control algorithm such expert systems.

Knowledge-based (expert) control tries to formalize the domain-specific knowledge, and uses reasoning mechanisms for determining the control action from the knowledge stored in the system and the available measurements. Knowledge-based control systems try to enhance the performance, reliability and robustness of current control systems by incorporating knowledge that cannot be accommodated in analytic models upon which conventional control algorithms are based. Knowledge-based systems can be used to realize the closed-loop control actions directly, i.e. replace conventional closed-loop controllers, or they can complement and extend conventional control algorithms via supervision, tuning or scheduling of local controllers.

Considering object with n inputs and one exit:

$$p = f(m_1, m_2, ...m_n), \tag{1}$$

where p - exit variable (corner of a deviation of elevators, directions, aileron,); $m_1, m_2, ...m_n$ - entrance variables (speed, height, corners of attack, sliding, pitcha, their derivatives etc.).

Variables $m_1, m_2, ...m_n$ and p are quantitative, known limits of their change:

$$M_i = [m_{i\min}, m_{i\max}], i = \overline{1, n}; \tag{2}$$

$$P = [p_{\min}, p_{\max}], \tag{3}$$

where $m_{i\min}(m_{i\max})$ - the minimum (maximum) value of entrance variable m_i, $i = \overline{1, n}$; $p_{\min}(p_{\max})$ - the minimum (maximum) value of exit variable p.

The problem consists in that for vector $M^* = [m_1^*, m_2^*, ..., m_n^*]$ of the fixed values of entrance variables $m_i^* \in M_i, i = \overline{1, n}$ of the set system «the plane – intellectual system - environment - damage» to define necessary operating influence intellectual system $p^* \in P$, i.e. accurate value of adjustable size submitted on the plane.

For estimation of linguistic variables m_i, $i = \overline{1, n}$ and p we will use fuzzy sets: $S_i = [s_i^1, s_i^2, ..., s_i^{l_i}]$ - fuzzy set of the variable m_i, $i = \overline{1, n}$; $V = [v_1, v_2, ..., v_r]$ - fuzzy set of variable the p, where s_i^q - q fuzzy set of linguistic variable $m_i, q = \overline{1, l_i}, i = \overline{1, n}$; v_j - j fuzzy set of linguistic variable p; r - number of various decisions in considered area. Generally $l_1 \neq l_2 \neq ... \neq l_n$.

Names of separate terms $s_i^1, s_i^2, ..., s_i^{l_i}$ can differ also from each other for various linguistic variables m_i, $i = \overline{1,n}$. Linguistic sets $s_i^q \in S_i$ and $v_j \in V, q = \overline{1,l_i}, i = \overline{1,n}, j = \overline{1,r}$ we will consider as the fuzzy sets set on universal sets M_i and P, defined by parities (2), (3).

Fuzzy sets s_i^q and v_j we will define:

$$s_i^q = \int_{m_{i\min}}^{m_{i\max}} \mu^{s_i^q}(m_i)/m_i \, ;$$

$$v_j = \int_{p_{\min}}^{p_{\max}} \mu^{v_j}(p)/p \, ,$$

where $s_i^q(m_i)$ - function of the accessory entrance variable $m_i \in [m_{i\min}, m_{i\max}]$ to set $s_i^q \in S_i, q = \overline{1,l_i}, i = \overline{1,n}$; $\mu^{v_j}(y)$ - membership function of the accessory exit variable $p \in [p_{\min}, p_{\max}]$ - to decision $v_j \in V, j = \overline{1,r}$.

Let's admit, that is available N expert data, about effective actions of crews in the typical conditions plane damaged, establishing connection between the developed flight situation and necessary control action. Distributed them as follows: $N = k_1 + k_2 + ... + k_r$, where k_j - number of the data corresponding to exit decision $v_j, j = \overline{1,r}, r$ - number of exit decisions, $k_1 \neq k_2 \neq ... \neq k_r$. Preposed, that $N < l_1 \cdot l_2 \cdot ... \cdot l_n$, i.e. number of data less than full search of various combinations $(l_i, i = \overline{1,n})$.

Let's number N data as follows:

$11, 12, \ldots, 1k_1$ - numbers combinations entrance variables for controlling influence v_1 on the plane;

$21, 22, \ldots, 2k_2$ - numbers combinations entrance variables for controlling influence v_2 on the plane;

$j1, j2, \ldots, jk_j$ - numbers combinations entrance variables for controlling influence v_j on the plane;

$r1, r2, \ldots, rk_r$ - numbers of combinations of entrance variables for operating influence v_r on the plane.

By results of expert estimations about communication between inputs and an exit we construct the table following control rules (tab. 1), which reflects experience and knowledge pilots in similar situations.

Dimension of a matrix: $(n+1) \times N$, where $(n+1)$ - number of columns, and $N = k_1 + k_2 + ... + k_r$ - number of lines;

The first n matrix columns correspond entrance variable $m_i, i = \overline{1,n}$, and $(n+1)$ column corresponds to values $v_j, j = \overline{1,r}$ of target variable p.

Each line of a matrix represents some combination of values entrance variables, carried by the expert (pilot) to one of possible values of exit variable p. Thus: the first k_1 correspond lines to value of the exit variable $p = v_1$, the second k_2 lines - to value $p = v_2$ etc., the last k_r lines - to value $p = v_r$.

Thus linguistic estimation s_i^{jq} gets out of fuzzy set corresponding to variable m_i, i.e. $s_i^{jq} \in S_i, i = \overline{1,n}, j = \overline{1,r}, q = \overline{1,k_j}$. The generated table “knowledge base” is presented.

Table 1

Matrix of knowledge

Number combination	Entrance variables				Exit variable
	m_1	m_2	m_i …	m_n	p
11	s_1^{11}	s_2^{11}	s_i^{11}	s_n^{11}	v_1
12	s_1^{12}	s_2^{12}	s_i^{12}	s_n^{12}	
…	…	…	…	…	
$1\,k_1$	$s_1^{1k_1}$	$s_2^{1k_1}$	$s_i^{1k_1}$	$s_n^{1k_1}$	
…					
$j\,1$	s_1^{j1}	s_2^{j1}	s_i^{j1}	s_n^{j1}	v_2
$j\,2$	s_1^{j2}	s_2^{j2}	s_i^{j2}	s_n^{j2}	
…	…	…	…	…	
jk_j	$s_1^{jk_j}$	$s_2^{jk_j}$	… $s_i^{jk_j}$ …	$s_n^{jk_j}$	
…					
$r\,1$	s_1^{r1}	s_2^{r1}	s_i^{r1}	s_n^{r1}	v_r
$r\,2$	s_1^{r2}	s_2^{r2}	s_i^{r2}	s_n^{r2}	
…	…	…	…	…	
$r\,k_r$	$s_1^{rk_r}$	$s_2^{rk_r}$	$s_i^{rk_r}$	$s_n^{rk_r}$	

The available expert data presented in the base of knowledge establish connection between a set of the entrance parameters characterizing systems «the plane - intellectual system - environment - damage» $m_1 - m_n$ and corresponding system's conditions control action $v_j, j = \overline{1,r}$ on the plane, in the form of logic statements: the first rule's part (if) specifies conditions system «the plane - intellectual system - environment - damage», the second part (then) prescribes the corresponding control action.:

If $(m_1 = s_1^{11})$ and $(m_2 = s_2^{11})$ and … and $(m_n = s_n^{11})$ or $(m_1 = s_1^{12})$ and $(m_2 = s_2^{12})$ and … and $(s_n = m_n^{12})$ or $(m_1 = s_1^{1k_1})$ и $(m_2 = s_2^{1k_1})$ and … and $(m_n = s_n^{1k_1})$, $p = v_1$, differently - the worse variant development extra situation;

If $(m_1 = s_1^{21})$ and $(m_2 = s_2^{21})$ and … and $(p_n = s_n^{21})$ or $(m_1 = s_1^{22})$ and $(m_2 = s_2^{22})$ and … and $(m_n = s_n^{22})$ or $(m_1 = s_1^{2k_2})$ и $(m_2 = s_2^{2k_2})$ and … and $(m_n = s_n^{2k_2})$, $p = v_2$, differently - the worse variant development extra situation;

If $(m_1 = s_1^{r1})$ and $(m_2 = s_2^{r1})$ and … and $(m_n = s_n^{r1})$ or $(m_1 = a_1^{r2})$ and $(m_2 = s_2^{r2})$ and … and $(m_n = s_n^{r2})$ or $(m_1 = s_1^{rk_r})$ and $(m_2 = s_2^{rk_r})$ and … and $(m_n = s_n^{rk_r})$, $p = v_r$, differently - the worse variant development extra situation,

where $v_j (j = \overline{1,r})$ - linguistic estimation exst variable p defined from fuzzy set P; s_i^{jq} - linguistic estimation entrance variable m_i in q line j disjunction, chosen from corresponding fuzzy set $S_i, i = \overline{1,n}, j = \overline{1,r}, q = \overline{1,k_j}$; k_j - quantity of the rules defining value exit variable.

Using operations $\bigcup$ (or), $\bigcap$ (and) the system's logic statements is presented in more compact kind:

$$\bigcup_{q=1}^{k_j} \left[\bigcap_{i=1}^{n} (m_i = s_i^{jq}) \right] \to p = v_j, j = \overline{1,r}. \qquad (4)$$

Thus, the required parity (1) establishing connection between entrance parameters, characterizing developed extra situation m_i and necessary for prevention developmenting this situation controlling p, formalized fuzzy logic statements are based on the knowledge base.

Linguistic estimations s_i^{jq} of variables $m_1 - m_n$ entering into logic statements "decisions" v_j considered as the fuzzy sets $S_i = [m_{i\min}, m_{i\max}], i = \overline{1,n}, j = \overline{1,r}$.

Let $\mu^{s_i^{jq}}(m_i)$ - membership function parameter $m_i \in [m_{i\min}, m_{i\max}], i = \overline{1,n}$ to fuzzy set $s_i^{jq}, i = \overline{1,n}, j = \overline{1,r}, q = \overline{1,k_j}$, and $\mu^{v_j}(m_1, m_2, ..., m_n)$ - membership function vector of entrance variables to value exit variable.

Communication between these membership functions are defined by the fuzzy knowledge base (4) which transformed to a following kind:

$$\begin{gathered}
\mu^{v1}(m_1, m_2, ..., m_n) = \mu^{s_1^{11}}(m_1) \wedge \mu^{s_2^{11}}(m_2) \wedge ... \wedge \mu^{s_n^{11}}(m_n) \vee \\
\vee \mu^{s_1^{12}}(m_1) \wedge \mu^{s_2^{12}}(m_2) \wedge ... \wedge \mu^{s_n^{12}}(m_n) \vee ... \vee \mu^{s_1^{1k_1}}(m_1) \wedge \mu^{s_2^{1k_1}}(m_2) \wedge ... \wedge \mu^{s_n^{1k_1}}(m_n), \\
\mu^{v2}(m_1, m_2, ..., m_n) = \mu^{s_1^{21}}(m_1) \wedge \mu^{s_2^{21}}(m_2) \wedge ... \wedge \mu^{s_n^{21}}(m_n) \vee \\
\vee \mu^{s_1^{22}}(m_1) \wedge \mu^{s_2^{22}}(m_2) \wedge ... \wedge \mu^{s_n^{22}}(m_n) \vee ... \vee \mu^{s_1^{2k_2}}(m_1) \wedge \mu^{s_2^{2k_2}}(m_2) \wedge ... \wedge \mu^{s_n^{2k_2}}(m_n), \\
\mu^{vr}(m_1, m_2, ..., m_n) = \mu^{s_1^{r1}}(m_1) \wedge \mu^{s_2^{r1}}(m_2) \wedge ... \wedge \mu^{s_n^{r1}}(m_n) \vee \\
\vee \mu^{s_1^{r2}}(m_1) \wedge \mu^{s_2^{r2}}(m_2) \wedge ... \wedge \mu^{s_n^{r2}}(m_n) \vee ... \vee \mu^{s_1^{rk_r}}(m_1) \wedge \mu^{s_2^{rk_r}}(m_2) \wedge ... \wedge \mu^{s_n^{rk_r}}(m_n),
\end{gathered} \tag{5}$$

where $\vee$ - logic OR, $\wedge$ logic And.

The fuzzy logic equations (5) are received from fuzzy knowledge base by replacement of linguistic terms s_i^{jq} and v_j on corresponding membership functions, and operations $\bigcup$ and $\bigcap$ on operation $\vee$ and $\wedge$. The system of the logic equations (5) is written down in compact kind:

$$\mu^{v_j}(m_1, m_2, ..., m_n) = \mathop{\vee}_{q=1}^{k_j}[\mathop{\wedge}_{i=1}^{n} \mu^{s_i^{jq}}(m_i)], j = \overline{1,r}$$

Conclusions: instead of use one control law as in classical regulators, in "knowledge base" intellectual system using quantity private control laws, for each point information field. Suppress stochastic influence more effectively. Knowledge-based systems have higher level of flexibility and adaptability to various kinds influences (turbulence, flaws, etc.).

A.A. Tunik Doct. of Sci.(Eng.), Professor, e-mail: aatunik@yahoo.com (NAU, Ukraine)
M. A. Touat, Post. Graduate student, e-mail: mohand_touat@yahoo.fr(NAU, Ukraine)
M.M. Komnatska, Post. Graduate student, e-mail: knopka_forever@ukr.net(NAU, Ukraine)

COMBINATION OF FUZZY AND CRISP CONTROL IN THE AIRBORNE ROBUST MULTIVARIABLE SYSTEMS

This paper is devoted to the combination of the 'crisp' and 'soft' algorithms applied to multivariable robust flight control. The control design is divided into two stages .At the first stage a crisp inner loop controller is designed based on Luenbreger observer and linear quadratic regulator. Robust $\boldsymbol{H_2 / H_\infty}$-optimization procedure is applied to the above controller to seek the trade-off between the robustness and performances of the inner loop. The second stage consists of the outer loop controller design based on fuzzy inference system. The designed soft controller possesses the ability of learning from a reference model adjusting its knowledge base. The case study is devoted to the application of aforementioned approach to the small UAV flight control.

Introduction

Flight Control System (FCS) has to suppress exogenous stochastic disturbances produced by turbulent atmosphere and to provide required performance and stability in the presence of parametrical internal disturbances for all flight modes inside the flight envelope. Nowadays the robust control can be a solution for this problem, especially in the area of the Unmanned Aerial Vehicles (UAV). This is explained by the fact, that parameters of the small UAV are very susceptible towards changeable atmosphere conditions. The FCS for such kind of UAV must be low in price, weight, power consumption. The limited number of navigation sensors, in turn, restricts the number of measured states. The traditional optimal control procedure supposes that all components of the state space should be available for measures. In case, when the full measurements are not available for measurements, a state observer is necessary to restore them. In this paper we suppose that measurements are not affected by noises that justify the use of Luenberger observer as an alternative to Kalman Filter. It is explained by the fact that usage of Kalman Filter leads to increasing of the controller's order, thus control law is getting more difficult for practical implementation. From other hand, including Kalman observer in the closed loop system leads to some decreasing of its robustness [16].

At this stage of design we are ready to apply the robust $\boldsymbol{H_2 / H_\infty}$- optimization procedure. The aim of this procedure is to seek a compromise between the robustness and performances of the closed loop system and finding such kind of controller that could guarantee stability and acceptable performance for the family of nominal and parametrically perturbed models.

The second stage of this paper is devoted to the design of the outer loop controller, which is based on fuzzy inference system. The fuzzy controller used in this report is inspired from the adaptive conventional control [8, 10]. The aforementioned controller has the ability of learning from a reference model, which approximates the UAV flight dynamics. The design of the fuzzy controller includes the choice of a lot of parameters by the designer on the basis of the expert's knowledge about the system, for this reason some errors in the knowledge base or in the choice of some parameters may occur. For this reason the fuzzy controller should have the ability to synthesize or to update its knowledge base, if some uncertainties in the model of UAV occurred during the flight.

The combination of the crisp and soft control is motivated by the high order of the controlled plant. Such method allows simplifying the fuzzy control law from one hand and avoids the redundancy of the rules in the knowledge base from other hand, reducing the amount of the inputs to the fuzzy controller to the minimum [10-11].

We have designed crisp controller in the inner loop for the Pitch Angle Hold Mode (PAH) and the Velocity Hold Mode (VHM). The Altitude Hold Mode (AHM) is designed using the fuzzy controller, the output of the outer loop constitutes the reference to the PAH. The efficiency of the design method is proven in the case study of Aerosonde UAV's longitudinal channel [2] by control system synthesis and its simulation.

Synthesis of Luenberger observer and restoring complete state space vector of the UAV

It is well known, that Flight Control System for small UAV with cheap navigation sensors and airborne computer with limited abilities should provide nominal performance and robust stability. Therefore, the control law should be simple enough to be implemented in the airborne equipment. The flight control system is provided by incomplete measuring of the state space vector, thus for constructing optimal controller first of all the full state vector should be restored using state observer; in our case Luenberger observer is adopted as it was mentioned above. Let the following equation describes the model of the controlled model:

$$\mathbf{\dot{x}(t) = Ax(t) + Bu(t)}, \tag{1}$$

Measured part of the state space vector is described by the following expression:

$$\mathbf{y(t) = Cx(t)}. \tag{2}$$

Besides that, $\mathbf{A} \in \mathbf{R}^{\mathbf{nxn}}$, $\mathbf{C} \in \mathbf{R}^{\mathbf{lxn}}$, where $l < n$. Thus, number of measuring variables l less than number of all phase coordinate n, so we must define observer's gain matrix $\mathbf{F}$ that minimize the error $e = x - \tilde{x}$.

Let the vector $\mathbf{p(t)}$ defines the state variables that are not available for measure [12]:

$$\mathbf{p(t) = C^{'}x(t)}$$

where $\mathbf{C}^{'}$ stands for the observation matrix of variables to be restored. According to the following relation:

$$\mathbf{y(t) = Cx(t)}$$

$$\mathbf{p(t) = C^{'}x(t)}$$

The full state variables of the system are defined as:

$$\mathbf{x(t)} = \begin{pmatrix} \mathbf{C} \\ \mathbf{C}^{'} \end{pmatrix}^{-1} \begin{pmatrix} \mathbf{y(t)} \\ \mathbf{p(t)} \end{pmatrix}.$$

It is conveniently to write down

$$\begin{pmatrix} \mathbf{C} \\ \mathbf{C}^{'} \end{pmatrix} = (\mathbf{L}_1, \mathbf{L}_2),$$

thus:

$$\mathbf{x(t) = L_1 y(t) + L_2 p(t)}$$

Next we define the estimation of $\tilde{p}(t)$ using following differential equation:

$$\dot{\tilde{p}}(t) = C^{'}AL_2\tilde{p}(t) + C^{'}AL_1 y(t) + C^{'}Bu(t) \tag{3}$$

where $\mathbf{y(t)}$ and u(t) are systems output and control variables respectively. The estimation of error between measured and unmeasured components of the state vector x(t) can be defined as follows [12]:

$$q(t) = \tilde{p}(t) - Fy(t). \tag{4}$$

In accordance with [12] from equations (3), (4) it is possible to find $\mathbf{q(t)}$ and restored complete state vector $\tilde{x}(t)$ using Luenberger observer:

$$\dot{q}(t) = [C'AL_2 - FCAL_2]q(t) + [C'AL_2F + C'AL_1 - FCAL_1 - FCAL_1F]y(t) + [C'B - FCB]u(t) \tag{5}$$

$$\tilde{x}(t) = L_2 q(t) + (L_1 + L_2 F)y(t). \tag{6}$$

Equation (5), (6) describes low-order observer. This observer must be stable, so it is necessary to choose the observer's gain matrix $\boldsymbol{F}$, which can place the eigenvalues of the matrix $(C' - FC)AL_2$ in the left half plane at some distance from imaginary axis. In MATLAB it is possible to do with command "place.m", thus completing the synthesis of observer.

Sub-optimal control synthesis

Using completely restored state vector $\tilde{x}$ it is possible to find an optimal deterministic controller that minimizes a discrete cost function

$$J_d = \sum_{n=1}^{\infty}\left(\tilde{x}(n)^T Q\,\tilde{x}(n) + u(n)^T R\,u(n)\right) \tag{7}$$

where Q, R are diagonal matrices, weighting each state and control variables respectively. In the common performance index (8). This controller uses output static feedback:

$$u(n) = -K\,\tilde{x}(n) \tag{8}$$

where gain matrix $\boldsymbol{K}$ is determined by expression:

$$\boldsymbol{K = (R + B^T PB)^{-1} B^T PA} \tag{9}$$

and **P** - solution of the algebraic Riccati equation, represented below:

$$\boldsymbol{P = Q + A^T (P - PB(R + B^T PB)^{-1} B^T P)A} \tag{10}$$

This controller is optimal with respect to the estimation $\tilde{x}$, but sub-optimal with respect to the actual state vector x(t). Optimal stochastic control requires the application of the separation theorem and Kalman filtering.

Parameterization and "robustization" of the inner loop controller

The robustness requirements to the flight control system design include some specifications of parameter's uncertainty, within which control system must preserve its stability and acceptable performance. This uncertainty could be caused by various physical reasons, which produce certain deviations of model's parameters from their "nominal" values. In this case we can consider several models, produced by parametric disturbances, and the task of the robust control is to find such single controller, which could guarantee stability and acceptable performance for the family of the nominal and perturbed models. The solution of this problem can be achieved by the convex optimization procedure using Composite Performance Index (CPI), consisting of estimations of performance and robustness for the nominal and perturbed closed loop systems with corresponding LaGrange factors, weighting the contribution of each estimation in the CPI [6, 13, 14]. The entries of the controller gain matrix $\boldsymbol{K}$ from (9) and eigenvalues of the observer computed in the last section can be used as the initial variables for the optimization procedure. Running optimization procedure several times with different LaGrange factors allows finding the desirable trade-off between performance and robustness. It is known [1, 4, 6], that the performance of system could be estimated by $\boldsymbol{H_2}$-norm for deterministic as well as for stochastic case when the model of the turbulence, represented in this report by the Dryden filter, is connected in series to the model. We shall consider both this cases, because it is important to stabilize the UAV at the deterministic commands as well as under turbulent wind during long time. The $\boldsymbol{H_\infty}$-norm of the closed loop system is used to estimate the robustness of the system. The same computations are performed for the nominal closed loop system and for perturbed models.

$\boldsymbol{H_2}$-norm for nominal and perturbed systems in the deterministic case is given by the following expression:

$$\boldsymbol{J_d = \sqrt{\sum_{n=1}^{\infty}\left(X^T(n)\,Q\;X(n) + U(n)^T RU(n)\right)}} \tag{11}$$

with corresponding diagonal weight functions Q, R for each state space and control variables. In the stochastic case, represented in Fig.1, $\boldsymbol{H_2}$-norm is computed for the nominal model and the perturbed models as follows:

$$\boldsymbol{J_s = \left(E_M\sqrt{\sum_{n=1}^{\infty}\left(X^T(n)\,Q\;X(n) + U(n)^T RU(n)\right)}\right)} \tag{12}$$

where E_M is the symbol of the expectation operator, produced by the ensemble averaging.

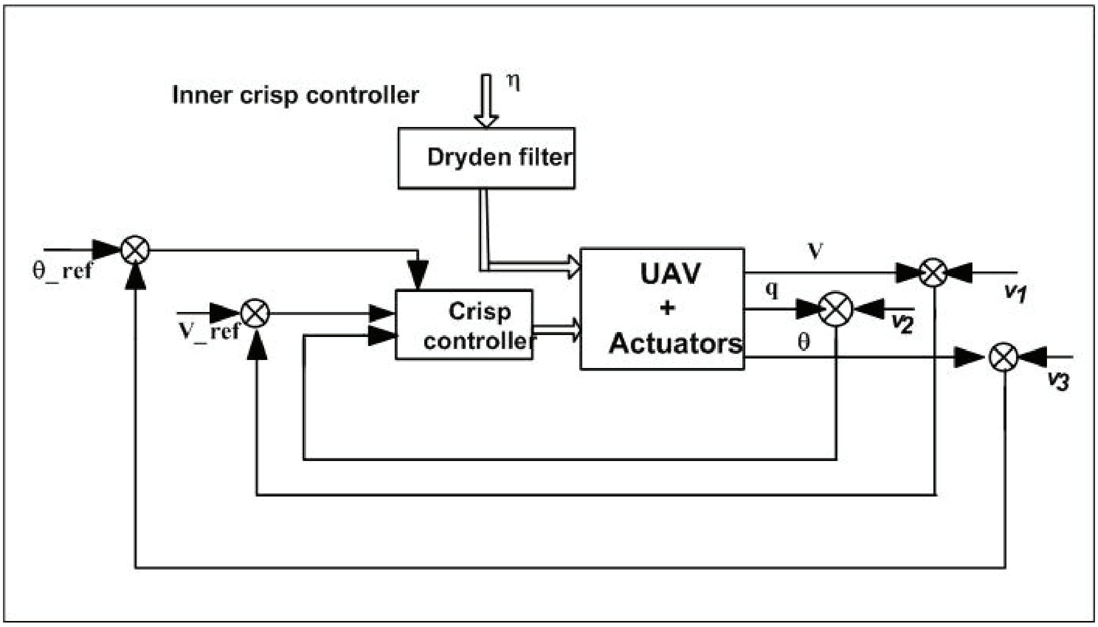


Fig.1. Inner loop controller.

The H_∞-norm is computed for the complementary sensitivity function and is given by the following expression:

$$\|T\|_\infty = sup\,\overline{\sigma}(T(j\omega)),\; 0 \le \omega \le \infty \tag{13}$$

where $\overline{\sigma}(T(j\omega))$ is the maximal singular value of the transfer matrix $T(j\omega)$ at the current frequency ω.

The CPI is given in the following:

$$J_1(K,eig) = \lambda_{dn}J_d + \lambda_{dp}J_d^p + \lambda_{sn}J_s + \lambda_{sp}J_s^p + \lambda_\infty\|T\|_\infty + \lambda_\infty^p\|T\|_\infty^{\;p} \tag{14}$$

where the subscripts d and s stand for the deterministic and stochastic, respectively. $\lambda_{dn},\lambda_{dp},\lambda_{sn},\lambda_{sp},\lambda_\infty,\lambda_\infty^p$ - are the corresponding LaGrange weight coefficients. Increasing or decreasing the weights it is possible to reach the trade-off between the performance and robustness of closed loop system. Moreover, the total cost function (14) for running optimization procedure has to include some penalty function (**PF**) for violation of the location's area of the closed loop system poles in the complex plane. The penalty function used in this paper is defined by the following relation [6]:

$$PFi\;(d_m) = \begin{cases} 0, if\; d_m \ge d_{m1} \\ \dfrac{P}{2}\left[1+cos\left(\dfrac{\pi(d_m-d_0)}{d_{m1}-d_0}\right)\right] & if\; d_0 < d_m < d_{m1} \\ P, if\; d_m \le d_0 \end{cases} \tag{15}$$

where P is a very large value (for example $P = 10^4 \div 10^6$). Optimization procedure has to find optimal values for the components static gain matrix K and eigenvalues of the Luenberger observer defined by vector eig. Some parameters of controller could be chosen sometimes unrealistically large. In this case it is useful to add to PF well-known restrictive term: $PF_r = \sum_{r=1}^{\ell} \lambda_r \cdot p_r^2$, where ℓ is a number of parameters p_r, which need to be restricted, λ_r is the weight factor.

Finally, the total cost function to be optimized is represented as:

$$J(K,eig) = J_1(K,eig) + PF \tag{16}$$

Design and implementation of fuzzy controller [7, 9, 10, 15]

Fuzzy control provides a formal methodology for representing, manipulating and implementing a human's heuristic knowledge about how to control a system. This artificial intelligence system is also used for increasing robustness of the flight control systems [17]. In this report Fuzzy Model Reference Learning Control (FMRLC) is designed as solution to this problem [10].

The block diagram in Fig.2. represents the structure of the aforementioned controller for the altitude hold mode. As it is depicted in figure, the FMRLC has four main parts: the inner loop control model, which is described in the previous chapter; the fuzzy controller (FC), the reference model (RM) and the learning mechanism, which is divided into two parts: fuzzy inverse model (FIM) and knowledge base modifier (KBM) [10]. The goal of this method is to synthesize fuzzy controller and to adjust its membership functions in order to withstand to the action of parametric disturbances in the controlled plant. The different parts of the scheme are explained in the next section.

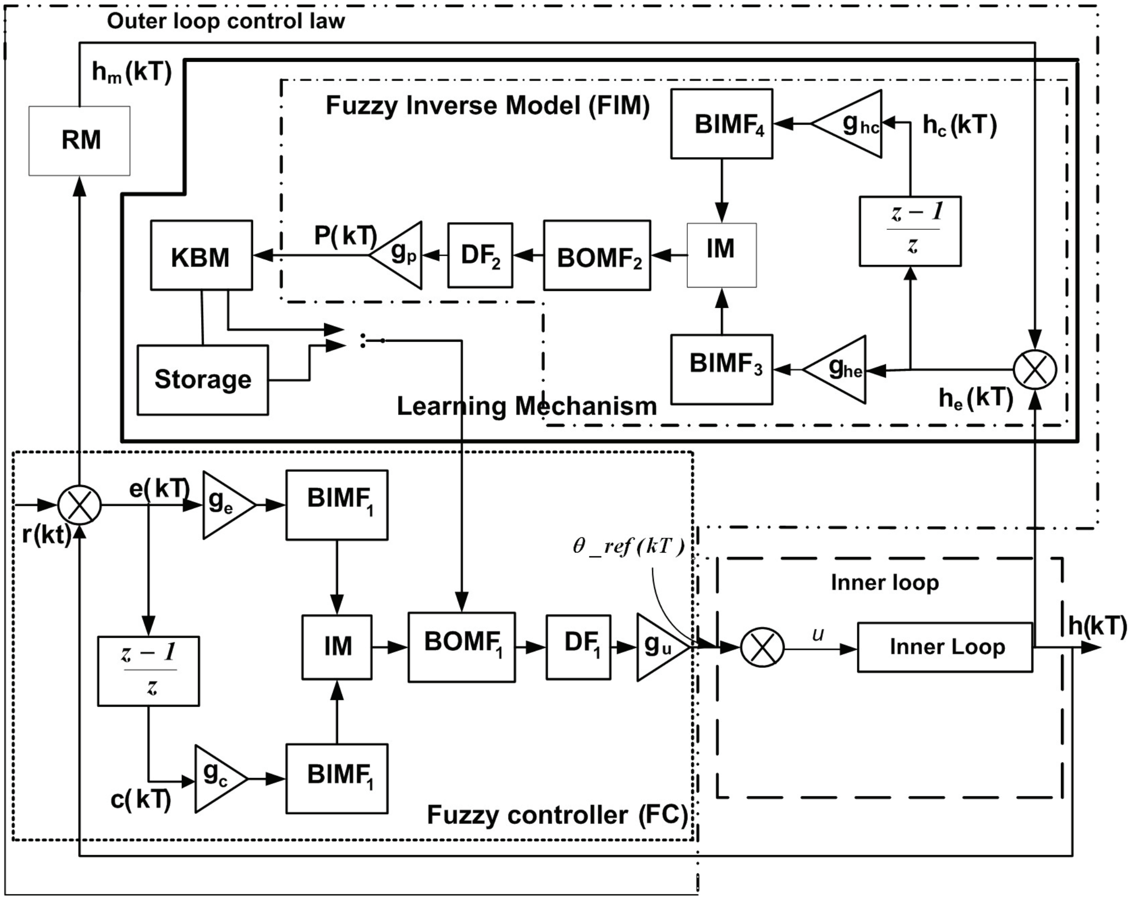


Fig.2. Block diagram of FMRLC

The goal of the Fuzzy Controller (FC) designed in this paper is to hold the altitude at the given reference $\boldsymbol{r(kT)}$ using error signal $e(kT)=r(kT)-h(kT)$. The first difference of this error $c(kT)=e(kT)-e((k-1)T)$ is used for improvement of the transient process in this system. The input scaling factors $\boldsymbol{g_e}$ and $\boldsymbol{g_c}$ are used to normalize the error and its derivative to be inside the interval $\boldsymbol{[-1 \quad 1]}$. The input membership functions are implemented in $BIMF_1$ for the altitude error and $BIMF_2$ for the derivative of the altitude error, the output membership functions are given in the $BOMF_1$. The inference mechanism (IM) used in this study is Mamdani-type. It is expressed in the form of "IF-THEN" rules. Defuzzification uses the Center Of Gravity (COG) method and it is implemented in the block DF_1. The output of FC constitutes the inner loop (pitch hold) reference input $\boldsymbol{\theta\_ref(kT)}$ and it is normalized to same interval as the input with the scaling factor $\boldsymbol{g_u}$.

The inner loop represents the generalized plant with its actuators augmented with the turbulence model (Dryden filter) controlled by the inner loop's crisp controller synthesized in the first section. The desired dynamics of the UAV is approximated with the second order Reference Model (RM), with $\boldsymbol{30\,sec}$ settling time and without overshoot. The last part of the block diagram is the learning mechanism. It modifies the knowledge base (membership functions) of the direct fuzzy controller so, that the closed loop system tries to behave like the reference model. These knowledge base modifications are made on the basis of observing data from the controlled process, the reference model and the fuzzy controller. In accordance with Fig. 2 the learning mechanism consists of two parts: a fuzzy inverse model (FIM) and a knowledge base modifier (KBM). FIM performs the function of mapping the error $h_e(kT)$ and the change of error $h_c(kT) = h_e(kT) - h_e((k-1)T)$, to the variations of the FC output membership function's parameters $p = [p_1, \cdots, p_r]^T$ in BOMF$_1$, which are necessary to force $h_e(kT)$ to zero. These parameters are the shifts of positions of the output membership function's centers. KBM performs the function of modifying the fuzzy controller's knowledge base to perform the needed change in the plant's inputs.

The fuzzy inverse model uses the same inference mechanism as the fuzzy controller (FC). FIM simply maps outputs $h_e(kT)$ and $h_c(kT)$ to the necessary changes in the plant inputs, that is why it is called "fuzzy inverse model". Hence, FIM is used to characterize how to change the plant inputs to force the plant output $h(kT)$ to be as close as possible to $h_m(kT)$. Likewise to the fuzzy controller, the FIM shown in Fig.2 contains normalizing scaling factors, namely g_{he}, g_{hc} and g_p for each universe of discourse. Selection of the normalizing gains can impact the overall performance of the system. The knowledge base for the fuzzy inverse model is generated from fuzzy rules of the form:

$$\text{IF } \tilde{h}_e \text{ is } H_e^j \text{ AND } \tilde{h}_c \text{ is } H_c^k \text{ THEN } \tilde{p} \text{ is } P^{j,k}$$

$P^{j,k}(kT)$ is the necessary variation of position of the membership function's center, decreasing $h_e(kT)$.

The knowledge base modifier (KBM) performs the function of modifying the FC rule base to achieve better performance. By modifying the fuzzy controller's knowledge base, we may force the fuzzy controller to produce a desired output to make $h_e(kT)$ smaller. Then the next time we get similar values for the error and change in error, the input to the plant will be one that will reduce the error between the reference model and the plant output.

Assume that we use symmetric output membership function for the fuzzy controller, and let b_l denote the center of the membership function associated with $\tilde{\theta}_l\_ref$. Knowledge base modification is performed by shifting centers b_l of the membership function of the output linguistic value $\tilde{\theta}_l\_ref$, which are associated with the fuzzy controller rules that contributed to previous control action $\theta\_ref(kT - T)$. This is two-step process:

1. Find all FC rules, which satisfy the following condition:
$$\tau_k(e(kT - T), c(kT - T)) \succ 0 \tag{14}$$
$k = (1, l)$, τ_k defines the set of the Degrees of Firing (DOF) of rules at time $kT - T$, also called "active set".
2. Let b_l denote the center of l^{th} output membership function at time kT. For all rules in the active set, use $b_l(kT) = b_l(kT - T) + p_l(kT)$ to modify the output membership function centers. Rules that are not in the active set do not have their membership function modified. KBM includes also the storage (see Fig. 2), which preserves the results of tuning of membership functions, in order to be used when the output of the FC at time kT is the same at $kT - 1$.

Design and implementation of FMLRC

The total design procedure for the FMRLC, which is used in combination with "crisp" feedback, involves the following steps:

- The specification of a direct fuzzy controller with the set of membership functions that can be tuned. This fuzzy controller can be chosen via conventional (heuristic) fuzzy control design techniques for the nominal plant.

- The specification of the control system's reference model, which characterizes the desired system performance.
- The specification of the fuzzy inverse model, which characterizes how the plant's inputs should be changed in order to achieve desired performance.
- The selection of the normalizing gains for the fuzzy controller and the fuzzy inverse model.

So far as the selection of the normalizing gains for both the fuzzy controller and the fuzzy inverse model can impact the overall performance, it is necessary to provide a procedure for choosing these parameters. Due to physical constraints for a given system, the ranges of values for the process inputs and outputs are generally known from a qualitative analysis of the process especially, when the crisp prototype of system is determined via some known procedure of control synthesis. As a result, we can determine the range of values or the universe of discourse for $e(kT)$, $u(kT)$, $h_e(kT)$ and $p(kT)$. Consequently, g_e, g_c, g_u, g_{he} and g_p are chosen so that the appropriate universes of discourse are mapped to $[-1 \quad 1]$.They could be determined on the basis of the "crisp" prototype by iteratively applying inputs to $r(kT)$, observing $c(kT)$, and finding scaling factors to map the universes of discourse to $[-1 \quad 1]$.

Case study

Consider Aerosonde UAV nonlinear model linearized at different trim conditions [2, 3] inside the flight envelope. The state space vector for longitudinal channel: $x=[u,w,q,\vartheta,h,Щ]$, where **u** - horizontal velocity component, w-vertical velocity component, **q** - pitch rate, ϑ - pitch angle, **Щ**- the engine's rotation speed (r.p.m). The control vector u consists of elevator and throttle deflections. Without loss of generality, we examine three models, nominal and two parametrically perturbed models. The nominal model is trimmed at true airspeed: $30\ m/sec$, the first and second parametrically models are trimmed at $25\,m/sec$ and $35\ m/sec$, respectively. It is explained by the fact that UAV flies in a wide range of velocity variations. It is known that parameters of the small UAV are vulnerable to the atmosphere conditions (air pressure, density, temperature). The aerodynamic and propulsive forces and moments that act on the aircraft are functions of the dynamic pressure, which takes into account changes in airspeed and air density, expressed as:

$$q_{dyn} = \rho V^2/2$$

Hence, the purpose of the optimization procedure consists of satisfying the performance and robustness requirements to the closed loop system with the same control law for the nominal and perturbed models.

The state space description of actuator connected in series with UAV model is the following:

$$\left[\begin{array}{c|c} A_a & B_a \\ \hline C_a & D_a \end{array}\right] = \left[\begin{array}{c|c} -1/T_a & 1/T_a \\ \hline 1 & 0 \end{array}\right],$$

where $T_a = 0,5$ - time constant.

Description of these plants can be represented with state space matrices A, B:

- for the nominal plan:

$$A_n = \begin{bmatrix} -0.2933 & 0.3877 & -0.5578 & -9.7843 & -0.0000 & 0.0138 \\ -0.5509 & -5.3691 & 29.2779 & -0.1849 & 0.0009 & 0 \\ 0.3382 & -5.6317 & -6.1948 & 0 & 0 & -0.0107 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0.0189 & -0.9998 & 0 & 29.9997 & 0 & 0 \\ 41.5394 & 0.7850 & 0 & 0 & -0.6355 & -3.8541 \end{bmatrix}; \quad B_n = \begin{bmatrix} -0.3375 & 0 \\ -3.7062 & 0 \\ -50.1802 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 2.6639\cdot 10^3 \end{bmatrix}$$

- for the first perturbed model:

$$A_{p1}=\begin{bmatrix} -0.2392 & 0.5304 & -1.1922 & -9.8089 & -0.0000 & 0.0116 \\ -0.5686 & -4.4716 & 24.3751 & -0.4762 & 0.0009 & 0 \\ 0.4302 & -4.8351 & -5.1587 & 0 & -0.0000 & -0.0090 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0.0485 & -0.9988 & 0 & 24.9998 & 0 & 0 \\ 34.6645 & 1.6829 & 0 & 0 & -0.0302 & -3.2321 \end{bmatrix}; \quad B_{p1}=\begin{bmatrix} 0.3521 & 0 \\ -2.5482 & 0 \\ -35.2102 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 389.6191 \end{bmatrix}$$

- for the second perturbed model:

$$A_{p2}=\begin{bmatrix} -0.35 & 0.28 & -0.05 & -9.82 & 0 & 0.01 \\ -0.55 & -6.25 & 35 & -0.01 & 0 & 0 \\ 0.28 & -6.43 & -7.21 & 0 & 0 & -0.01 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 35 & 0 & 0 \\ 48.5 & 0.08 & 0 & 0 & -0.78 & -4.43 \end{bmatrix}; \quad B_{p2}=\begin{bmatrix} 0.5 & 0 \\ -5 & 0 \\ -68.2 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 3040.3 \end{bmatrix}$$

where subscripts “n”, “p1”, “p2” stand for nominal and two perturbed models, respectively. The measured variables for the inner loop are $\overline{X}=[u \quad q \quad \theta]$, so the observation matrix is given as follows:

$$C=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}.$$

The state space description for the Dryden filter [5] for the nominal air speed $V_n = 30\ m/sec$ is given as follows:

$$A_{dr}=\begin{bmatrix} -1/\lambda_u & 0 & 0 \\ 0 & -1/\lambda_w & 0 \\ 0 & -K_q/\lambda_q^2 & -1/\lambda_q \end{bmatrix}; \quad B_{dr}=\begin{bmatrix} K_u/\lambda_u & 0 \\ 0 & K_w/\lambda_w \\ 0 & 0 \end{bmatrix}; \quad C_{dr}=\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & K_q/\lambda_q & 1 \end{bmatrix};$$

where the subscript w corresponds to vertical components and u for the longitudinal. In our case the Aerosonde flies at an altitude of $200m$, and in moderate turbulence. The parameters appearing in the state space of Dryden filter are given as follows [2, 5, 6]: $K_u=\sigma_u\sqrt{(2L_u/\pi V)}$, $\lambda_u = L_u/V$, $K_w = 2.2$, $\lambda_w = 0.6$, $K_q = 1/V$, $\lambda_q = 4b/\pi V$, where b is the Aerosonde’s wing span: $b = 2.9m$. The same parameters are defined for different models corresponding to different true airspeeds.

Simulation results

After running the robust H_2/H_∞ - optimization with appropriate LaGrange factors the compromise between the performances and robustness is achieved with the following gain matrix in relation (9);

$$K=\begin{bmatrix} 1.7863 & 0.7705 & -1.889 & -12.7676 & 0.0016 & 6.3863 & 0.0484 \\ 7.3209 & 1.1954 & -0.6379 & -24.0237 & 0.0837 & 1.1309 & 23.2957 \end{bmatrix}$$

the observer’s eigenvalues values are found as follows:

$$eig=[-14.7260 \quad -14.7261 \quad -22.6117]$$

The performances and robustness indices of the controller system for the nominal and perturbed plants are given in the Table 1.

Table 1

The performances and the robustness indices

Plant		H_2 Deterministic case	H_2 Stochastic case	H_∞-norm
Vn=30 [m/s]	nominal	0.1014	0.5658	3.6133
Vp1=25 [m/s]	Perturbed 1	0.0611	0.4416	3.4074
Vp1=35 [m/s]	Perturbed 2	0.1157	0.5695	3.9515

In order to hold the altitude at the reference input the parameters of the fuzzy model reference learning control are set as follows: the input scaling factors of the fuzzy controller (FC) are $g_e = 0.0357$ and $g_c = 0.6$ for the altitude error and change in altitude error, respectively, the output of FC is normalized to the interval $[-1 \quad 1]$ with $g_u = 0.87$. The initial rule base of the fuzzy controller is shown in the Table 2. The entries to this table are the centers of the output membership functions, which are chosen in this report to be symmetric triangles. The same structure for the fuzzy inverse model (FIM) is used with the scaling factors $g_{he} = 1/115$ for the error and $g_{hc} = 0.84$ for the change rate of the error; the output membership functions are normalized with $g_p = 0.0004$.

Table 2

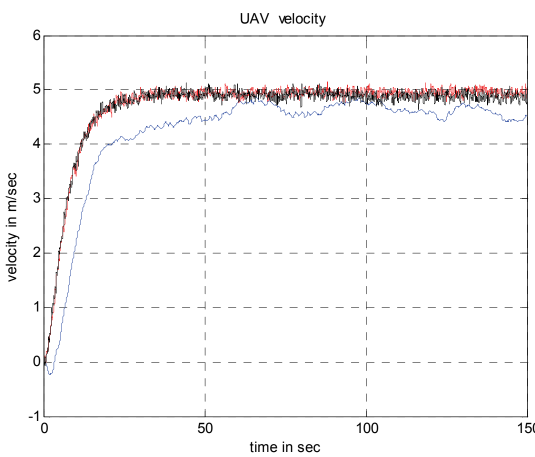
Initial rule base of the fuzzy controller

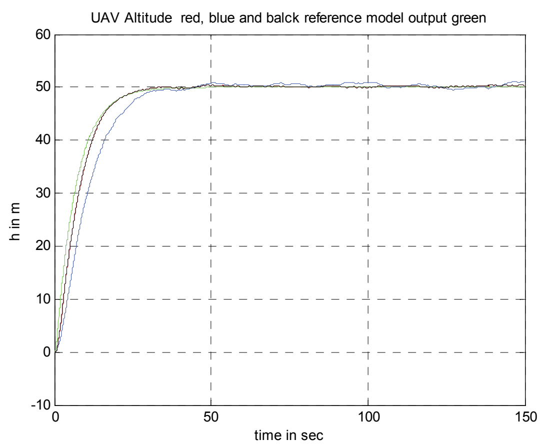
$U^{i,j}(kT)$		$e^i(kT)$										
		-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
	-1	-1	-1	-1	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0
	-0.8	-1	-1	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0	0.2
	-0.6	-1	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4
	-0.4	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6
	-0.2	-1	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8
$c^j(kT)$	0	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
	0.2	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1	1
	0.4	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1	1	1
	0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1	1	1	1
	0.8	-0.2	0	0.2	0.4	0.6	0.8	1	1	1	1	1
	1	0	0.2	0.4	0.6	0.8	1	1	1	1	1	1

The reference model used in the simulation is a second order model with and is given in the following state space model

$$Ar = \begin{bmatrix} -1.1701 & -0.1701 \\ 0.5 & 0 \end{bmatrix}; \; Br = \begin{bmatrix} 1 \\ 0 \end{bmatrix}; \; Cr = [0 \quad 0.1701]; \; Dr = 0 .$$

The following figures show the simulation results with the altitude and velocity reference signals equal to $h\_ref = 50m$, $V\_ref = 5\,m/sec$ respectively.





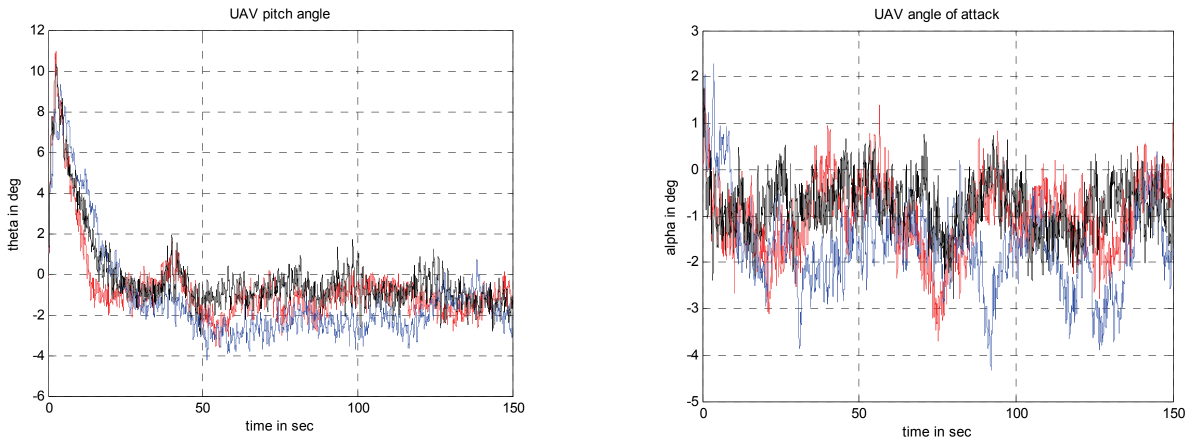


Fig. 3

The rule base of the fuzzy controller after learning from the reference model is given in the table 3, where adjusted entries are inserted in the bold rectangular.

Table 3.

The adjusted rule base

$U^{i,j}(kT)$	$e^i(kT)$											
		-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
	-1	-1	-1	-1	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0
	-0.8	-1	-1	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0	0.2
	-0.6	-1	-1	-1	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4
	-0.4	-1	-1	-1	-0.8	-0.5	-0.3	-0.1	0	0.2	0.4	0.6
	-0.2	-1	-1	-0.8	-0.6	-0.3	-0.1	0.001	0.2	0.4	0.6	0.8
$c^j(kT)$	0	-1	-0.8	-0.6	-0.4	-0.2005	-0.002	0.1	0.4	0.6	0.8	1
	0.2	-0.8	-0.6	-0.4	-0.2	-0.001	0.1	0.3	0.6	0.8	1	1
	0.4	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1	1	1
	0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1	1	1	1
	0.8	-0.2	0	0.2	0.4	0.6	0.8	1	1	1	1	1
	1	0	0.2	0.4	0.6	0.8	1	1	1	1	1	1

Conclusion

The purpose of the paper is robust autopilot design using combination of crisp control with hard computing and fuzzy control with soft computing. Procedure of robust H_2 / H_∞ optimization has been used to achieve the trade-off between the robustness and performances of the system with crisp structure for inner-loop. The Table 1 proves that purpose of the paper is achieved. The effectiveness of the proposed control scheme has been tested by computer simulation; the figures show that the flight requirement was respected for the nominal as well as for all perturbed models. The maximum deflections of the angle of attack and pitch angle are enclosed within acceptable intervals: $-3 < \alpha < 3$ **deg** and $-4 < \theta < 16$ deg respectively. The altitude h and velocity V are also held at their reference signals $50m$ and $5m/sec$ respectively with acceptable deflections.

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V.C. Novikov, doctor of those. sciences, prof. (National Aviation University, Ukrane)
V.A. Borsoev, doctor of those. sciences, prof. (National Aviation University, Ukrane)
V.N. Torishiy graduate student (National Aviation University, Ukrane)

CALCULATION OF DOPPLER DISPLACEMENT OF FREQUENCY FOR THE RADIO ENGINEERING SYSTEMS EXPLOITED IN HIGH BREADTHS

Intensity of influencing of reflecting layers ionospheres and tropospheres neodnorodnostey in high breadths substantially depends on speed of sun wind, state of the magnetic field of Earth, temperature of air, time of year, days and other factors. In the point of reception of pereotrazhennykh from different neodnorodnostey signals there can be a few and at imposition on each other these signals can bring in large errors during work RTS [1] .

For upgrading work RTS, exploited in high breadths, it is necessary to develop the method of division of lines and pereotrazhennykh waves, what the real article is devoted to.

Introductions to raising of task. Quality of work of radio engineering facilities (RTS) in an existent measure depends on properties of environment of distribution of radio waves in the different ranges of frequencies and in different geographic areas. In particular, in high breadths on quality of works RTS the features of arctic ionosphere, its heterogeneity and unstationaryness [1], influence can cause change of trajectories of distribution of radio waves and substantial distortion of descriptions of the adopted signals.

It is known that in the certain ranges of frequencies pithily reception plenty of pereotrazhennykh radio waves can come from different directions depending on the place of finding of neodnorodnostey. We will assume that reflecting the layers of neodnorodnostey located above an air ship (VS) and the following assumptions are here executed: heterogeneity is flat, ideally by a mirror surface and does not test moving, an earthly surface is considered flat, the trajectory of flight of VS is rectilineal and permanent on a height, the ground speed of flight is permanent.

We will consider that pithily F, moving in relation to an earthly surface and heterogeneity of troposphere with the ground speed $\overline{W}$, from the source of radiowill, located in a point A, the direct wave of AF and pereotrazhennaya comes from heterogeneity of troposphere wave of ABF (fig. 1). Above a terrene we will designate the height of finding of heterogeneity through $h_{тр}$, height of flight of airplane - according to H_n. We will designate a corner between the trajectory of pereotrazhennoy wave of BF and trajectory of flight of airplane through β, and corner between the trajectory of superficial wave of AF and plane of earth through ξ.

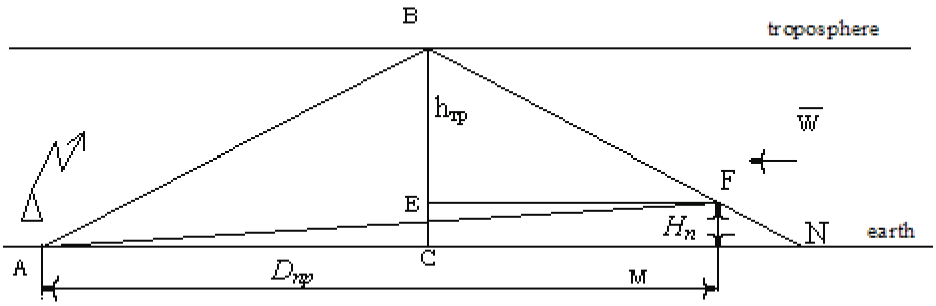

Fig. 1. Motion of rays of line and pereotrazhennoy radio waves of the taken the bearing wireless station.

It is known [2]that doplerovskoe displacement of frequency of the radio waves accepted on a mobile object, concernes by radial speed with which this object moves in relation to the point of radiation,

$$F_Д = \frac{f\overline{W}}{c}\cos\xi.$$

where: f - frequency of the radiated signal; $\overline{W}$ - the ground speed of locomotive object; c - velocity of light; ξ - corner between the trajectory of motion of object and trajectory of spreading radio wave.

Then, taking into account denotations on a fig. 1, doplerovskoe displacement of frequency for a direct wave can be certain on a formula:

$$F_{Дпр} = \frac{f\overline{W}}{c}\cos\xi. \quad (1)$$

and for a pereotrazhennoy wave on a formula:

$$F_{Дпер} = \frac{f\overline{W}}{c}\cos\beta. \quad (2)$$

From formulas (1) and (2) it is necessary that for the calculation of doplerovskogo displacement of frequencies to each of radio waves are the known sizes frequency radiations of signal and ground speed of locomotive object. At the same time corners unknown to us ξ and β desirably to express through the height of reflecting layer of heterogeneity of $h_{тр}$, height of flight of airplane of H_n and distance from the taken the bearing wireless station to the airplane Dnp (fig. 1), here corner ξ, it is possible to define as follows.

From ΔFMA we will define a corner ξ :

$$\xi' = arctg\frac{H_n}{D_{np}}. \quad (3)$$

Because ξ = ξ',

$$\xi = arctg\frac{H_n}{D_{np}} . \quad (4)$$

corner β concernes from ΔBEF

$$\beta = arctg\frac{BE}{EF}. \quad (5)$$

$$\frac{BC}{BE} = \frac{AC}{EF}, \quad \text{where we will find from} \quad AC = \frac{BC\cdot EF}{BE}. \quad (6)$$

From a fig. 1 it is necessary that

$$D_{np} = AC + CM . \quad (7)$$

$$CM = EF . \quad (8)$$

Then putting (6) and (8) in (7), we have:

$$D_{np} = \frac{BC}{BE}EF + EF \text{ , from where } EF = \frac{D_{np}}{1+\frac{BC}{BE}}. \quad (9)$$

Putting in expression for β the values of BE and BC (fig. 1), we have:

$$\beta = arctg\frac{(h_{TP} - H_{\Pi} + h_{TP})}{D_{np}}. \quad (10)$$

$$\beta = arctg\frac{2h_{TP} - H_{\Pi}}{D_{np}}. \quad (11)$$

Taking into account the values of corners ξ and β formulas (1) and (2) will assume a following kind:

$$F_{Дпр} = \frac{f\overline{W}}{c}\cos\left(arctg\frac{H_{\Pi}}{D_{np}}\right). \quad (12)$$

$$F_{Дпер} = \frac{f\overline{W}}{c}\cos\left(arctg\frac{2h_{TP} - H_{\Pi}}{D_{np}}\right). \quad (13)$$

At presence of inplane azimuthal corner q between direction of arrival of radio waves and trajectory of flight of airplane of expression (12) and (13) will be transformed to the kind:

$$F_{Дпр} = \frac{f\overline{W}}{c}\cos\left(arctg\frac{H_П}{D_{пр}}\right)\cos q\,. \qquad (14)$$

$$F_{Дпер} = \frac{f\overline{W}}{c}\cos\left(arctg\frac{2h_{TP} - H_П}{D_{пр}}\right)\cos q\,. \qquad (15)$$

It is necessary to mark that at flight of VS from the wireless station doplerovskaya frequency will matter negative (frequency of the adopted vibrations is below than frequency of the radiated signal) and, vice versa, at flight on the wireless station doplerovskaya frequency will be positive (frequency of the adopted vibrations is higher than frequency of the radiated signal).

At arrival pithily reception of a few pereotrazhennykh radio waves from neodnorodnostey a calculation for every wave is carried out on a formula (15).

We will define the difference of doplerovskogo displacement of frequencies between a line and pereotrazhennymy waves from vyrazhenyy (14) and (15):

$$\delta F_Д = \frac{f\overline{W}}{c}\left[\cos\left(arctg\frac{2h_{TP} - H_П}{D_{пр}}\right) - \cos\left(arctg\frac{H_П}{D_{пр}}\right)\right]\cos q\,. \qquad (16)$$

We will transform expression (16) taking into account a formula [3]:

$$\cos(arctgx) = \frac{1}{\sqrt{1+x^2}}\,. \qquad (17)$$

Then:

$$\cos\left(arctg\frac{2h_{пр} - H_П}{D_{пр}}\right) = \frac{D_{пр}}{\sqrt{D_{пр}^2 + (2h_{TP} - H_П)^2}}\,. \qquad (18)$$

$$\cos\left(arctg\frac{H_П}{D_{пр}}\right) = \frac{D_{пр}}{\sqrt{D_{пр}^2 + H_П^2}}\,. \qquad (19)$$

Putting (18) and (19) in expression (16), we will get, that the difference of doplerovskogo displacement of frequencies between a line and pereotrazhennymy waves is equal:

$$\delta F_Д = -\frac{f\overline{W}D_{пр}}{c\sqrt{D_{пр}^2 + H_П^2}}\left(1 - \frac{1}{\sqrt{1 + \frac{4h_{пр}(h_{пр} - H_П)}{D_{пр}^2 + H_П^2}}}\right)\cos q\,. \qquad (20)$$

Consequently the size of difference of doplerovskogo displacement of frequencies between a line and pereotrazhennoy waves of $\delta F_Д$ substantially depends on ground speed $\overline{W}$, height between heterogeneity of troposphere and terrene $h_{тр}$, , height of flight of airplane of H_n, distances to the taken the bearing lighthouse *Dnp,* corner of q between direction of arrival of radio wave and trajectory of flight of airplane. For objects flying on a maximum low height or locomotive by earth ($H_n = 0$), at the value of corner of q = 0 formula (20) can be simplified to the kind:

$$\delta F_Д = \frac{f\overline{W}D_{пр}}{c}\left(1 - \frac{D_{пр}}{\sqrt{D_{пр}^2 + 4h_{TP}^2}}\right). \qquad (21)$$

From the analysis of formula (21) ensues that at $D_{пр} \to \infty$ that at the large deletes from the wireless station, difference between doplerovskymy displacements of frequencies between a line and pereotrazhennymy waves, aspires to the zero, t.e. $\delta F_Д \to 0$. At flight on a transmitter, t.e. at diminishing *Dnp,* displacement of $\delta F_Д$ aspires to the limit equal $\frac{fW}{c}$.

On a fig. 2 dependence of doplerovskogo displacement of frequency of line and pereotrazhennoy wave is resulted on distance to the ground lighthouse radiative signals on f =118 Mhz. Calculations were conducted for a helicopter, executing flight by speed W = 50 km/hour.

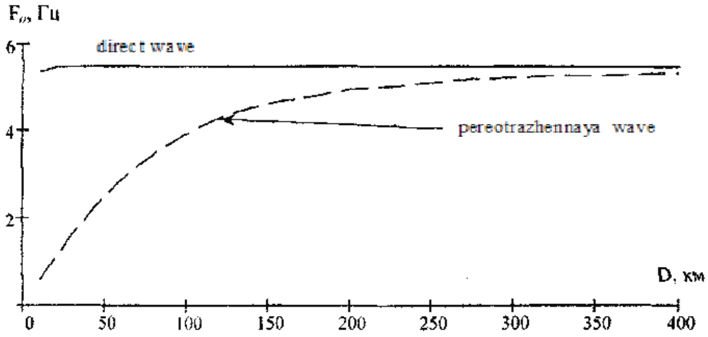

Fig. 2. Graph of dependence of doplerovskogo displacement of frequencies from distance to the ground lighthouse.

Conclusion. It ensues from poluchenykh expressions and resulted graph, that during setting of receiver on a mobile object possibly division of pereotrazhenykh and direct radio waves.

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V.N.Shutko, doctor of technical science (National Aviation University, Ukraine)

A NEW MATHEMATICAL TECHNOLOGY OF COMPRESSION AND QUICK DECOMPRESSION OF VIDEOIMAGES

The new method is proposed, which allows to increase digital picture compression by 40 % on the average at the same quality as compared with well-known wavelets.

All modern systems of transmission and storage of digital photos, digital video etc. use algorithm for picture compression. Thus one minute recording of video TV format 720*576 pixels 25 shots per second in RGB system needs 1.86 GB of memory for its storage. So one DVD-ROM of 4.7 GB volume of memory can contain about two and half minutes and one CD-ROM of 700 MB of memory can contain less than one minute of film in such format. Some dozens of discs would have to be bought for watching video film without picture compression algorithms.

For solving above mentioned technical problems methods of picture compression are being developed. It is the most urgent commercial problem for mathematicians worldwide since satellite digital television, digital photo and video cameras, video telephones, internet videoconferences, video security systems, film and photo recordings on CD-ROM and DVD-ROM etc. operation is impossible without such algorithms.

It should be noted that modern photocodecs: JPEG, JPEG-2000 and videocodecs: MPEG2, which are more popular in Europe, MPEG4, DIVX5, H.264 are developed in the USA. Photo and videocodecs are programs for coding and decoding similar to compression and decompression of digital pictures.

Loss of digital picture quality as compared with the original one takes place in compressing. In digital photo and video systems there are some levels of stored information quality. The higher level of picture compression gives the more photo and video information may be recorded per unit of memory and more quality losses correspondingly. Efficiency of such algorithms is compared at compression level at the same quality or at the quality of decompressed picture at the same level of compression. Cosine Fourier Transformation is the basis of compression methods in the last generation. Modern system use wavelet transformations. Worldwide development of such algorithms as to their degree of compression at the same quality progresses 5-6% annually.

I have developed the method, which allows to increase digital picture compression by 40 % on the average at the same quality as compared with well-known wavelets. Comparative analyses of concrete examples is given below.

The main advantage of the given development is that for video picture compression the main decompression operation needs the least number of calculus resources among the world leaders of the given software (e.g. 2.38 times less than the same operation in MPEG4). It opens new spheres for digital video in mobile software, as there are essentially effects the increase of battery working power and decrease of necessary power in processors of the given mobile devices.

Another advantage of the given development in terms of commerce is that it is mathematical technology. Expensive production or equipment is not needed for its realization, it needs only office work of programmers.

Main market where a new developed videocodec may have advantage all world leaders of the given software may be in:

- mobile multimedia devices (videoplayers);
- receivers of digital mobile TV (including pocket digital TV);
- mobile phones;
- internet-TV, mobile internet-TV;
- DVD-players;
- satellite digital TV, mobile satellite digital TV;
- web-cameras and a number of industrial applications.

Of special interest is the development of videocodec for notebooks as suggested method basically influences batteries working power of these notebooks.

Examples of colour pictures compression with wavelets Daubechies 5-th order (application of other wavelets show the same results) and suggested method are given below.

LenaOrig.bmp

LenaWavelet_100

LenaNov_100

LenaWavelet_71

Fig. 1

Titles to pictures should be read in the following way:

LenaWavelet_100, LenaWavelet_71 – pictures restored after compression with wavelets in 100 and 71 times correspondingly.

LenaNov_100 – pictures restored after compression in 100 times with the suggested method.

Comparison was made in the following way:

At first the pictures were compressed by the same amount (for Lena in 100 times) by both methods and average quadratic deviations of restored pictures relatively original in three palettes (R, G, B) were fixed then the picture was compressed by wavelets up to the level of average quadratic deviations, the same as for suggested method (for Lena in 71 times).

The same is for the rest of the pictures.

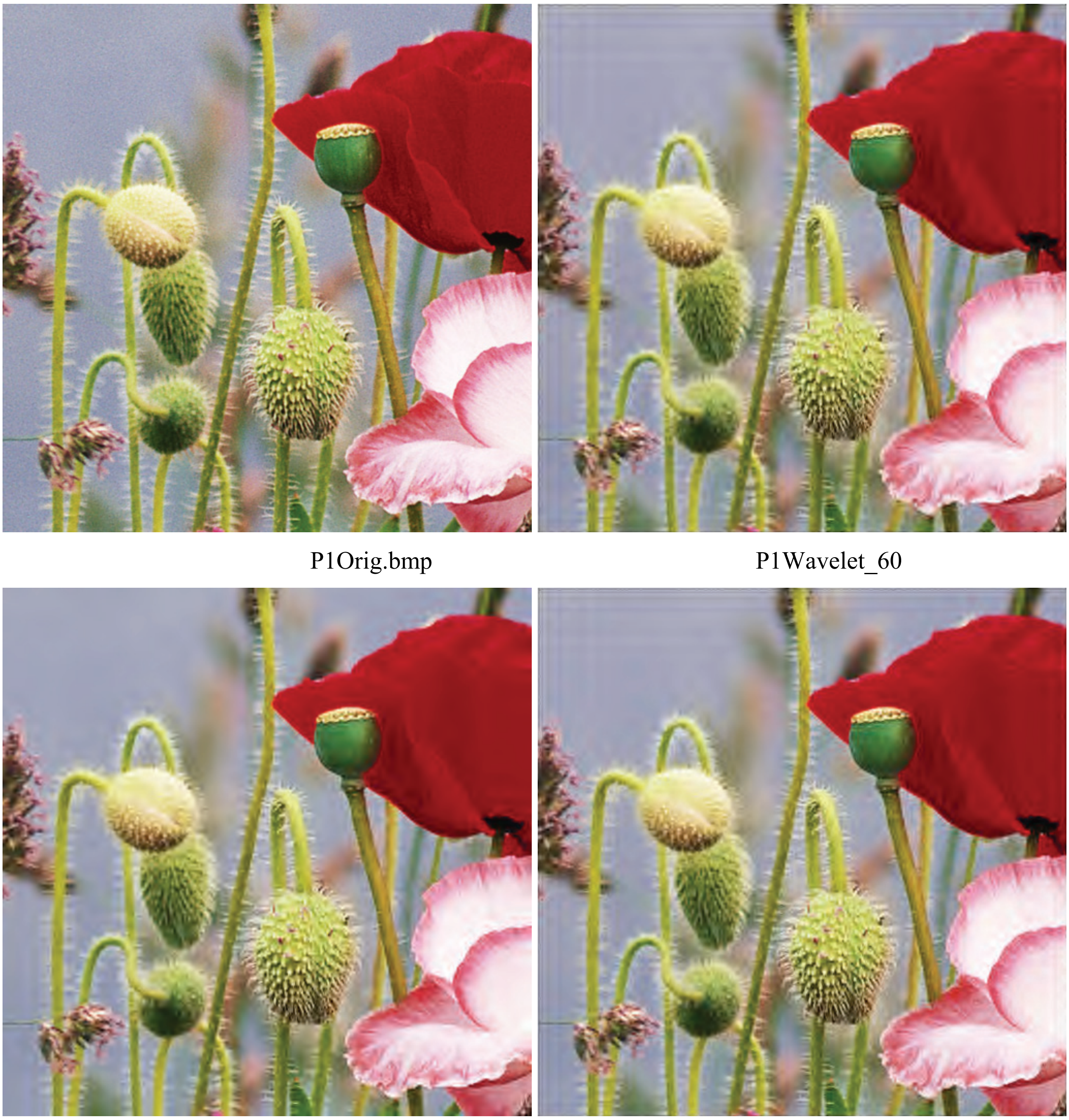
Average quadratic deviations of restored pictures relatively to original in three palettes (R, G & B):

LenaWavelet_100 – STD_R=10.08, STD_G=10.47, STD_B=10.67;

LenaNov_100 – STD_R=8.08, STD_G=8.95, STD_B=9.29;

LenaWavelet_71 – STD_R=8.47, STD_G=8.81, STD_B=9.31.

Next example is picture P1.



P1Orig.bmp P1Wavelet_60

P1Nov_60 P1Wavelet_46

Fig. 2

Average quadratic deviations of restored pictures relatively to original in three palettes (R, G & B):

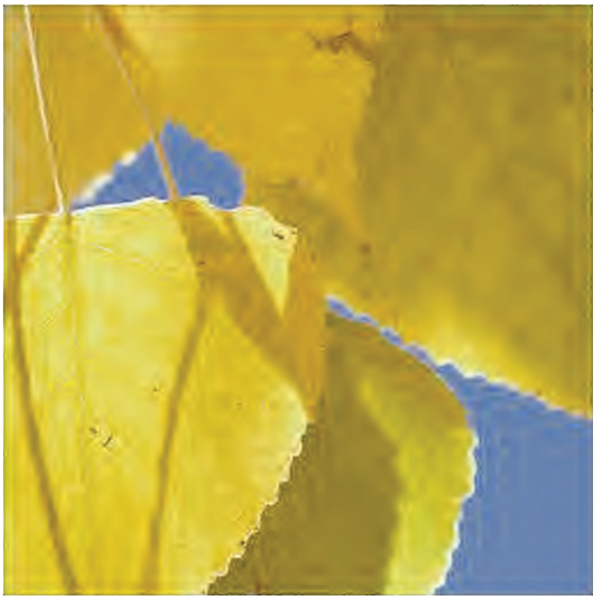
P1Wavelet_60 – STD_R=10.47, STD_G=8.69, STD_B=10.90;

P1Nov_60 – STD_R=9.06, STD_G=7.49, STD_B=9.64;

P1Wavelet_46 – STD_R=9.23, STD_G=7.58, STD_B=9.62.

Next example is picture P2.

P2Orig.bmp



P2Wavelet_100

P2Nov_100

P2Wavelet_57

Fig. 3

Average quadratic deviations of restored pictures relatively to original in three palettes (R, G & B):

P2Wavelet_100 – STD_R=8.78, STD_G=8.35, STD_B=13.86;
P2Nov_100 – STD_R=6.72, STD_G=6.75, STD_B=11.30;
P2Wavelet_57 – STD_R=7.03, STD_G=6.82, STD_B=11.14.

Quick result may vary in wide limits and tuned to specific device according to the task.

Flexibility of the given technology allows to develop videocodecs for videophones and internet videoconferences with both quick decompression and compression of video pictures. IT is necessary to know technical conditions of the customer since suggested mathematical technology allows to solve this problem in several ways.

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V.N.Shutko, doctor of technical science (National Aviation University, Ukraine)

THE DOPPLER RADIO-LOCATING SIGNALS PROCESSING

The article is devoted to consideration of new antijamming method approbation results, the use of which enables to get high-quality descriptions of exposure of doppler signals for the wide spectrum of natural hindrances, by the computer design and treatment of the real signals records from workings radio-locators.

The new spectral method for doppler radio-locating signals detection is proposed. A priori unknown deflections of real signals from ideal harmonic model bring to considerable falling of detecting characteristics. The proposed method is remarkable for its stability to these deflections. Using of this method show the sizeable effectiveness for processing real signals recording. Middle gain in signal-to-noise ratio is 4 dB for voltage (1,6 times for voltage or 2,56 times for power).

This method may be used for detecting low-sized targets against a sea background, prevention ships collision, investigation clouds to hailing danger, processing acoustic vibrations, disclosure earthquakes and avalanche victims, measuring speed of blood stream (in medicine), etc.

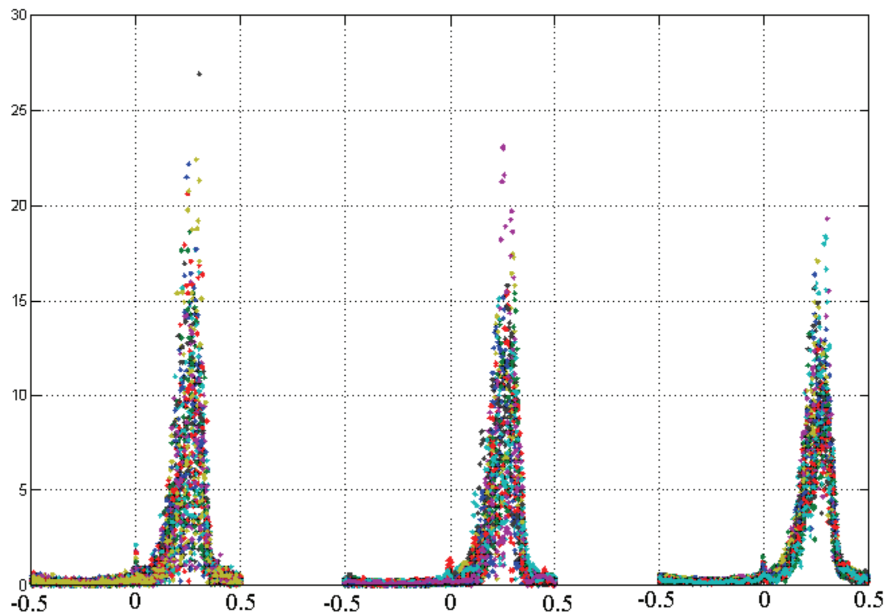
The method is applying on the base of using equipment and need not buying new one, that allow to increase effectiveness of the radio-locating system.

Using of this system allow to attain goal characteristics of radio-locating station with the less power of transmitter. This is decrease radiation treatment of attendants.

The algorithm is realized into device that is based on programmable logical integral circuits.

The signals spectrum amplitude estimations are showed on the picture 1. These signals were observed the Holland radar TARA.

The doppler radio-locating signals, with sample size N=256, observed twenty times in the same corner direction from the same distance ring. The spectrum estimations from all twenty realizations (M=256*20=5120) are showed on the picture 1.



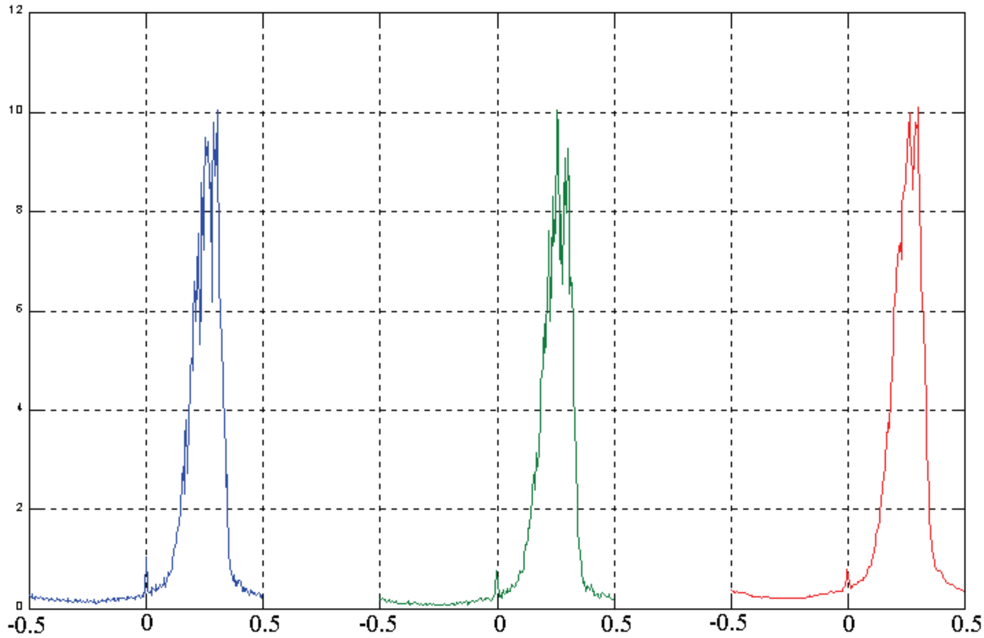
a) b) c)

Picture 1. The radio-locating signals spectrum amplitude estimations, which were calculated by:

a) the classic method FFT, b) the Kaiser's window using, c) the proposed method

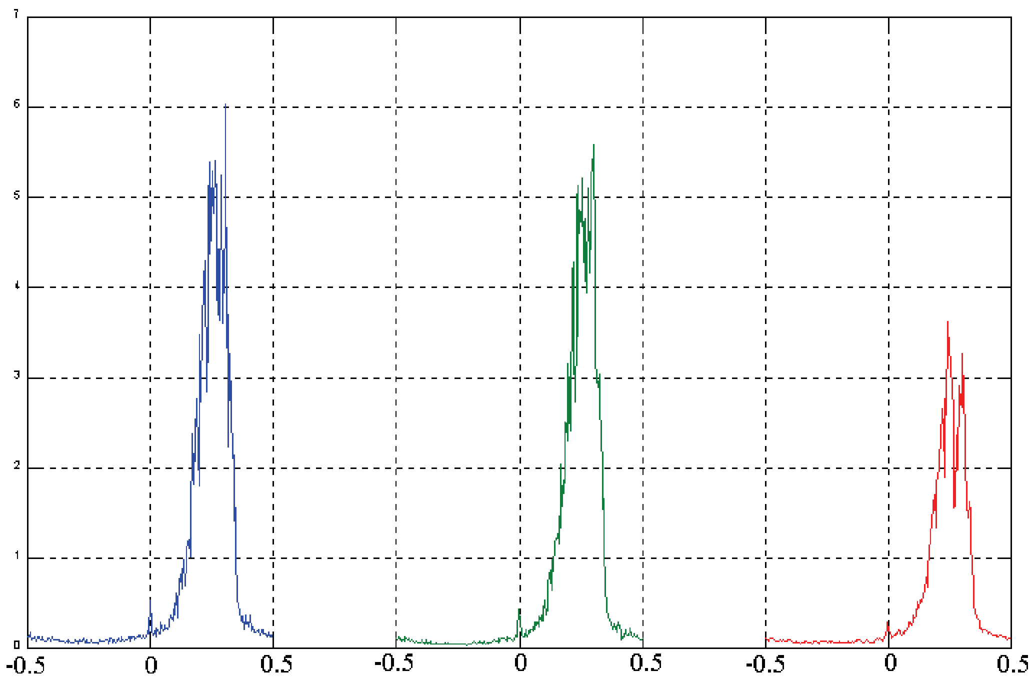
The pictures 2, 3 and 4 show correspondingly the middle gains of signals spectra, mean-square deviations of twenty spectra relatively to the middle gain and estimations of signal-to-clutter ratio (for voltage) for next three methods:

a) the classic method FFT, b) the Kaiser's window using, c) the proposed method



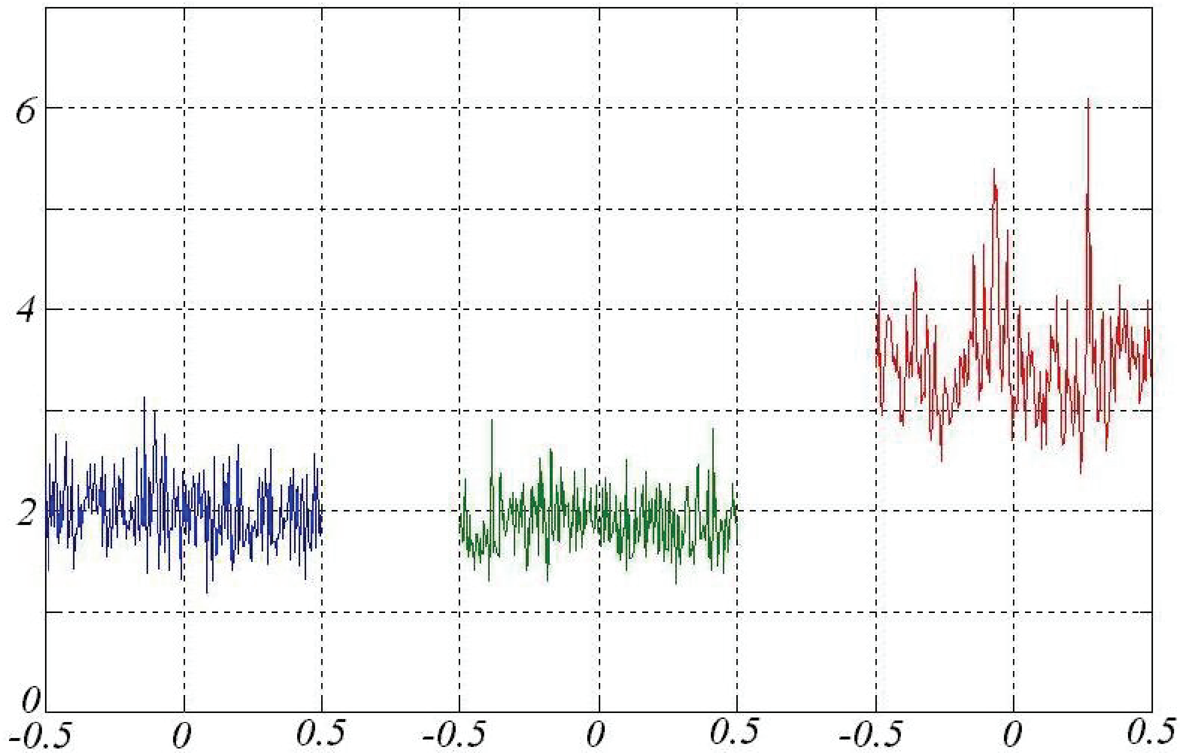
a) b) c)

Picture 2. The middle gains of amplitude spectra of radio-locating signals, which were calculated by: a) the classic method FFT, b) the Kaiser's window using, c) the proposed method



a) b) c)

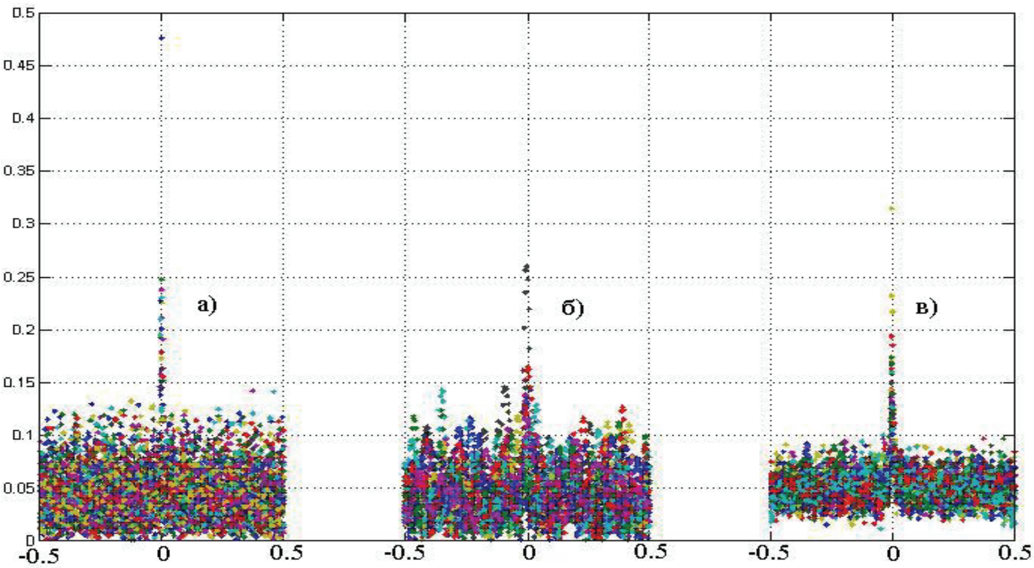
Picture 3. The mean-square deviation of amplitude spectra of radio-locating signals, which were calculated by: a) the classic method FFT, b) the Kaiser's window using, c) the proposed method



a) b) c)

Picture 4. The signal-to-clutter ratio estimations (for voltage) for amplitude spectra of radio-locating signals, which were calculated by: a) the classic method FFT, b) the Kaiser's window using, c) the proposed method

The spectrum estimations also from twenty realizations (M=256*20=5120, TARA) of the real signals, but from the distance ring, where the effective signal is absent (there is only noise on the receiver entry), are showed on the picture 5.

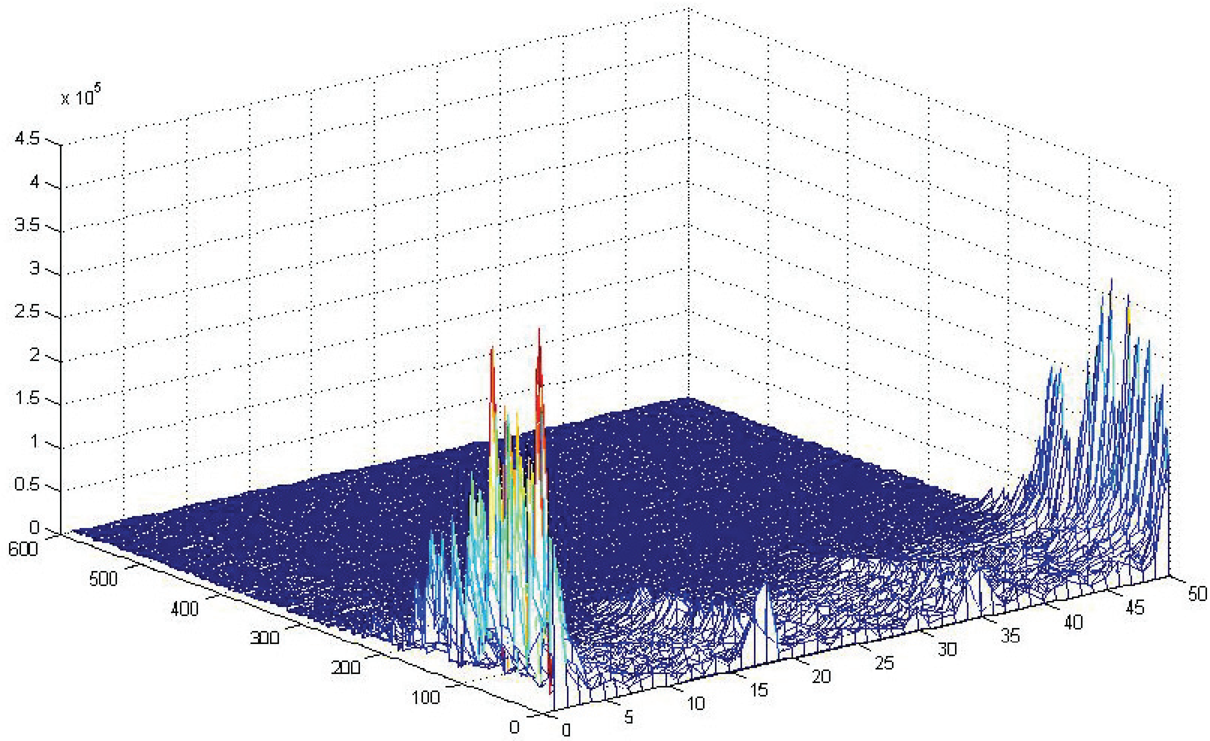


a) b) c)

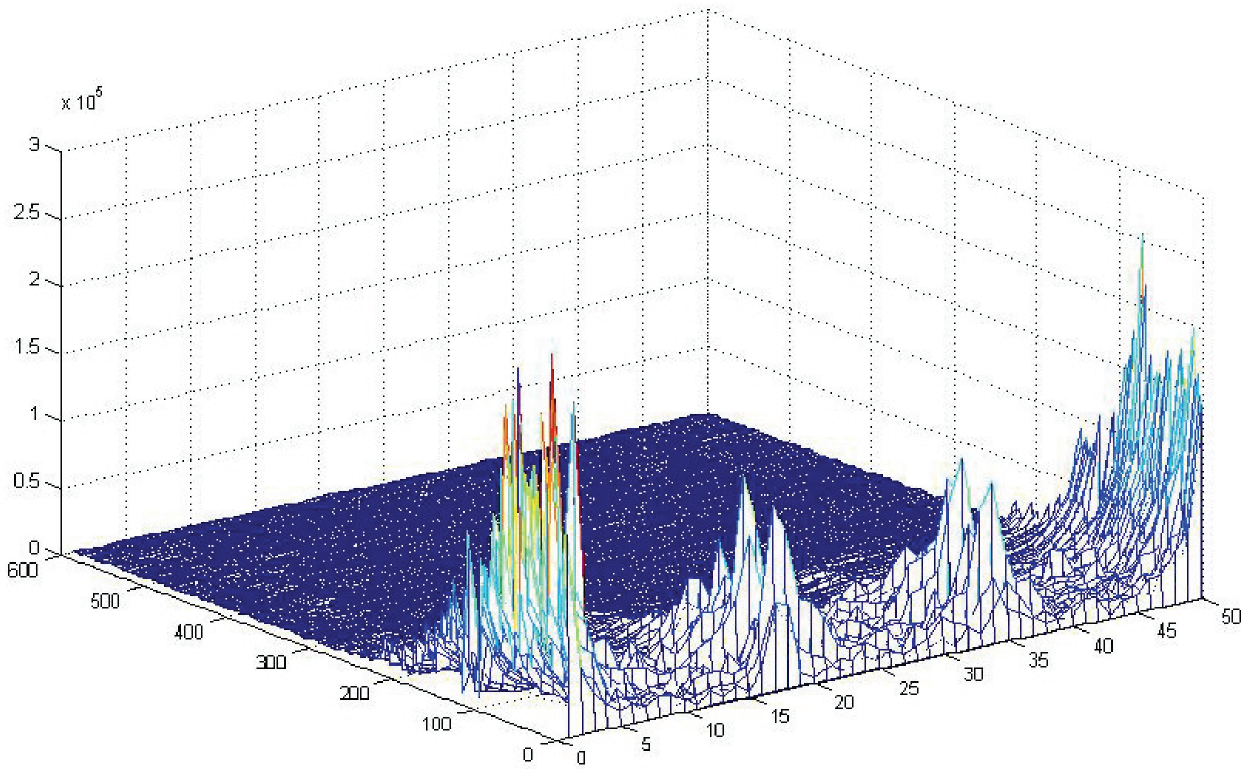
Picture 5. The radio-locating signals spectrum amplitude estimations, which were calculated by:

a) the classic method FFT, b) the Kaiser's window using, c) the proposed method

Pictures 6, 7 show advantages of this method in signal-to-noise ratio. The real signals were observed by Ukrainian radar. These signals spectrum estimations are showed on the pictures. The sample size N=50, the distance rings quantity – 600.

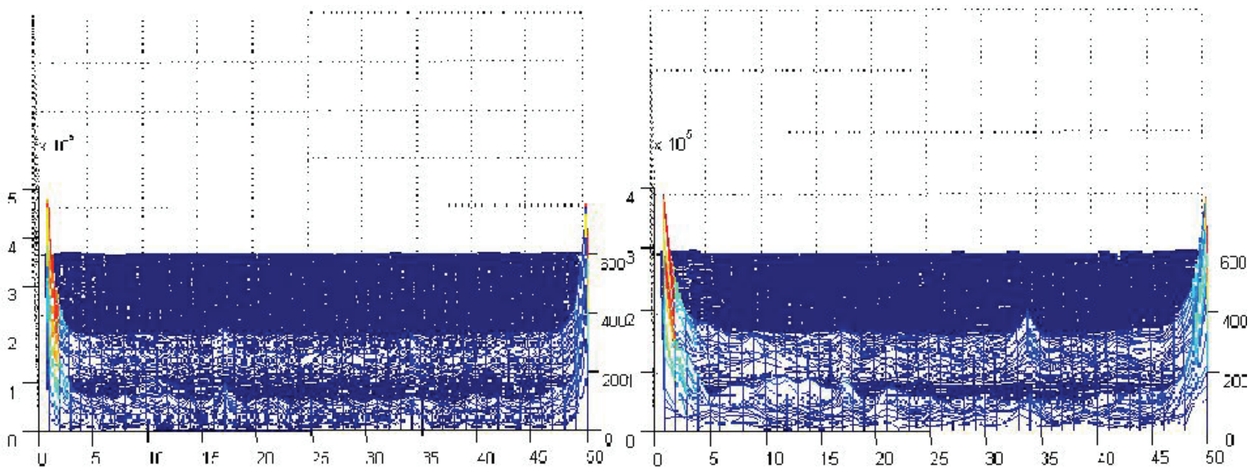


Picture 6. The radio-locating signals spectrum estimations, which were calculated by the classic method FFT



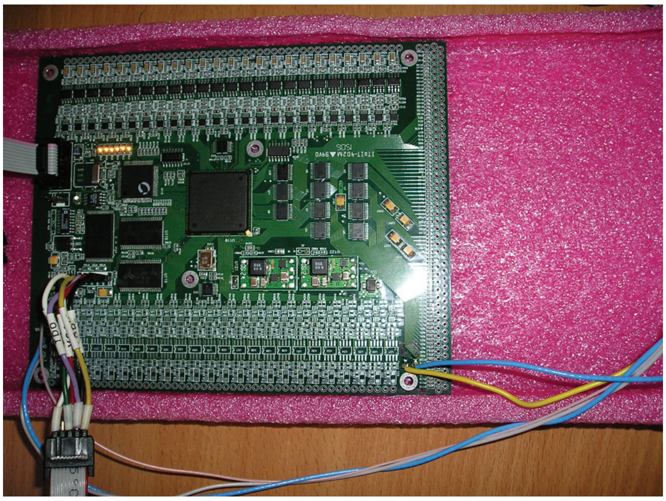
Picture 7. The radio-locating signals spectrum estimations, which were calculated by the proposed method

Picture 8 shows abilities of this method in detecting low-sized targets. The real signals were observed by Ukrainian radar. These signals spectrum estimations are showed on the pictures. The sample size is N=50, the distance rings quantity is 600.



Picture 8. The radio-locating signals spectrum amplitude estimations, which were calculated by: the classic method FFT (left), the proposed method (right).

Picture 9 shows the device that is based on programmable logical integral circuits where the algorithm was realized.



Picture 9. The device that is based on programmable logical integral circuits

Conclusions

Using of this method show the sizeable effectiveness for processing real signals recording.

This method may be used for detecting low-sized targets against a sea background, prevention ships collision, investigation clouds to hailing danger, processing acoustic vibrations, disclosure earthquakes and avalanche victims, measuring speed of blood stream (in medicine), etc.

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Aznakayev E. G., d.ph.(National Aviation University, Ukraine)
Melnikov D. E. (National Aviation University, Ukraine)

NON-LINEAR MODEL OF BIOLOGICAL SYSTEM INVESTIGATION

It is designed and explored mathematical model, describing muscular fibre of the myocardium, as nonlinear inertial element.

Statement of the problem. The Signals of the muscular fibres of the myocardium carry to itself information on condition of the warmhearted muscle, its capacity to work and presence what or pathological change. So simulation occurring in her processes presents itself important problem, having broad practical application.

The feature of the under investigation element. The muscular fibre of the myocardium, providing сократительную function heart, consist of muscular hutches (the cardiomiocites), united inserted disk. The diameter cardiomiocites constitutes 10–20 mkm, length – 50–120 mkm. Excitability is conditioned by ability cardiomiocites to generate in response to irritation electric potential of action.

The signals of the nervious system act through receptors of the myocardium ventricle, auricles, knots of conducting systems and smooth of the muscles of the blood vessels. Regulation is realized under mechanism direct and feedback. The sensor are baroreceptors.

The Mathematical model of the investigation element. Such model was offered in the manner of equations of the electric condition of the resonator. The decision to models was conducted by numerical methods, but results reckoning were compared since experimental data.

The univariate model of the carrying the charge q in nonlinear inertial system at the form of the equation of the balance is of the form of:

$$\frac{dq(t)}{dt} + \frac{1}{\tau_r(q)} q(t - \tau_0(q)) = \sum_{k=1}^{n} \sigma_k(q) u_k(t), \tag{1}$$

where $g = \int_V \rho_{cp} d\xi$, $\rho_{cp.}$ — average density of the charge; $\rho_{cp.} = {}^1\!/_V \int_V \rho d\xi$; τ_r — time to relaxations of the charge; $\tau_0 = l/V$ — time of the carrying the charge; l — a length of the stairwell; V — a velocity of the driftage; σ_k — instant value of the input conductivity of the under investigation element; u_k — an input voltage; n — a number of inputs.

On the form equation proposed models presents itself nonlinear uniform differential first-order equation with deviating argument. The decision of this equation in afore-cited type by possible only numerical methods. For reception of the analytical decision (in linear approximation) required to use the different types of the asymptotic decisions and their approach. We use approach τ_r = const and τ_0 = const. The last lawfully under sufficient magnitude of the voltage of the offset U_0 defining field, under which velocity of the driftage of the charge reaches the magnitudes of the saturation, and V = const.

In this case nonlinearity will be concentrated in dependencies σ(q) and equation to models will take the type

$$\frac{dq(t)}{dt} + \frac{1}{\tau_r} q(t - \tau_0) = \sum_{k=1}^{n} \sigma_k(q) u_k(t) \tag{2}$$

Analytically solve the equation (2) possible using method of the small parameter [4]. Herewith parameter ε is entered in equation and decomposition is executed on parameter q and σ(q). In the event of introduction to equation of the parameter ε and upon n=1, equation takes the type

$$\frac{dq(t)}{dt} + \frac{1}{\tau_r} q(t - \tau_0) = \sigma(q)(U_0 + \varepsilon U(t)) \tag{3}$$

We Shall watch the decision (2.5) in the manner of $q=q(t,\varepsilon)$

$$q = q(t, \mathrm{e}) = \sum_k q_k(t) \mathrm{e}^k \tag{4}$$

at satisfaction of the condition

$$q\big|_{t=0} = q(t,\mathrm{e})\big|_{t=0} = q_0 \tag{5}$$

Let in vicinities of the point q_0 σ(q) possible distribute in row of Taylor

$$\mathrm{y}(q) = \sum_n \frac{\mathrm{y}^{(n)}(q_0)}{n!}(q - q_0)^n \tag{6}$$

In turn

$$\frac{dq}{dt} = \sum_k \frac{dq_k}{dt}\mathrm{e}^k \tag{7}$$

Substituting (4), (6) and (7) in (3) shall get

$$\sum_k \left(\frac{dq_k(t)}{dt} + \frac{1}{\tau_r} q_k(t-\tau_0)\right)\varepsilon^k = \left(U_0 + \varepsilon U(t)\right)\sum_n \frac{\sigma^{(n)}(q_0)}{n!}\left(\sum_k q_k(t)\varepsilon^k\right)^n \tag{8}$$

As a result of decisions (8) shall get the system linear differential equations. We shall SELECT from (8) equation first approximation:

$$\frac{dq_1(t)}{dt} + \frac{1}{\tau_r} q_1(t-\tau_0) - \frac{1}{\tau_r}\frac{d\sigma_i}{di}\bigg|_{I_0} U_0 q_1(t) = \sigma_0 U_m \sin(\omega t) \tag{9}$$

With provision for external influence, the type $u(t) = U_0 + U_m(t)$, shall select from (8) equation second approximation:

$$\frac{dq_2(t)}{dt} + \frac{1}{\tau_r} q_2(t-\tau_0) - \frac{d\sigma}{dq}\bigg|_{q_0} U_0 q_2(t) - \tfrac{1}{2}\frac{d^2\sigma}{dq^2}\bigg|_{q_0} U_0 q_1^2(t) = \frac{d\sigma}{dq}\bigg|_{q_0} q_1(t) U_m \sin(\omega t) \quad (10$$

The analytical equations of the more high degrees of the approximation present itself else more bulky expressions.

At description of the dynamic features fibre myocardium, the equation (1) allows to define only one forming complete current - a current to conductivities

$$i_n = \sigma(q)\left[U_0 + U(t)\right].$$

The second forming — a current of the offset, is assigned by type to nonlinear capacity fibre myocardium: $i_C = C(q_C)\cdot\left(dU(t)/dt\right)$.

For fibre of the myocardium typical ambiguity to dependencies $\mathrm{y}(q)$, that at presence delay τ_0 brings about relaxation fluctuations in mode of the givenned offset $U_0(I_0)$.

Us are offered analysis relaxation fluctuations fibre myocardium, brought on described above model.

Considering ambiguity to dependencies $\mathrm{y}(q)$ and supposing $\tau_0 = \text{const}$, shall present the model in the manner of:

$$\begin{cases} \dfrac{dq(t)}{dt} + \dfrac{1}{\tau_r(q)} q(t-\tau_0) = \sigma U_0 \\ G(q,\sigma) = 0 \end{cases}. \tag{11}$$

The received results. The Analysis(Test) to models is conducted by numerical method. The dependency $\tau_r(q)$ was assigned in the manner of $\tau_r(q) = \tau_{r0} \big/ 1 + \left(q/q_0\right)^4$.

The Result of the decision in the manner of pulse of the current to duration commensurable since time of delay is shown on fig. 1 and corresponds to the instant conductivity $\mathrm{y}(q)$ for $U_0 = 2$ V, $\tau_0 = 10^{-8}$ s and $q_0 = 10^{-12}$ K. On fig. 1 b are shown experiment results.

Summary. From result of the called on investigations is seen that form relaxation fluctuations, got on proposed models qualitative corresponds to experimental results.

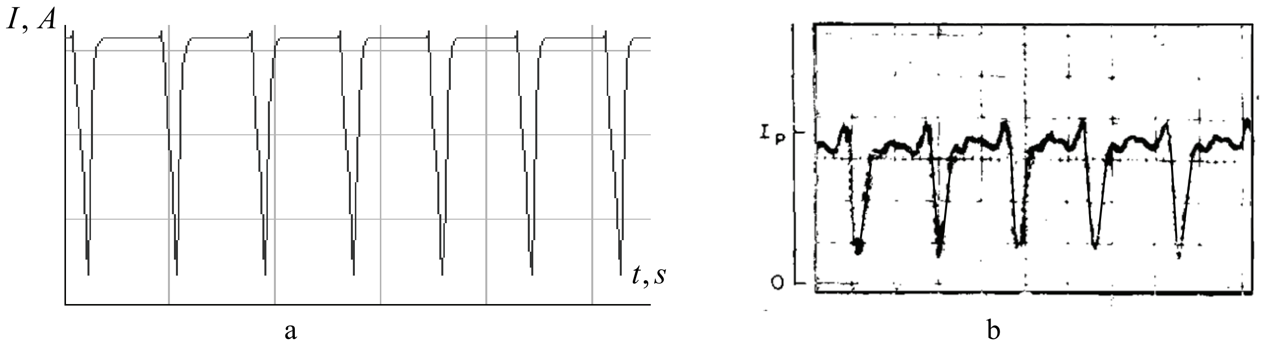

Fig. 1 Thereby, use proposed models a carrying the charge allows to get the important dynamic features a fibre myocardium simple manner, having provided at adequacy result experimental research.

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V.M.Khimin, professor (National Aviation Universyty, Ukraine)
O.P. Slobodyan (National Aviation Universyty, Ukraine)
Iman Sadeghzadeh, student (National Aviation Universyty, Ukraine)

3D NAVIGATION FOR AN UNMANNED AERIAL VEHICLE (UAV)

Introduction

Unmanned Aerial Vehicles (UAVs) have many potential uses in both civilian and military roles. A large proportion of these uses require the UAV to navigate through built-up environments such as urban canyons. In the field of Robotics, navigation typically includes capabilities such as localization, safe wandering, path planning and mapping. In order to perform safe wandering,

1 a UAV would need to detect and avoid obstacles around it. Given such a capability, the UAV could be used to perform tasks such as exploration, mapping and Urban Search and Rescue. Path planning, on the other hand, requires at least a partial map of the environment and the ability to find a route to a goal location based on the map. Given such a capability, a UAV could be used for tasks such as package delivery, surveillance, patrolling, systematic searching and communications bridging. A certain class of UAV, namely Rotorcraft UAV, is particularly suited to environments where there is limited space for maneuvering, since they can perform vertical takeoff and landing, as well as hovering in place. In this dissertation, we present techniques which allow a rotorcraft UAV to perform safe wandering and path planning in a 3D urban environment.

Abstract

We address the 3D navigation problem for an Unmanned Aerial Vehicle (UAV) through urban environments, specifically an autonomous robotic helicopter. In doing so, we investigate techniques which would allow a UAV to perform two kinds of navigation: safe wandering and path planning based on a partially accurate world model, with dynamic replanning as unmodeled obstacles are detected.

Typically UAVs operate at high altitudes where obstacle avoidance is not needed. This limits the applications they can be used for. A UAV capable of safe wandering through an urban environment could perform tasks such as exploration, mapping and Urban Search and Rescue. To perform safe wandering, the UAV would need to detect and avoid obstacles in real-time. Having the ability to plan a path through an urban environment would allow a UAV to perform tasks such as package delivery, surveillance and patrolling. In developing these capabilities, we address obstacle avoidance, path planning, replanning, and system integration with a real helicopter.

The Challenge of Vision-based Navigation for an Autonomous Helicopter

Although a rotorcraft UAV such as an autonomous helicopter has the advantage of maneuverability, it has the drawback of being very hard to control. Helicopters are by nature unstable non-linear systems, and the low-level stability control needs to deal with these characteristics.

Left to its own devices for a few moments, a fixed wing UAV will tend to glide in a stable manner. On the other hand, if an autonomous helicopter fails to receive stabilizing control commands for even a brief period, it will most likely become unstable and crash. This makes conducting research on an autonomous helicopter very challenging. There is little room for error, and when things go wrong the results can be catastrophic.

For ground-based mobile robots, basic obstacle avoidance is practically a ’solved problem’,but for flying robots many challenges still remain. The problem is greater because flying robots operate in 3D-space as opposed to the 2D surface that ground robots navigate on. Since small to medium scale UAVs have limited payload capabilities, they are rarely able to carry the types of sensors that are typically used for obstacle avoidance on ground-based robots (such as laser range-finders). Computer vision provides a viable solution to sensing on UAVs, as cameras are light and power efficient. With the increasing miniaturization of CCD cameras, vision even offers the potential to be used on Micro Air Vehicles (MAVs). Also, unlike a scanning type sensor, cameras take an almost instantaneous snapshot of the environment, which is beneficial on a dynamic platform.

Although computer vision has many characteristics that make it suitable for obstacle avoidance on a UAV, it does present many challenges too. Using vision outdoors is notoriously difficult because of varying lighting conditions. Even if the lighting is favorable and the scene can be captured accurately in an image, there is the problem of making sense of the image and extracting information such as the distance to features. As humans, we take for granted how well our vision system works - we are easily able to make sense of a scene and judge the distance to features around us. For a computer, this is not the case. After three decades of computer vision research, we have techniques such as optic flow and stereo vision, which can enable a machine to sense motion in an image sequence and build a 3D snapshot of its environment. Even so, this snapshot can hardly compare to the information that the human vision system provides us with, both in terms of level of detail and accuracy. Cameras generate data that are sparse, and are prone to noise. In order for a helicopter to travel to a goal location, it needs to be able to plan a safe path to the goal. Given an accurate 3D model of the environment, a number of techniques exist that will plan such a path. The planning challenge is largely one of complexity, as the state space for a six degree of freedom body in an extensive environment can be very large, making it difficult to perform planning quickly. This is particularly important when planning for a flying vehicle, as decisions need to be made quickly. When the model of the environment is not accurate, the problem becomes even harder, as a path may be planned through an area that is incorrectly designated as free space in the model. The UAV then needs to rely on its sensors to detect such unmodeled obstacles so that it can avoid them and generate an alternative route to the goal.

The problem is made harder still if constraints are added to the planning task. For an urban environment, an obvious constraint is height. We might want the helicopter to find a path to the goal while staying below a certain altitude - a flight ceiling. Such a constraint could be imposed externally by airspace control regulations, as is often the case in built-up areas. This constraint would eliminate the trivial planning solution of simply flying over all the buildings. A further possible constraint is visibility: we might want the helicopter to reach the goal while minimizing its visibility from a certain point of view. This would allow for stealthy navigation for example.

Alternatively, we might want it to maximize its visibility so as to maintain communications. The planner needs to take these constraints into consideration when planning the route to the goal. Given these difficulties associated with controlling an autonomous helicopter, vision-based obstacle avoidance and planning, one can begin to appreciate why reliable vision-based navigation of a UAV through an urban environment is so challenging, and has not yet been achieved.

Our research is on enabling a UAV to fly between buildings using path planning and visionbased obstacle avoidance techniques. As such, in this chapter we review related work in the following areas: 1) Optic flow techniques and its uses , 2) Stereo vision-based obstacle avoidance , 3) Path planning and 4) Techniques for 3D navigation of UAVs.

1. Optic Flow

Optic flow is the 2D motion field which results in an image from the projection of 3D velocities of features onto the image plane. Optic flow has been used for a range of applications including egomotion estimation, motion detection and obstacle avoidance. It is generally recognized that using optic flow for obstacle avoidance has biological inspirations, and much research has been done to understand how insects use optic flow. Srinivasan et al. [63] show that honeybees use optic flow to fly between obstacles. In this work honeybees were trained to fly down a long tunnel 20cm wide. Textured patterns on the tunnel walls could be moved to generate optic flow. It was found that the bees adapted their flight paths so as to balance the perceived flows on both sides.

If the pattern on the right wall was moved backwards for example, the bees would fly closer to left side of the tunnel.

Optic flow has also been used for obstacle avoidance on aerial robots. For example, Barrows etal. describe how optic flow can be used for Micro Air Vehicle (MAV) flight control, including maneuvers such as landing, saccading away from obstacles, hovering and determining the time-tocollision with an obstacle to the front. Muratet et al show simulation results for using optic flow to navigate a helicopter through an urban environment with a single camera. Centeye Inc. have developed VLSI based optic flow sensors weighing just 4.5 grams and these have been used on small fixed-wing UAVs for altitude control, terrain following, takeoff and landing as well as avoiding sparse obstacles.

2. Stereo Vision

Stereo vision is the process whereby two images taken from different viewpoints can be used to gauge distance to features in the images based on triangulation. An overview of stereomatching techniques is presented in .

One of the earliest examples of using stereo vision for obstacle avoidance is reported by Moravec in 1980. Moravec's robot was able to navigate a 20m corridor containing obstacles, although it took roughly 5 hours to do so because of the limited processing power available at the time.

By the 1990's, stereo vision was being successfully used for obstacle avoidance on a number of robotic vehicles, ranging in size from small rovers to cars and vans. For example in ,Badal presents a stereo-based technique for obstacle avoidance on a car-like vehicle. This technique relies on knowing the precise camera location with respect to the ground plane and assumes that the ground plain is flat. Once the system is calibrated, the expected disparity of each pixel on the ground plane is known. Measured disparities are compared to the expected disparities,and discrepancies over a certain threshold are considered obstacles (not on the ground plain).

Similarly, Weber et al. [71] present a stereo-based technique for detecting features above the ground plane for use in autonomous highway driving. This technique also assumes that the pose of the camera with respect to the ground plane is known, but they do present an approach for using the image to update the relative pose estimate of the camera.

3 Path Planning

Robot path planning is the problem of finding a clear path for a robot to navigate to a goal in an environment containing obstacles. Early path planning work was focused on planning paths for robotic manipulators. In these cases, a perfect world model and precise knowledge of the joint angles were assumed. For mobile robotics operating in partly known environments and with localization uncertainties, these assumptions do not hold.

One of the first techniques presented to address this problem was the Potential Field method.In this technique, the world is modeled by a field function; obstacles act as repulsive poles while the goal acts as an attractive pole. To plan a path through the world, the algorithm follows the steepest slope of the field function towards a goal. The Potential Field method suffered the problem of local minima.

Randomized approaches have since been presented to overcome this problem, including Probabilistic Roadmaps (PRM) and Rapidly Exploring Random Trees (RRT). Kavraki, Kolountzakis, and Latombe, and Svestka and Overmars introduced the Probabilistic Roadmap approach as a fast and efficient algorithm for geometric, multiple-query path planning. This is a two-phase method for solving the robot motion planning problem in static workspaces. In the preprocessing phase, PRM constructs a probabilistic roadmap as a collection of configurations randomly selected across the free C-space. In the query phase, it uses this roadmap to quickly process path planning queries, each specified by a pair of configurations. While building the roadmap, this method heuristically identifies difficult regions in the free C-space and generates additional configurations in those regions to increase the connectivity of the roadmap graph. The final distribution of configurations is therefore not uniform across the free C-space, but is denser in regions that are considered difficult by the heuristic function. This helps to overcome the problem of finding a path through a narrow passage for example. PRM planners are probabilistically complete, meaning that as the number of samples of the configuration space approaches infinity, the probability of finding a path through the space (if there is one) approaches one.

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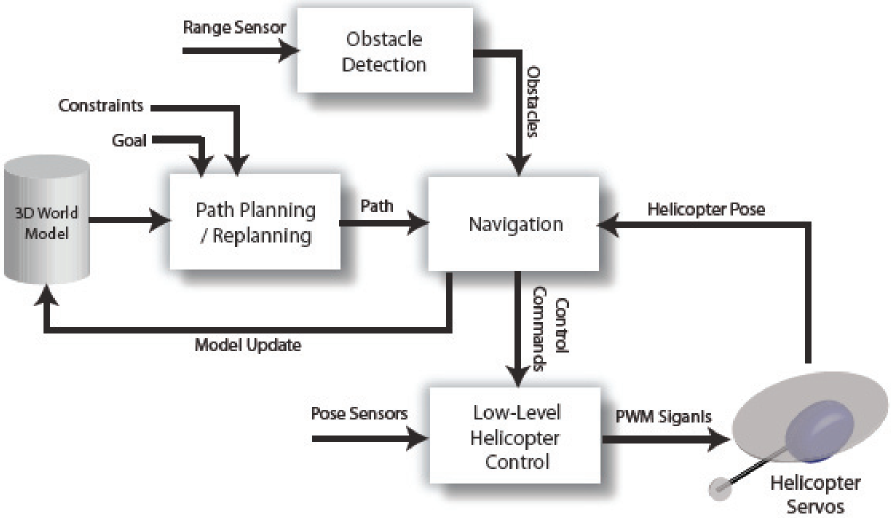
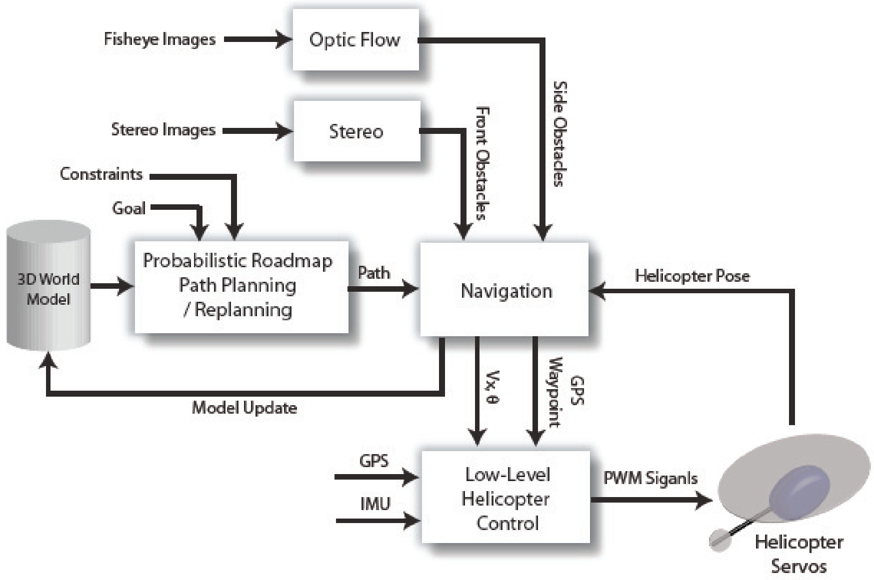
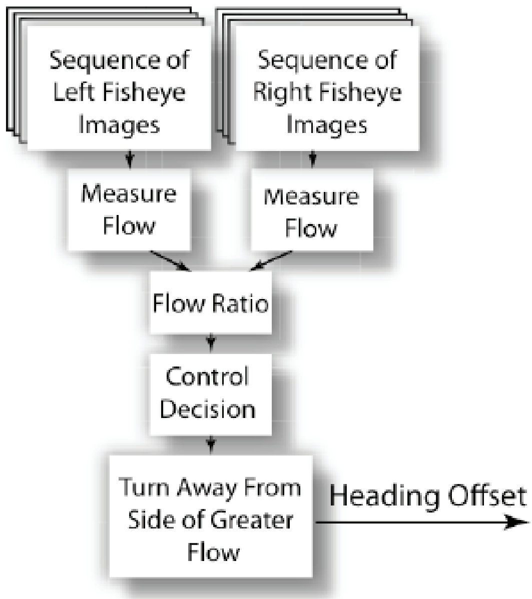


Components of the 3D Navigation Problem



Components of our solution to the 3D Navigation Problem



The optic flow-based control process

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V.D. Tronko, prof. (National Aviation Universyty, Ukraine)
A.V. Skrypets, prof. (National Aviation Universyty, Ukraine)
O.P. Slobodyan (National Aviation Universyty, Ukraine)

MEASURING OPTOELECTRONICAL METHOD OF PHASES DIFFERENCE OF INFRA- AND LOW -FREQUENCY RANGES

A new method of measuring of phase difference of electromagnetic signals by a photopolarimetric method is offered in this work. The advantage of offered method before the known ones of phase measuring is shown. Potential error of method is about 10^{-3} degrees.

For measuring of phase difference φ of two electric signals u_1 and u_2 the method of full-wave current rectification by phase detector is used [1], the output voltage of which is equal to

$$U_{\text{out}} = u_{01} \cdot u_{02} \cos \varphi. \qquad (1)$$

where u_{01} and u_{02} are the amplitudes of electric signals; φ is the phase difference between them.

Consequently the exactness of phase registration is determined by exactness of measuring u_{output}, u_{01} and u_{02}, the measuring error of which doesn't exceed one percent. Let's determine an absolute phase error from the formula (1)

$$\Delta\varphi = \frac{1}{tg\varphi}\left(\frac{|\Delta u_{\text{out}}|}{u_{\text{out}}} + \frac{|\Delta u_{01}|}{u_{01}} + \frac{|\Delta u_{02}|}{u_{02}}\right) \qquad (2)$$

The error of phase measuring is equal to zero by $\varphi = \frac{\pi}{2}$ and doesn't depend on amplitude fluctuations. This is a characteristic property of the method. If only φ deflects from the value $\frac{\pi}{2}$, the phase meter is no longer in asymmetrical operating mode and the amplitude fluctuations cause error increase. For instance, by values $\varphi = \frac{\pi}{4}$ and relative error of amplitude measuring ~ 10^{-2}, the absolute value of error lies within the limits 1° – 5°. The defect of the method is the dependence $\Delta\varphi$ on φ, which can be partly eliminated by the etalon phase-changing facility.

Phase difference conversion technique in a time slot τ [2, 3] became widespread with a further development of digital and microprocessor technology. The error of phase difference is equal to

$$\Delta\varphi = 360^\circ f\Delta\tau , \qquad (3)$$

where f is the frequency of researching signal, Δτ is the exactness of measuring of a time slot. For example, if $f = 10^5$ and $\Delta\tau = 10^{-8} \div 10^{-9}$sec., then $\Delta\varphi$ = 0,1° ÷ 0,03° [4,5,6,7]. The exactness is considerably higher. The defect of the method is the dependence of error on frequency of measuring signal.

A new photopolarimetric measuring method of φ with higher exactness is given in this report. This became possible due to signal amplitude conversion into angle of polarization twisting of light (angle of optical polarization twisting) (Fig.1). Current I is generated by a signal, the phase of which must be measured by a photopolarimetric method, by measuring of angle of optical polarization twistingθ. The angle θ can be measured to $\Delta\theta = 10^{-3} \div 10^{-4}$ degree [8.9.10].

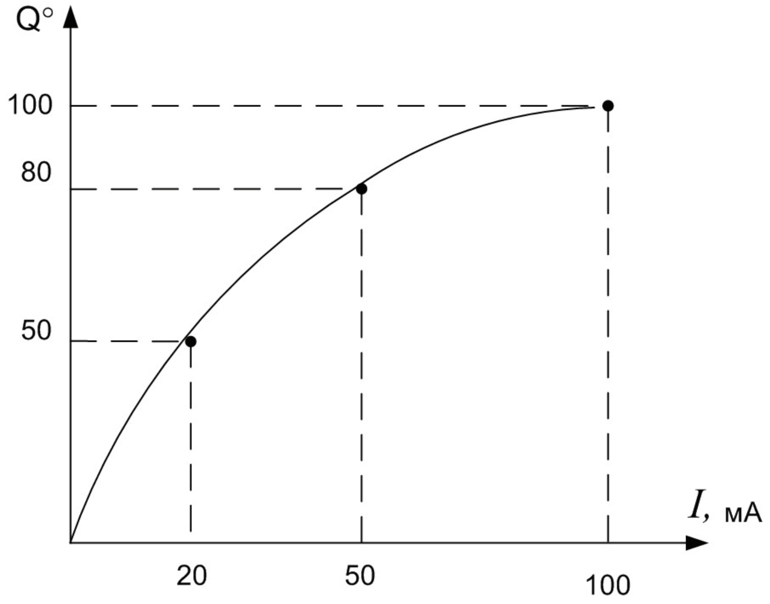

Fig.1. Typical depending of angle of optical polarization twisting on current in magnetizing coil [14]

In fact, let reference and measuring signals be equal

$$u_1 = u_{01} \sin \omega t \tag{4}$$

$$u_2 = u_{02} \sin(\omega t - \varphi) \tag{5}$$

Then angles of optical polarization twisting are respectively equal

$$\Theta_1 = \Theta_{01} \sin \omega t \tag{6}$$

$$\Theta_2 = \Theta_{02}(\sin \omega t - \varphi) \tag{7}$$

It is possible to fix points of time with the exactness of measurement error $\Delta\theta$, when θ_1 and θ_2 are equal to zero.

$$\Delta\Theta_1 = \Theta_{01} \sin \omega t_1 \tag{8}$$

$$\Delta\Theta_2 = \Theta_{02}(\sin \omega t_2 - \varphi) \tag{9}$$

where t_1, t_2 are the points of time of signal passage through zero

According to (8, 9) we get value of error in registration of phase

$$\Delta\varphi = \omega(t_2 - t_1) - \varphi = \frac{|\Delta\Theta_1|}{\Theta_{01}} + \frac{|\Delta\Theta_2|}{\Theta_{02}} \approx \frac{2|\Delta\Theta|}{\Theta_0}, \tag{10}$$

(Let's consider that amplitudes of signals are equal in quantity. $\theta_{01} = \theta_{02}$, though this condition is not obligatory).

Usually quantity $\theta_0 \approx 10^0$ [10, 11], having inserted it in (9), we get a real value of error of measuring phase $\Delta\varphi \approx 2$ ($10^{-3} \div 10^{-4}$ degree), that is on two orders higher than exactness of measurements of known methods.

Let's discuss the possibilities of the use of magneto-optical optron in the mode of phase measurement of electric signal, and more precisely the point of time registration, when signal amplitude is equal to zero. Magneto-optical optron is represented in Fig. 2. The principle of operation is described in detail in the works [8, 12].

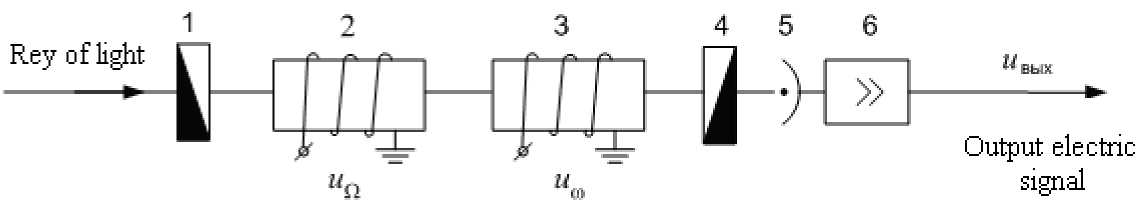

Fig. 2. Magneto-optical optron

where 1, 4 are the polarizer and analyzer; 2, 3 are the magneto-optical crystals (dice) with magnetic biasing coils, 5 is the photodetector, 6 is the narrow-band amplifier.

We will denote signal the phase of which must be measured as U_ω and infill signal will be denoted as U_Ω (it is significant, that their frequencies are different and $\Omega >> \omega$)

$$u_\omega = u_{0\omega} \sin(\omega t - \varphi) \tag{11}$$

$$u_\Omega = u_{0\Omega} \sin \Omega t \tag{12}$$

The optical ray, falling on photodetector 5 in time will be modeled in intencity under (Maljus law) [10].

$$I = I_0 \cos^2 \Theta = I_0 \cos^2 [\Theta_0 + \Theta_{0\omega} \sin(\omega t - \varphi) + \Theta_{0\Omega} \sin \Omega t] \tag{13}$$

The initial angle between the polarizer and the analyzer $\theta_0 = \frac{\pi}{2}$, and $\theta_{0\omega}, \theta_{0\Omega}$ are amplitudes of swinging angle of polarization twisting by changing and infill signals. Let's factorize (13) according to Bessel functions [13].

$$I = \frac{I_0}{2}\left\{1 - \left[J_0(2\Theta_{0\omega}) + 2\sum_{p=1}^{\infty} J_{2p}(2\Theta_{0\omega})\cos 2p(\omega t - \varphi)\right]\left[J_0(2\Theta_{0\Omega}) + 2\sum_{p'=1}^{\infty} J_{2p'}(2\Theta_{0\Omega})\cos 2p'\Omega t\right] + \right.$$
$$\left. + 4\sum_{p=1}^{\infty} J_{2p-1}(2\Theta_{0\omega})\sin(2p-1)(\omega t - \varphi)\sum_{p'=1}^{\infty} J_{2p'-1}(2\Theta_{0\Omega})\sin(2p'-1)\Omega t\right\} \tag{14}$$

An optical signal (14) is converted by photodetector 5 into electrical one. Let's put conditions $\Omega >> \omega$, and narrow-band intensifier has such passband to amplify only spectral rectangular components $\Omega \pm \omega$, Ω. We will get voltage on the amplifier output.

$$u_{\text{out}} = u_0' J_1(2\Theta_{0\omega}) J_1(2\Theta_{0\Omega}) \sin(\omega t - \varphi) \sin \Omega t = u_0 \sin \Omega t\,, \tag{15}$$

where $u_0 = u_0' J_1(2\Theta_{0\omega}) J_1(2\Theta_{0\Omega}) \sin(\omega t - \varphi)$

u_0 is the output signal amplitude slowly changing in time relative to $\sin\Omega t$ function.

The point of time, when $u_0 = 0$, we denote as t_2, then

$$\omega t_2 - \varphi = n\pi \tag{16}$$

where $n = 1, 2, 3\ldots.$

Let's count time t_2 relative to the moment of equality to zero of the reference signal on intensifier output 6. $\omega t_1 = 0$ or $n\pi$. It is necessary to pass reference signal $u_\Omega = u_{0\Omega} \sin \Omega t$ and measuring signal $u_\omega = u_{0\omega} \sin(\omega t - \varphi)$ through two identical optron channels (1 and 1') (Fig. 3a).

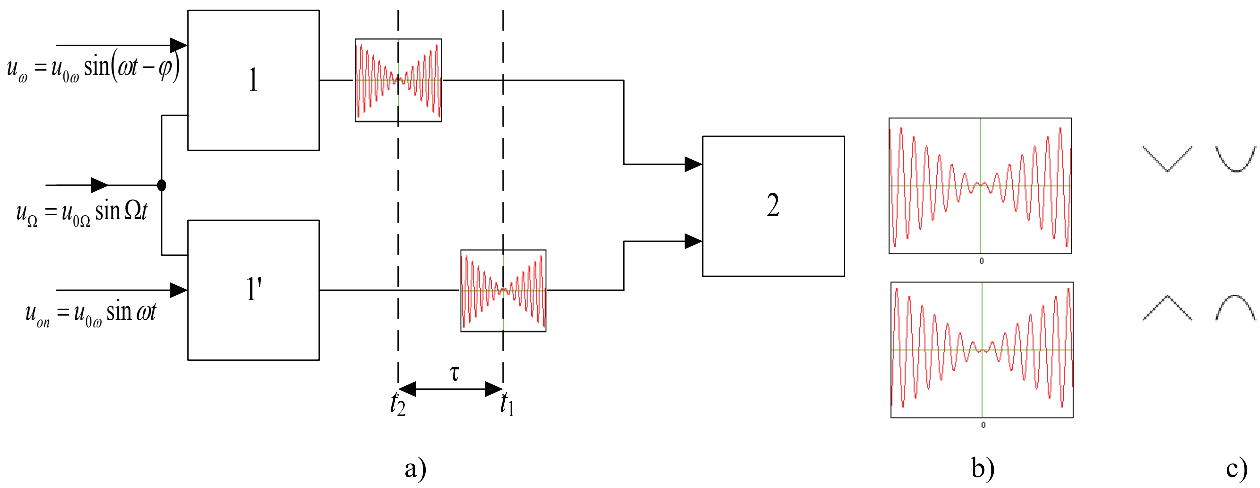

Fig.3. Photopolarimetric phase meter

where 1, 1' are optrons for signal U_ω and reference signal U_ω.

2 is the digital microprocessor of the interval measurement τ.

The signal phase is changing on the opposite one (on π) in points t1, t_2, that's why the signal doesn't change polarity (Fig. 3b). Depending on phase quantity the signal can have critical tops (depressions) and mildly sloping tops (depressions) in the points of time t_1, t_2 (Fig. 3c). Under condition $\Omega >> \omega$ we can not see them. They will be covered in noise.

The ratio of signal and noise is determined by analogy with work [11] taking into account expression (14), for perfect analyzer and polarizer taking into account flash noise of the photodetector (generation-recombination noise for semi-conductor photodetector and shot noise for photomultiplier). We will disregard depolarization of light in magneto-optical crystals (dice). We are not going to regard dark noise, because flash noise is much less. The ratio of signal and noise is equal to

$$S / N = \frac{u_{\text{out}}^2}{u_{\text{light}}^2} = A\left(\Theta_{0\omega}\Delta\varphi\right)^2 \tag{16}$$

The quantity A ~ 10^6, $\Theta_{0\omega}$ ~ 10° [10, 11], then at the ratio of signal and noise S/N = 1, $\Delta\varphi$ ~ 10^{-4} degree.

In conclusion we should emphasize, that photopolarimetric method of phase registration of electric signals allows at least on an order to increase exactness of measuring. Probably, the offered method of measuring of phase will find application first of all for infra- and low-frequency signals.

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S.S.Kostina, Ph.D., (National Aviation University, Ukraine)

COMPUTER LABORATORIES FOR COMPLEX RESEARCH OF RADAR

In report some questions of designing of problem-oriented complexes of programs (computer laboratories) with using of mathematical models, of data and knowledge are considered. These applications are relating to realization of research and of designing of Radar and its elements, of education, training, simulation and testing of Radar equipment

Mathematical modeling is one of basic methods for the designing automation with using the computer of modern technical systems (Radars is related to this class) [1,..3]. Strict resources limitations, necessity of qualitative tests of technical solutions and algorithms of processing of Radar information for different situations, the aspiration to optimization of Radar results to necessity of wide use of mathematical modeling and to essential increase of the requirements to its organization. Generally we may formulate these requirements as obtaining of authentic and not inconsistent information under condition of acceptable time of its obtaining, minimal resources and convenience of user's work. The similar requirements are advancing in process of analyzing of Radar and methods of processing of radar information, of preparation of the specialists in corresponding subject area (SA) etc. For solving of this problem it is necessary to ensure the completeness of information for mathematical modeling (data, mathematical models, modeling algorithms and computer programs), effective methods of processing of the information and the automation of work for computing experiment and user's convenience [3].

Today one of ways of the solving of this problem is the creation of universal tools of simulation, for example MATCHCAD [4]. These tools allow to reduce a time of research but the required high level of user's skills frequently restricts their effective using. Besides, these tools are not intended for large-scale researches of Radar with different multifunctional programs.

Other way is creation of problem-oriented program complexes (computer laboratories (***CL***)) for obtaining such results as quality indexes and characteristics represented for most full estimation of efficiency of some Radar functioning in various conditions or few Radar in uniform conditions, and for solving a task of parametrical optimization of Radar and its elements, too[5,…9].

In report a questions connected with the creation and the realization of ***CL*** (principles of design, basic quality indexes and criterions of efficiency, examples of functioning etc.) are considered.

The notion “automation” and user’s convenience supposes for ***CL***:

- the exemption of the researcher from unspecialized and routine work (data forming, models choice, programming, information preparation, storing of data in various formats etc.) in the process of obtaining, the processing and presentation of the information relating to the SA of Radar information processing;
- the opportunity of preservation of data which define conditions of experiment and the using of this data for following sessions of work with ***CL***;
- the opportunity of obtaining of theoretical information (basic mathematical expressions etc.);
- the opportunity of realization of research program (plan) - of series of experiments intended for the decision of some problem in chosen SA;
- the opportunity of the forming of information in separate plan with addition by results of other sessions of work ***CL*** or with removal of unnecessary information;
- interactive mode of work with realization of dialogue « man - computer» in the limited natural (professional) language with using of the graphic forms for the identification and solving of a task and choice of kind of output information.

Further we will use such designations:

O - the multitude of research objects;

W - the multitude of tasks connected with elements of ***O***; these tasks are solving with using of ***CL***;

ΘM - the multitude of mathematical models and modeling algorithms used for solving of tasks from ***W***;

Ω - the multitude of intermediate decisions for tasks from ***W***;

Φ – the multitude of forms of representation of decisions from **Ω**,

U - the multitude of final decisions of tasks from ***W*** (results of processing of one or several decisions from **Ω** that are transformed to some formalized kind from ***Φ***).

Radar, its input influence, *n* element of Radar, its input influence are considered as *research objects* (elements of multitude ***O***), *n*=1,..N. Radar and its elements are described with using of structural-parametrical definition. It is necessary to take into account that the decomposition of Radar has ambiguous character and its result may be considered as single-level structure or multilevel structures with different basic functions etc. For example, as Radar elements we can choose sub-systems of processing of Radar signals and data, different channels of processing of signals, of detection and tracking of trajectories and corresponding devices and algorithms for processing of Radar information.

As rule, the multitude ***W*** consists from tasks connected with the estimation of quality of functioning of Radar or of its elements for given conditions and different assumptions about its structure and parameters or tasks of the obtaining of chosen characteristics of input components.

As elements of the multitude **Ω** we can consider such decisions of tasks from ***W*** as:

- results of functioning, criterions of efficiency and quality indexes (or their estimations) for Radar or its elements;
- different characteristics (statistical, dynamic etc.) of input influence.

Decisions from **Ω** may be obtained with using analytical and numerical methods, simulation or combinations of methods. Therefore used mathematical models are differed by mathematical description, complexity, accuracy and resource parameters. According to this classification we can form various versions of mathematical models and modeling algorithms and consider corresponding sub-multitudes $\{\Theta M_i\}_1^I$ of ***ΘM***.

As rule, it is necessary to transform decisions of research tasks (basic characteristics, indexes of quality etc.) to kind that is convenient for substantial and comparative analysis (for example, standard graphic forms widely used for chosen SA).

Usually several decisions are processing for obtaining of one form that allows to establish the tendencies with taking into account the different factors. Such representation forms as different curves, diagrams, dynamic models etc. are elements of multitude ***Φ***. The multitude ***Φ*** is defined on the base of SA learning, of the generalization of typical tasks, of the processing of obtained decisions with using algorithms of statistical and functional analysis, of interpolation algorithms and optimization procedures.

The multitude ***U*** consists from all information obtained at solving of tasks from ***W*** including multitude **Ω**.

For solving of task in ***CL*** we must determine:

initial conditions: structure, parameters and characteristics (vector $\bar{b}_0$) of research object (s);

a type of *decision* (of result of experiment) and requirements to it;

the method of decision obtaining and the realization of chosen method which ensure the implementation of b);

a type of *output information* and requirements to it.

Quality of output information we can estimate with using:

- of vector $\bar{\pi} = \{\varepsilon, \rho, \tau\}$ of quality indexes of obtained decisions (ε - accuracy, ρ - complexity, τ - reliability);
- of vector $\bar{\partial}$ of quality indexes of information representation with such components as information value, visuality, expressive adequacy.

Quality indexes of functioning of ***CL***:

- time $t_{\varepsilon\rho\alpha}$ of obtaining of one decision with given characteristics $\overline{\pi}_0$;
- time t_∂ of obtaining of output information (on the base of several decisions) with given characteristics $\overline{\partial}_0$;
- time $t_\wp$ of forming of instruction for obtaining of output information;
- volume V_p of required software;
- vector $\overline{\wp}$ of requirements to quality of dialogue "man - computer" (conceptual clearness, the reliability, the simplicity of realization, user's convenience).

Generalized index t_{proc} is determined as time of implementation of all operations for obtaining of information with required quality:

$$t_{proc} = t_{\varepsilon\rho\alpha} + t_\partial + t_\wp \,. \tag{1}$$

As generalized parameter of information completeness of ***CL*** (or of the opportunity of decisions obtaining for tasks from ***W*** at ***CL***) we can use a probability $P_{\inf}^W = \mathrm{P}(U \mid \overline{\pi} = \overline{\pi}_0, \overline{\partial} = \overline{\partial}_0, t_{proc} = t_0, W)$ of the obtaining of decisions multitude with given quality $\overline{\pi}_0$ which are computed at acceptable time t_0 and represented according to given requirements $\overline{\partial}_0$.

This index can characterize the openness of ***CL*** (the ability to updating), too. As procedure of computing of probability $P_{\inf}^W$ is not formalized the definition of this index carries rather subjective character and requires the participation of the experts.

On the base of considered indexes we can form the vector of main indexes of quality $\overline{Q} = \{t_{proc}, P_{\inf}^W, \overline{\wp}, V_p\}$ for ***CL***. The level of process support of programming, the using of standard software for the work with ***CL*** etc. are considered as auxiliary characteristics.

Efficiency **E** is determined as an advantage from the using of ***CL*** at designing of Radar. It is possible to express **E** quantitatively (the reduction of research's time, of used resources etc.) and qualitatively (increase of research's quality at the expense of expansion of multitude of tasks which may be solved at ***CL***, increase of representation quality of information and of the intellectualization of works etc.). It is necessary to take into account that at designing Radar can be of interest not only ***CL*** but also its information components (for example, data, scripts of conditions and situations of Radar functioning, technique of organization of tests etc.). Algorithms and the programs can use at designing the test software (simulators, complexes of testing of the equipment and etc.) [7].

As it is difficult enough to formalize the task of optimum designing of ***CL*** we can consider some simplified variant.

If optimized parameter is chosen as the time t_{proc} of obtaining of information with required quality $\{\overline{\pi}, \overline{\partial}\}$ a task of optimization may be formulated as minimization of t_{proc} for given restrictions of indexes $P_{\inf}^W$, $\overline{\wp}$, V_p:

$$t_{proc} \to \min \tag{2}$$

$$P_{\inf}^W \geq P_{\inf 0}, \qquad \overline{\wp} \geq \overline{\wp}_0, \qquad V_p \leq V_{p0}\,. \tag{3}$$

Thus, according to definition of t_{proc} from (1) for effective functioning of ***CL*** it is necessary to minimize or to limit $t_\wp$, $t_{\varepsilon\rho\alpha}$, t_∂ by given mode.

The solving of this problem is depending from choice of mathematical models, of algorithms for simulation and calculating, of methods of representation of data and knowledge and of the structure of ***CL*** (elements, interrelations of elements, control of functioning of elements).

Accordingly we can define the base for designing of ***CL*** as choice at the solving of tasks from ***W*** of such attributes:

a) type(s) of object of research from ***O***;

b) type(s) of versions of mathematical models and modeling algorithms from ***ΘM***;

c) type(s) of forms of information representation from ***Φ***.

This approach allows to consider separate tasks and tasks sets for different research programs.

Traditionally decomposition of multitude ***W*** as ***W***=$\bigcup_{1}^{N} W_n$ with using attribute a) allows independent research of *each n-th object* from ***O***, n=1,…N. As rule, such decomposition are considered at creation of N independent ***CL***, but sometimes - for one ***CL***, for example, when it is necessary to research channel of processing of Radar information and simultaneously its elements.

Using of the attributes a) and c) allows to consider two-level decomposition of the multitude ***ΘM*** as ***ΘM***=$\bigcup_{1}^{N} \Theta M_n = \bigcup_{1}^{N} \bigcup_{l=1}^{L_n} \Theta M_{nl}$, where index l corresponds to number of version of mathematical model used for obtaining of decision of chosen task from W_n.

On the base of the attribute b) for everyone of n-th object from ***O*** we can determine submultitudes $\Phi_n \subset$ ***Φ*** and $U_n \subset$ ***U***, n=1,…N, when $\Phi = \bigcup_{1}^{N} \Phi_n$ and $U = \bigcup_{1}^{N} U_n$.

For effective work of ***CL***, all stages of tasks solving should be executed with required quality, with chosen requirements to resource and with friendly interface "man - computer".

Interaction “man - computer” at ***CL*** we can describe as:

A) the forming by interactive mode of instruction (of request) Z for obtaining of task decision represented by required mode and for operations with it (the storing in the chosen format, the display on the screen, the transfer to clipper or the file, the removal);

B) the forming by interactive mode of instruction (of request) Z for obtaining of decisions of *I* tasks represented by required mode and for operations with them (the storing in the chosen format, the display on the screen, the transfer to clipper or the file, addition to existing data with their updating, the removal).

For simplification of the forming of user's requests to obtaining of required information we can use such formulations of *basic instruction* for ***CL*** as:

A) the instruction (request) $Z_{nmikl} =< o_{nm}, w_{nmi}, \bar{b}_{nmi}, \varphi_{nmik}, \bar{\pi}_{nmi}, \bar{\partial}_{nmi}, \theta_{nmil} >$ for obtaining of *decision* $u_{nmikl} \in U_n$ of *one research task* $w_{nmi} \in W_n$ of object $o_{nm} \in \mathrm{O}_n$ with required characteristics (vector $\bar{b}_{nmi}$), when decision quality (vector $\bar{\pi}_{nmi}$), *one* representation form $\varphi_{nmik} \in \Phi_{nm}$, the quality of representation (vector $\bar{\partial}_{nmik}$) and *one* version of mathematical model $\theta_{nmil} \in \Theta M_{nmi}$ are given, l=1,…L, m=1,…M, n=1,…N, i=1,…I;

B) the instruction (request)

$$Z_{nmkl} =< o_{nm}, \{w_{nmi}\}_1^I, \{\bar{b}_{nmi}\}_1^I, \{\Phi_{nmi}\}_1^I, \{\bar{\pi}_{nmi}\}_1^I, \{\bar{\partial}_{nmi}\}_1^I, \{\Theta M_{nmi}\}_1^I >$$

for obtaining of *I decisions* $\{u_{nmikl}\}_1^I \in U_n$ of *I research t*asks $\{w_{nmi}\}_1^I \in W_n$ of object $o_{nm} \in \mathrm{O}_n$ with required characteristics (vectors $\{\bar{b}_{nmi}\}_1^I$), when

- quality of decisions (vector $\{\bar{\pi}_{nmi}\}_1^I$) are given;
- one or some of representation forms $\Phi_{nmi} = \{\varphi_{nmik}\}_1^{K_{0i}} \in \Phi_n$ and quality of their representation $\{\{\bar{\partial}_{nmik}\}_1^{K_{0i}}\}_1^I$, K_0=1,…K, are defined;
- one or some of versions of mathematical models $\Theta M_{nmi} = \{\theta_{nmil}\}_1^{L_0} \in \Theta M_n$, L_0=1,…L, are defined; m=1,…M, n=1,…N, i=1,…I.

Such approach allows effectively enough to formulate and to describe not only tasks, but also the various research programs (plans) focused on the decision of tasks set with use of different versions of mathematical models and of forms of information representation.

We will consider as elements of the multitude ***O*** Radar and its elements (subsystems and channels of processing of Radar information) when variants of their structural - parametrical definition and catalog of algorithms and devices for processing of Radar information are known.

In this case is of interest the conception of integrated informational environment (***IIE***) that allow optimal using of information and software for execution of different research tasks of Radar and its elements [5]. ***IIE*** scheme is given on Fig.1.

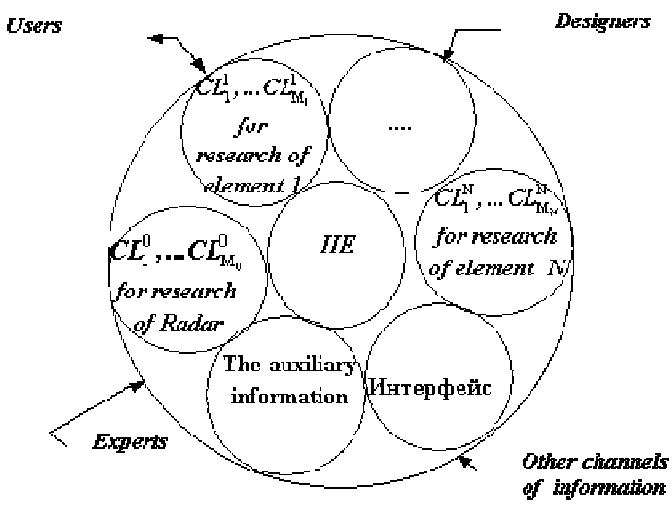


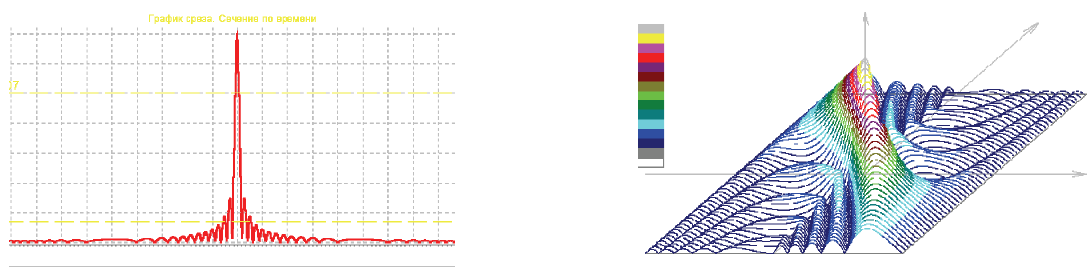
Fig.1. ***IIE*** scheme

Basic elements of ***IIE*** (computer laboratories $\boldsymbol{CL_1^0,...CL_{M_0}^0}$ destined for Radar research and computer laboratories $\boldsymbol{CL_1^1,...CL_{M_1}^1},...\ \boldsymbol{CL_1^N,...CL_{M_N}^N}$ destined for research of single Radar elements) are denoted between the first and second circles of ***IIE*** scheme. Auxiliary elements are such ***IIE*** components as glossaries, the bases of tasks and of research programs, the specifications, technical information, of algorithms of a control and commutation, of scenarios, explanations, recommendations and interfaces, too. In general, these informational structures may be considered as off-line elements. Service information of ***IIE*** consists from the database, the bases of the knowledge, of mathematical models (including analytical and algorithmic models), of presentation forms of information and software etc. Some components of this list are practically interesting to different users as independent informational structures. Channels of the information to ***IIE*** and users are denoted beyond the bounds of outside circle.

This approach is the base of the ideology of systemic modeling [10].

Further we will consider some examples of representation of information obtained with using different ***CL*** (fragments of interfaces).

Examples for illustrating of signal processing (autocorrelation function and uncertainty body of linear FM signal) are shown on Fig.2a, b (***CL SIGNALS 1***). For this ***CL***, the channel of processing of Radar signal and its input signals are considered as research objects and given by alternative variants.



a) autocorrelation function of linear FM signal b) uncertainty body of linear FM signal

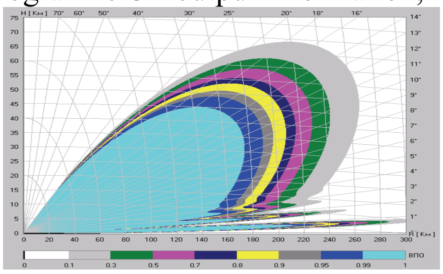
Fig.2. Fragments of ***SIGNALS 1*** interface

Note, that analyzing of results represented in frameworks of one form becomes essentially simpler. *Zones of equalprobable detection* (or *zones of Radar visibility*) are considered as basic forms of the information representation for $\boldsymbol{CL_1^0}$ (for example, ***SCOVD 1*** as kind of $\boldsymbol{CL_1^0}$). Some *zones of the visibility* represented in vertical and horizontal planes and obtained with using ***SCOVD 1*** are illustrated by Fig.3a,b,c. There are considered 10 value of instantaneous probability of the detection P_D, probability of false alarm $P_{FA}=10^{-6}$ and statistical model of return signal of Sverling 2.

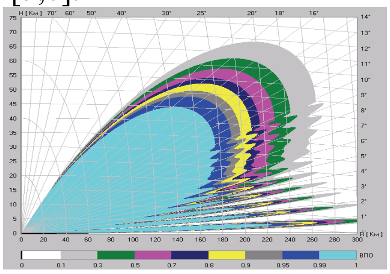
Data of Fig.4a, b is illustrating two representation forms of signal reduction function.

Detection probabilities are presented in the dependence from a range on the Fig.5a, b without and with reference to influence of surface (a) and for sea surface (b).

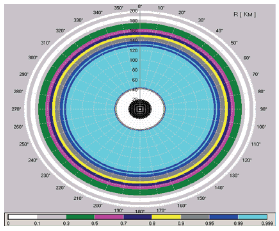
Possibility of the choice of different conditions of Radar functioning (for example, type and characteristics of surface, of conditions observability and other characteristics) allow to execute different research programs with using given ***CL***. Series of such results united by common research program is ***CL*** output information, too [5,6].



a) zones of Radar visibility in vertical plane

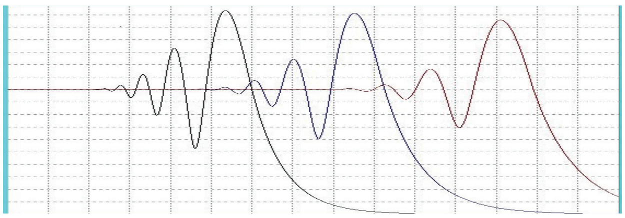


b) zones of Radar visibility in vertical plane

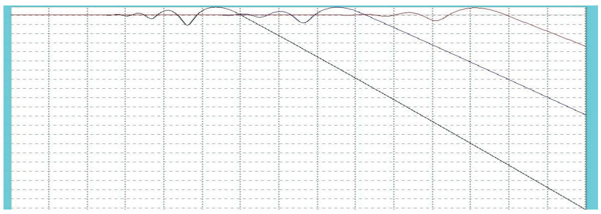


c) zones of Radar visibility in horizontal plane

Fig.3. Fragments of ***SCOVD 1*** interface

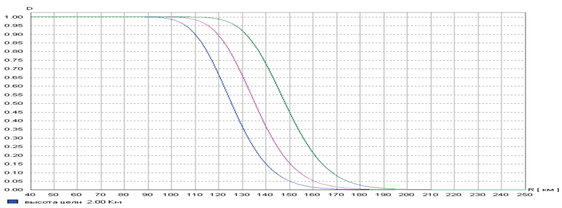


a) signal reduction functions (V)

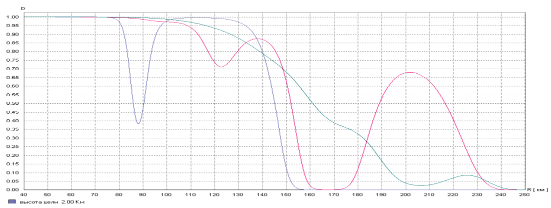


b) signal reduction functions (dB)

Fig.4. Fragments of ***SCOVD 1*** interface



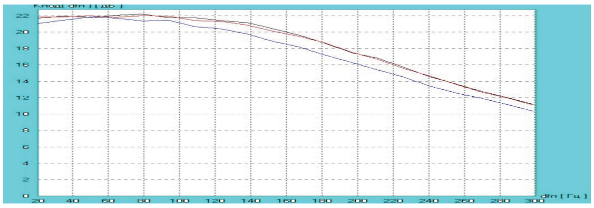
a) Dependences of detection probabilities from a range (without reference to influence of surface)



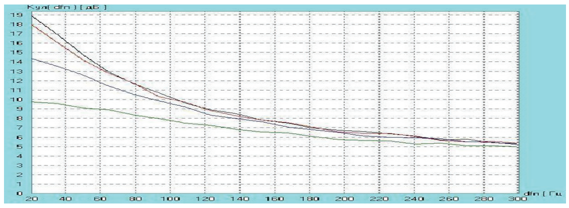
b) Dependences of detection probabilities from a range for sea surface

Fig.5. Fragments of ***SCOVD 1*** interface

Dependences of cancellation factors and improvement factors from spectrum width are presented on Fig.6a,b (***CL FMTI 1***).



a) Dependences of cancellation factors from spectrum width



b) Dependences of improvement factors from spectrum width

Fig.6. Fragments of ***FMTI 1*** interface

Fig.7 is illustrated the movement of a few air objects as their trajectories projections on different planes (***CL TRAJECT 1***) [7,8].

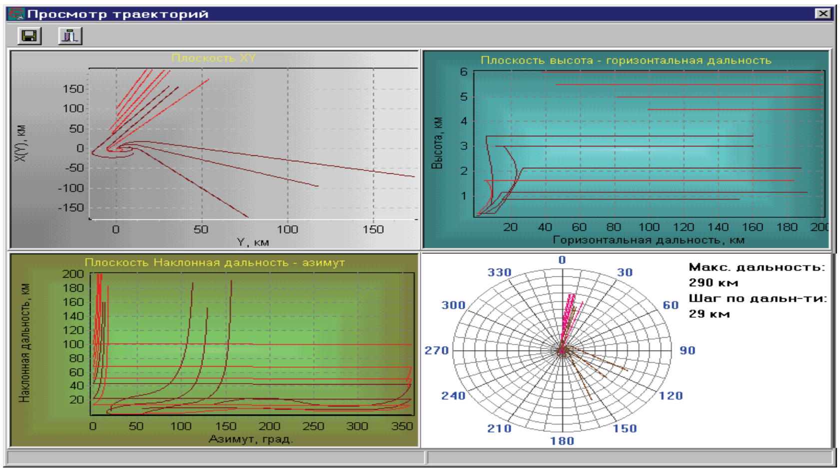


Fig.7. Fragments of ***TRAJECT 1*** interface

One of factors of realization of ***CL*** is level of support of processes of programming and using. Modern software and its development do preferable orientation to means of programming, for which we can execute functions of ***CL*** as systems of support of processes of designing Radar, of scientific researches and acceptance of the decisions with use of the appropriate service opportunities of the computers and advantages of a computer network.

Conclusions

❑ the designing of ***CL*** is based on the decomposition of multitude of tasks of research of Radar and of its elements with using of some classification attributes that characterize main stages of research and learning - choice of research object, determining of requirements to decisions quality, choice of methods of obtaining of decisions and forms of their representation;

❑ optimal structure of ***CL*** defines on the base of chosen criteria of efficiency and indexes of quality;

❑ using of different ***CL*** allows solving the following problems:

- the obtaining of the information about a quality of radar observation with taking into account of characteristics of the Radar, antenna pattern, of algorithms of radar information processing, of aircrafts movement trajectories, of return signal characteristics and of characteristics of a surface etc.;
- the obtaining of the information about a input influence of Radar and its elements;
- the cataloging of plans of standard situations for the describing of the Radar input influence with taking into account of characteristics of the modern aircrafts and of the requirements to this information (for example, air traffic control system requirements, conditions of the functioning of airports etc.);
- the obtaining of the qualitative illustrative data for projects, scientific and technical reports etc.;

- the preparation of the information for the solving of optimization tasks;
- examinations of the technical decisions used for design of Radar.
- the preparation of the information for the making of technical and organizational decisions;
- learning of given SA.

Elements of ***CL*** are useful for the forming of informational maintenance of such processes as:

- scaled-down modeling (the simulation of aircrafts movement trajectories, signals and interferences, measuring information etc.) and the simulation of the functioning of algorithms and processing devices as well;
- full-scale testing (the processing of experimental data, the interpretation of this processing results, the combination of experimental data – natural and obtained on a computer);
- the training of the personnel (the development of scenarios of various situations (regular and not regular), simulation of input influence according to given scenarios);
- the forming of plans of experiments for the training, for the testing etc.

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V.I Morzhov, professor (National Aviation University, Ukraine)
J.V.Galla, advanced student (National Aviation University, Ukraine)

COMPUTER AUDIT SYSTEM FOR PILOT PHYSICAL STATE DETERMINATION UPON ANALYSIS OF HANDWRITTEN TEXT

In this article possibility of building of automatically system of diagnostics the physical condition of the summer group according handwritten text. Justified practicability of building such a system; given descriptions of studying the handwritten texts, structure of automated system, algorithm of its functioning; considered the main problems, which arise in the process of developing; described a method of obtaining the dynamical characteristics of the text.

Introduction.

Experts of Interstate Aviation Committee (IAC), which investigated the plane crashes of the former CIS in almost 90% of these extraordinary events, recognized “human factor”. The general scheme of crashes is typically: to get into a difficult situation (mostly because of bad weather or faultiness of plane), the crew of plane makes not logical actions. According to reports of IAC is seen, that pilots are confused in test indication, lose spatial orientation and makes mistakes in manipulation, for example, crash of TU–154 of airline company “PULCOVO” over Donetsk region, of airbus A -310 of airline company “Siberia” in Irkutsk [1, 2]. Such situations often IAC staff explains of low skilled, but from point of view of psychologists, the reason of crashes were low resistance of pilots in condition of stress.

The specialists of aviation medicine consider, that organisms of pilot with big experience is elder, than his calendar age for 7 – 10 years. The psychic wares out faster. In pointed above crashes, pilots showed low psychological resistance and under influence of stress made tragically mistakes in maintains of airplane. The stress resistance is controlled on earth: all pilots have to pass psychological tests periodically. But summaries of psychologists ware recommendation character, and psychological tests are hold rare.

In the past years in psychological medicine scientific foundation of human factor conception is given, according to which the crew is reviewed as a main component of system “pilot-plane-medium”.

Building this concept, necessary to develop activities to improve the professional psychological selection using diagnostic methodology that can be implemented in automated systems. Analysis of the majority of violations of the health of summer crew demonstrated, that they are correlated with many indicates of psychological sphere, which are studied with help of psychodiagnostics tests for valuation of professionally important qualities of pilot and situational given by psychological reaction. Currently, there is a need for computer systems for diagnosis to detect violations of the health on pre-clinical level. For this a development of automatic system of valuation the physical health of pilot according to manuscript text is offered.

The principles of manuscripts researches.

Researching of manuscripts relate to number of more popular expertise in criminalistics and psychoanalysis. The main purpose of them is to identify the executor, but with their help questions, which refer to conditions of doing the manuscripts, characteristics of personality of author and his physical condition are solved.

Researches of scripts are based on general provisions of the theory of identification, on data of psychophysiology of higher nervous activity of human. The ability to write-acquired remains as a result of a lengthy education and training and is being sent to automaticity, with relatively persistent identification signs handwriting [3].

There are:

– Technical skills (carriage at the time of writing, position of papers, type of keeping the writing tool, etc.);

– Graphic skills (written reproduction of signs and their connections);

– Written language skills (vocabulary and construction of the text, etc.).

The combination of technical skills and graphics that appear in the manuscript, characterize human handwriting. Under the influence of internal and external factors of writing a lot of features appear and complex of them become unique. In scripts of different people partly similar features can be met, but their complex in every person is individual.

Features of scripts can be divided in two groups:

– General that characterize the handwriting as a whole, as a system of movements;

– Private, which show the movements especially when writing individual letters, their parts and character spacing combinations.

General features can be divided into three large groups:

1. Signs that show the degree and nature of the formation of writing and motor skills. This is depletion handwriting; coordination of movements - the accuracy and regularity of its movements when writing letters, respect for their size, italicized; pace letters; structure handwriting.

2. Features that show the structural characteristics of movements. This transformation incense form movements (straightforward-angular, round, mixed), the direction of movements (right-turning, left-turning, mixed); handwriting size, which determines at an average altitude of lowercase letters, the length of horizontal movements - dispersal of handwriting, communications account handwriting, that is ability to write, not removing writing tool of the paper, special number signs; pressure handwriting.

3. Features that show the spatial orientation of manuscript fragments and movements (topographic).

Private features of handwriting:

– Movements in the performance and the combination of letters and their components;

– The direction of movements when writing;

– Length of movements - the relative size of strokes different elements of letters;

– Connectivity of movements;

– The kind of connection between the letters;

– Relative placement points of the beginning, the end, crossing and connecting movements;

– A sequence of movements performed by different elements of letters and their connection;

– Difficulty in carrying out movements, compared with the letters in words.

Diagnostic test of manuscripts.

Features of handwriting contain important information about the author. In them physiological, anthropometrical and psychological features are shown.

The character of script and psychophysiological conditions of human are connected closely [4]. The reasons, which push to changes of script, are not usual pose of a person, tools and content of the text, an unusual state of human (intoxication, excitement, illness), violations of bone-muscle function apparatus or nervous system (trauma, nerve diseases, etc.).

For each of these states are characterized different levels of impact on features of handwriting, for example, the violations of the nervous system activity lead to a decline in the overall level of literacy, frequent corrections of letters, unevenness in recognition skills and size variations of letters, unstable slope, reducing coordination. Private features in that time do not have notable deviations.

In spite of diversity of reasons, which cause changes in handwriting, the system movements (dynamic stereotype) as a whole, is stable. Ability to iden-Communication Rights in the handwriting persists over time and even deliberate attempts to claim sentence or when changing the handwriting in old age. Ability of identification of human by script keeps during all time and even by effort of special distortion or with changing the scrip in the old age.

Formulation of aim for automated system.

The proposed diagnostic system must by scope of basic education standards of handwriting (manuscripts) of certain human(the pilot) has to make conclusion of deviation in handwriting, which showed an unusual condition of person, who had a stress, etc. When these values go over the braking bounds, the system must give a signal about dangerous condition of a human and a person must be examined by a doctor.

In the same time the system must accumulate results of the diagnostic of a person and examples of dynamic features of person scrip in its database. A pilot, which passes the diagnostic, must recreate some words before the flight and after it. An analysis of existing information will allow more fully and objectively judge the pilot's condition changes in each case.

The composition and functioning automated system.

Offered diagnostic system must consist of a computer and graphics tablet of A5 size. Also for the system possible use of the Pocket PC, although the small size of the screen and its lowest resolution graphics tablet with a relatively impose some restrictions. The software system should consist of the following functional modules:

- classical authentication module;
- processing module dynamic parameters: scaling, the allocation area for calculating local functional, calculation of functional;
- module of processing static parameters: the initial processing of images, symbols segmentation, recognition, analysis of general and private features of inscriptions;
- module of training and formation of standards;
- module valuation of the quality standards established in relation to the average biometric standard;
- module of databases and accumulation of information;
- module of dictionaries, and control grammar and synthesis control phrases;
- module of data analysis and decision-making;
- module of diagnostic summaries and long-term forecasts,

The function of system must go in a following way:
On the stage of studying of system, a person must give an education alphabet and realization of some phrases. These data are analyzed and put in database of etalons. On the stage of diagnostics the system must dictate the control phase, which a person must write. Further this phrase should be analysed and according the results, diagnostic decision is given.

Personal identification according to handwriting manuscript.

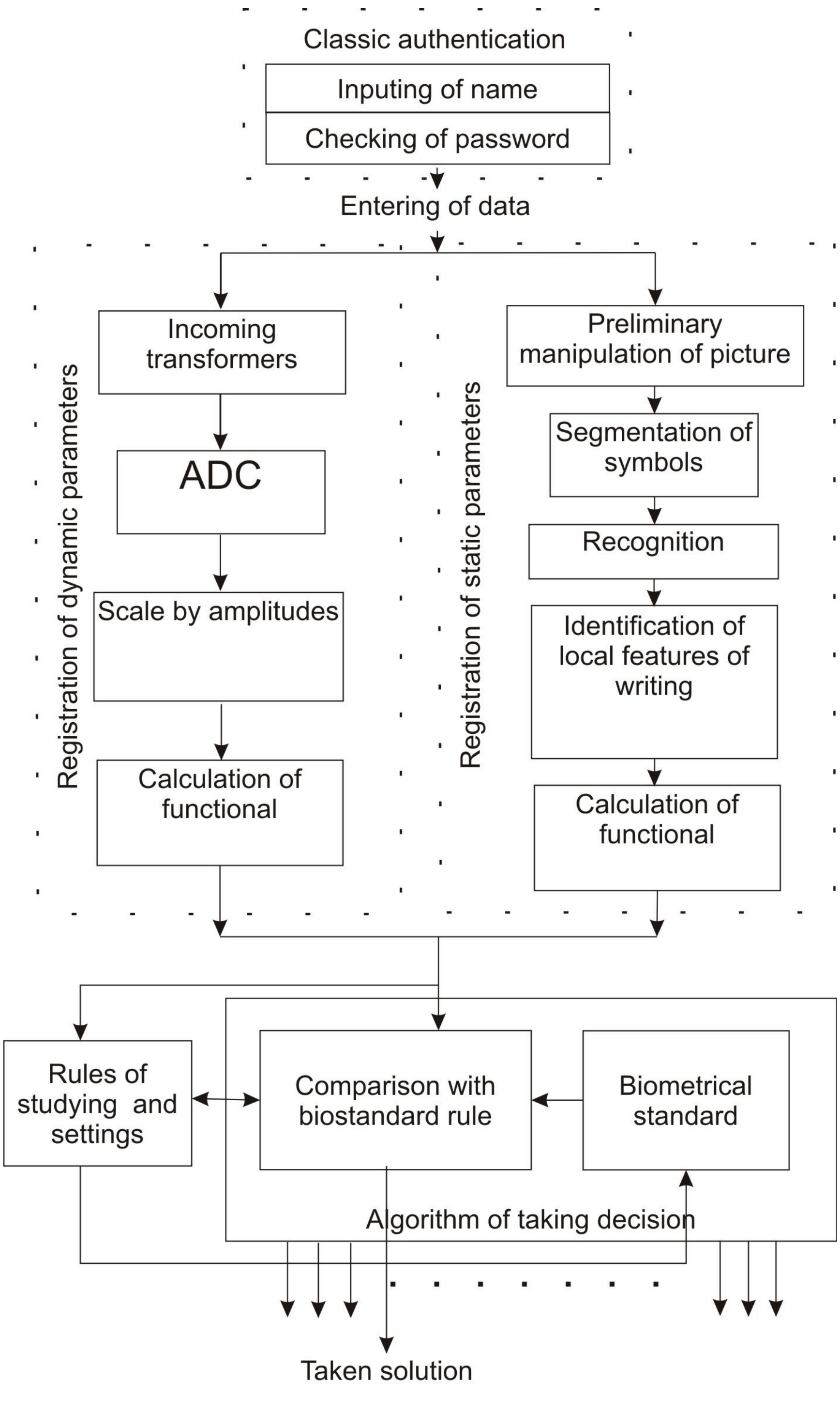
The tasks of identification and authentication of person according to physical features inherent to biometrical systems of security. Such systems are given to users of biometrical keys, give the decision of type “own/alien”. Offered diagnostic system is similar to them, but its aim is to find characteristically features of entered biometrical key of person (manuscript phase), comparing

of them with standard, valuation of changing rate of these features and given the result of physical condition of person.
During entering the manuscript phase, it is necessary to have a good look at two parts of biometrical data:

- dynamical (read the dynamics of playing key phrase author and control of individual characteristics of person's subconscious movements)
- static (comparison of written with standard) [5, 6]. Analysis of these components is the exact aim of diagnostic systems.

During analysis of dynamic parts of data, to analysis will be taken vibration of pen in writing process in three-dimensional space. In Cartesian coordinate system (X, Y, Z) data on the evolution - is a function of time vibration of pen in the plane graphic tablet X (t), Y (t) and the function of pressure at the surface of the surface Z (t).

Analysis of static components of data is more complex. Biometric identification systems and optical character recognition systems that use these data are mostly semiautomatic and the final decision takes an expert.



Pic. 1. Flowchart of information processing in an automated system

Features of regimes of biometric identification

Classical identification of some unknown objects and the establishment of its mathematical model which describes the entry / exit object identification with a given error. Biometric identification has deal only with feedback of abject - static and dynamic individual images.

The simplify structure can be shown in appearance of block-scheme, which shows main stages of handling the information (pic. 1).

Let's look at the process of dynamic parameters handling. The beginning is a classic diagnosis of authentication - the login of name and password. This is to sort out the system from the database of required standard for further work.

The first stage of processing is converting of non electrical quantities coordination of pen end into electrical signals. Then these signals become numerals and program processing of data is made. During program process is performed scaling of amplitudes input signals is made**,** which leads them to some standard value. Besides this, all signals to a single scale of time is going, splitting the signals into separate fragments with the next shift fragments signal to the optimal combination of them with the standard location.

After scaling calculation carried out vector functional (vector control parameters - v = (v1, v2,… vk)).

The regime of the system determines the totality of operations carried out further with the calculated parameters of vector v. If the biometric system is in learning mode, a pair of vectors v-meters enters into the block of training rules, which forms a standard biometric of person. Dynamic images of the person have substantial variability, so for the formation of a biometric standard need a few examples of implementations of the same image.

In the diagnostic mode vector of control parameters v, obtained by the given image, is compared with a decisive rule with biometric standard. If presented vector is close to a biometric standard, positive diagnostic decision must be taken. With significant differences of given vector and its biometric standard a conclusion should be formed about an unusual physiological position to a person who is diagnosed.

The first stage of processing parameters is preliminary processing of image quality. In this case, we need to use previously received information about writing characters. In doing so, consistently accurate movements of pen during writing characters, is additional information in the task of classification the letters. The task of previous handling makes easier the fact that during the introduction of characters, they clearly distinguished from the background. The aim of the final pre-processing is end separating of inscriptions from the background and its vectorization. The next stage is a segmentation of the inscriptions on individual characters and their recognition. The challenge of segmentation is complicated in cases of high connectivity of script. When low connectedness, the segmentation of characters can be made on the basis of dynamic data by pressure on the pen.

In the context of biometrics, separate attention deserves approach to the examination of learning. In the normal procedure of recognition, the system must find common characteristics among the many forms of writing letters and finding a particular letter, which meets these features - to make the assumption that the symbol is precisely this letter with a specific probability. In this case the task is divided into two parallel: the system must first identify the character as a specific letter (comparing the features of character with common features letters), and then, taking advantage of knowledge that considered symbol is exactly that letter, find the specific features of a particular person.

Choosing a determinative rule.

Type of used by system of decisive rules and type of standard biometric are inseparably linked. For most crucial rules of classical formation of biometric standard is a task that does not require special resources, and goes down to the calculation of mathematical expectations and dispersions. The exceptions are artificial neural networks, for which such parameters as the number of entrances neuron, the number of neurons, the type of excitation functions, the number of segments of the network, the type of links in the network should be seen as decisive parameters of the rules. Neurobalance values and the values shifted coefficients, received for a concrete person, should be viewed as parameters of a certain biometric standard, designed for neural decisive rules for the specific structure**.** Another crucial feature of neural rules is a significant reallocation of computing resources that are spent on education and decision-making procedures. Education of neural networks requires significant way by the more computing resources in comparison with the decision. For network acceptance of decision, setting of the weight coefficients of network - this is not very simple task and sometimes cannot be solved in within acceptable cost-duration resources.

Receipt of the dynamic parameters.

Dynamic parameters, which are take into consideration in the identification, are obtained by calculating some linear functional on the full realization of its inscriptions or fragments. The global dynamic parameters are calculated on the full realization of curves Y (t), X (t), Z (t). Local dynamic parameters are similar parameters, but calculated on some sections of curves Y (t), X (t), Z (t), for example, which are responsible for different letters of phrases.

In a capacity of calculating linear functional it is convenient to use orthogonal functional of Fourier. The choice of orthogonal transformation, dues to the fact that they provide data with a smaller internal correlation in comparison with other non-orthogonal functions. The global dynamic parameters will have meaning of Fourier coefficient rates with the cosine and sine, which are calculated as follows:

$$a_{xk} = \frac{1}{T}\int_0^T X(t)\cdot\cos\left(k\frac{2\pi}{T}t\right)dt,\ \ b_{yk} = \frac{1}{T}\int_0^T X(t)\cdot\sin\left(k\frac{2\pi}{T}t\right)dt;$$

$$a_{yk} = \frac{1}{T}\int_0^T Y(t)\cdot\cos\left(k\frac{2\pi}{T}t\right)dt,\ \ b_{yk} = \frac{1}{T}\int_0^T Y(t)\cdot\sin\left(k\frac{2\pi}{T}t\right)dt;$$

$$a_{zk} = \frac{1}{T}\int_0^T Z(t)\cdot\cos\left(k\frac{2\pi}{T}t\right)dt,\ \ b_{zk} = \frac{1}{T}\int_0^T Z(t)\cdot\sin\left(k\frac{2\pi}{T}t\right)dt,$$

where T - is full name of entering time of data.

For determining of unknown scales of entered data, it is necessary to solve 3 independent linear equation:

$$M_y\cdot\sqrt{\sum_{k=1}^{N}\left(a_{yk}^2+b_{yk}^2\right)} = C_y,$$

$$M_x\cdot\sqrt{\sum_{k=1}^{N}\left(a_{xk}^2+b_{xk}^2\right)} = C_x,\ (1.1)$$

$$M_z\cdot\sqrt{\sum_{k=1}^{N}\left(a_{zk}^2+b_{zk}^2\right)} = C_z,$$

where M_x, M_y, M_z are scales of just entered inscription; C_x, C_y, C_z are meaning of square root, which correspond to standard; N - is end numeral of accounted coefficients of Fourier rates.

For given of data according to scale of first inscription, it's enough to multiply the value of calculating linear functional on gotten from equation (1.1) scale coefficients.

Local dynamic parameters are calculating the same as global, with only difference, that period of integration takes equal to some good examined local segment of time. For example, the calculation at intervals of touch pen to the graphic tablet, between isolation of pen (during simultaneous approximations to zero functions Y (t), X (t)). Apart from the isolation pen from tablet for crushing fragments of inscription may use the crossing fragments trajectory inscription, points of changeable directions, angle point of the letters that have gaps of derivative [7].

Correlation between global and local dynamical parameters must be wise balanced. The global dynamical parameters describe likeness of inscription according to example in total, and local parameters let value the likeness of replying every letter with standard or every fragment of inscription.

Biometrical standard for this class of system is formed on stage of studying and must show as stabile and unstable components of biometrical data. Biometrical standard of inscription can be formed by several ways against from accepted in a system decisive rule. Partly, if decision in system is taken by neuron network, than role of biometrical standard will play the structure of artificial neuron network, shape and parameters of excitement functions and sense of neuron weights. In case when the decision is taken in decisive deterministic rule, the role of biometric standard can play a vector of measures mathematical expectations of dynamic parameters and vector dispersion of these measured parameters. In systems that take into account local characteristics reproduced inscriptions raises mixed fragmented inscriptions. In mechanical subconsciousness playing the word (letters) with some frequency new additional fragments appear, while the same can disappear (merge) previously separated neighboring fragments. As a result of splitting into fragments inscriptions become ambiguous, while studying several options for fixed chart present from the author. Of the situation ambiguous markings signature possible two exits. First exit is connected with the formation of several independent standards; in the same time for the formation of each need a few inscriptions, which complicate the process of learning the system. Second way linked to bringing all options to some averaging option.

Summary.

To provide high affectivity and reliability of functioning of aviation systems in future will be possible only on condition of development of their components, taking into account human factor and, firstly, psychophysiological characteristics of summer crew. Building and providing complex systems of constant diagnostic of pilots will make low risk of crashes because of human factor.

There is possibility to make summary, that described above automated system can be realized for detection of violation of health on pre-clinic level. More, that database of this system will include supervision on large interval of time. Such data can be used by experts avian-psychologists, as additional source of information.

In reviewing the following problems have been identified even not solved issues:

- Complexity of the solution to the static analysis of the inscriptions for the contemporary level of development of information technologies;
- The possible use for the analysis of local and global dynamic parameters of nonlinear functional;
- Needs further analysis of the selection rules for deciding to develop diagnostic system (deterministic or neural network), and jointly with medical definition of the borders deviations dynamic and static parameters text;
- Together with medical needs to develop an algorithm for determining painful and physiological states of the violations and their impact on the dynamics of subconscious movements.

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N. Sidorov (Doctor of Science),
V. Nedovodeev, E. Sidorov, V. Khomenko (Candidate of Science)
National Aviation University, Ukraine

REENGINEERING OF THE LEGACY SOFTWARE: THE AIR SIMULATOR CASE STUDY

There are the technical complexes consisting of components, parts of which are used, but the rest has lost working capacity owing to moral and physical deterioration. An example of such a complex is the aviation-flight complex "plane-simulator" [1]. High cost o plane do the actual task of restoring the out-of-order components (simulator). The considerable part of such complexes is the software, which requires the rework. The rework method is software reengineering.

1. Software Reengineering

In general, the software reengineering requires two processes - reverse and forward [2]. Input of the reverse process (fig. 1) are the legacy software and the additional information about the domain. The result of this process is the model - representation of the domain. This model then is used in the forward process for the new software creation.

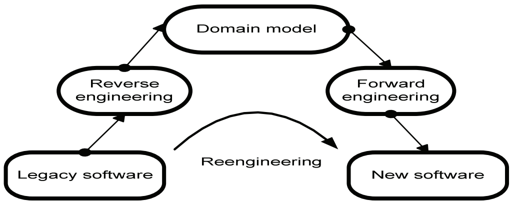

Fig.1. Processes of reengineering

In a context of engineering the domain of the software is an application area for which the software is developed [3]. The domain model is a description of the domain which is created by performance of one of the reverse engineering methods – design information recovery [4] or the domain analysis [3]. Irrespective of the method, for creation of the domain model the combination of the code, existing documentation, experience of staff, the common knowledge of a problem and application area [4] are used. Representation of domain model, depending on solved tasks and a domain maturity can be in the form of a taxonomy, functional models or domain language [4]. If model construction is carried out by the first of the specified methods of reverse engineering the legacy software plays an important role.

Reengineering - is an effective method of reuse of the software – prolongations of the legacy software useful period which can be applied to reuse in different aspects – restoring, reusing and reworking of the software [5].

Software restoring is usually fulfilled in the process of its support. Reengineering appears as a method of struggle against ageing of the software which is characterised by number of symptoms [6]: code "pollution", loss of knowledge of the software, a bad lexicon (style) [7], easing of cohesion of the components, architecture "stratification". The reasons for these symptoms occurrence are eliminated in the operating software [8].

Preparation for a reuse can be fulfilled in the operating software (on its replication) or on the liquidated. Usually separate components of the software which are preliminary processed by application reengineering are reused – owing to changing of their functionality or owing to migration (new computers, the operating system, programming language).

Software rework at reuse is fulfilled when software migration is carried out. The case of legacy software migration to a new hardware platform is especially hard. The migration task arises owing to obsolescence and physical deterioration of the hardware platform. It causes the impossibility of using the computer and legacy software or its separate working parts execution. In this case, as a rule, both the operating system and the programming language are replaced.

Implementation of reverse engineering processes is associated with two tasks solving [9]: evaluation of the expenses necessary for construction of domain model; estimation of quality of the reverse engineering processes and whole reengineering. The first task solving depends on the maturity of domain and can be grounded on models of software cost estimation requires. Thus, the more mature domain is needed the less cost for reverse engineering processes realisation. Quality of reverse engineering processes is usually estimated, showing the developed software adequacy to the legacy software or the subject domain model [9].

The article under consideration suggests the method which is developed for application on the software, that is in operation in the subject domain [10] and presents the results of its usage for the aviation simulator complex TL-410M (airplane L 410) software rework after the hardware platform was replaced. The computer complex of the simulator constructed on the computer “Robotron” basis, was obsolete morally and physically, therefore requires the replacement by the modern hardware. The complex hasn’t been maintained for more than fifteen years; there were disabled computers, units of the data exchange system, a considerable part of indicators in a cockpit and on the instructor console. Thereof executing of the simulator legacy software became impossible.

The rest of this article consists of three parts. In the second part the method of object–driven reengineering of legacy software is presented; in the third – case study of simulator software reengineering is described; in the fourth – adequacy of the reworked software is considered.

2. Object-Driven Reengineering Methods

The article considers the method of reengineering of legacy software which was created for work in a subject domain. It is so-called E – programs [10], that are used on automation of the person or society activity. Thus, the software becomes a part of real environment. As a rule, the software of this type functions on hybrid (digital-analogue) computer complexes, and its considerable part is related to processing of the information circulating between real object or its model and the computer complex. The structure of such complexes includes analogue to - digital and digital-to-analogue converters, sensors of real object or its model.

Features of a subject domain and E-programs define that legacy software reengineering of the considered type requires solving the traditional problems of recovering the design information and information about a real object or model. It also requires the special approach to the problem solving of the adequacy proof of the reworked software functioning in the real object or its model behaviour.

Real object information recovered at the reverse engineering process is the set of input parameters and their characteristics; characteristics of sensors, indicators and actuators of real objects or models. Information recover requires the usage of the traditional way: source code and documentation analysis and experimental researches of the real object or model.

Constructed software functioning adequacy proof cannot be carried out in traditional ways – comparison of the results of legacy and reworked software execution or comparison of results of reverse engineering with behaviour of corresponding model of a subject domain [9]. The first way cannot be used because there is no computing equipment on which it is possible to execute the legacy software, and the second – because the model of a subject domain, presented at the documentation, as a rule, contains errors. Besides, special position of the E – programs in the real world specifies that the basic attention at the adequacy proof should be given to the detailed analysis of the program behaviour in real operating conditions [10]. Thus, proof of functioning adequacy of the developed software real object or imitating model characteristics and properties in the real object should play the main role. It is the essence of the suggested method of the software reengineering (fig. 2).

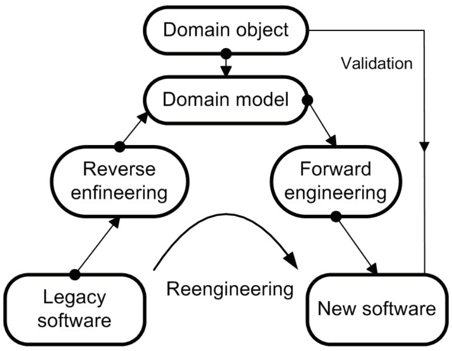

Fig.2 The reengineering method scheme

3. Reengineering Of The Legacy Software Of Aviation Simulator

The developed method was applied to the complex aviation simulator TL 410M (fig. 3).

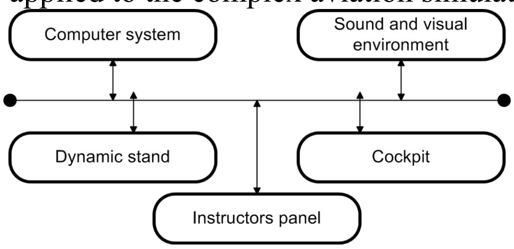

Fig.3 General scheme of simulator

The simulator computer system was built on the basis of computer “Robotron 4201” and the analogue-digital data exchange system. The software was written using autocode. Listings of the legacy software are presented at the documentation that includes seven volumes with total amount nearby 32000 LOC. The simulator had got the out-of-order analogue sound surround simulator. For visual environment imitation the television simulator on the face-to-face monochrome projective system and the stationary tablet on instructor workplace (co-ordinators, an airdrome breadboard model) have been used. The dynamic stand did not work, either. The instructor panel contained the indicators that duplicate one in a pilot’s cockpit and the television receiver for visual environment picture. The pilot’s cockpit simulated the cockpit of a real airplane L410.

The general scheme of the implemented hardware and software migration is shown on the fig.4.

The main computer “Robotron 4201” and the object communication device have been replaced by the industrial computer. The visualisation television system has been replaced by the computer system, based on the personal computer and a projector. On the industrial computer the MS DOS operating system was used and on the personal computer it was Windows. Migration of the legacy software was done from the assembler language to the high level language C. The restoration of the simulator electrical equipment that provides communication between computer system and a cockpit (cable system, power supply, functional nodes and intercom) was also executed.

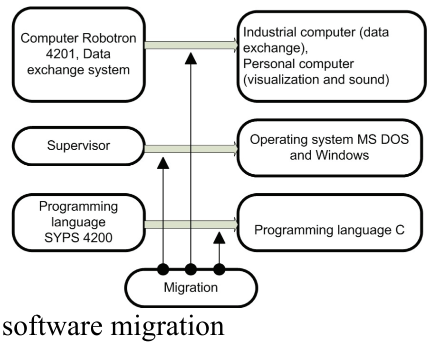

Fig.4. Simulator hardware and software migration

As the created software could not be checked up on correctness of functioning by performance of the legacy software (there was no computer) the reverse engineering, except traditional processes, included process of additional mutual check of the legacy code and model. Checking up of the domain mathematical model and the legacy source code were raised due to such reasons:

- the limited information about modelling principles of airplane flight dynamics and systems which have been used by the developer during creation of a simulator (1972);

- presence of errors present in technical documentation that was casually or deliberately brought in the model descriptions and the source code.

The following aspects were checked:

- scaling of variables – by the recalculation of equations factors of the simulators mathematical models (comparison of the expressions resulted in the documentation and their interpretation in a code listings has shown essential distinctions);

- realisations of factors - are used by the legacy software developers due to the limited characteristics of the modelling computers;

- realisations of the mathematical problems solving methods.

The main bulk of the errors was in factors of the model equations that describe dynamics of flight. Thus, for the factors adjustment the parts of the legacy source code were used in which calculation factors were defined. Interpretation of these parts «behind the table» allowed to define the values of erroneous factors. The following example shows the casual or deliberate error in mathematical model.

In power-plant mathematical model the analogue parameter *nv* – number of the air screw rotors is presented by the modelling equation

$$n_v = \frac{k}{1+\tau p} \tag{1}$$

where k – amplification factor; τ – screw time constant; p – Laplas operator. After a transformation, the definition (1) has the following differential equation form:

$$\frac{dn_v}{dt} = \frac{k - n_v}{\tau} = f(n_v) \tag{2}$$

According to the algorithm, applied in the modelling procedure, the equation (2) should be integrated by Euler's method:

$$n_{v(i+1)} = n_v + h \cdot f(n_{v(i)}) \tag{3}$$

where h is an integration step.

In the source program procedure the equation solving (2) is represented by the following text:

```
16334 01 02 0416      S27    LDA DEVP”
16335 100400                 UVR
16336 140040                 LOA
16337 0405 76                KAR 2
16340 00 04 0101             SPA AA2
16341 0405 75                KAR 3
16342 140401                 EKA
16343 00 06 0101             ADD AA2
16344 00 06 1757             ADD K12
16345 01 07 0512             SUB NVP”
16346 0405 75                KAR 3
16347 01 06 0512             ADD NVP”
…
16325 01 04 0512             SPA  NVP”
```

where – *DEV* – value that specifies control lever position of the air screw; *K12 = 0,595* – the constant.

Comparison of figure (3) and result of interpretation (4) shows that the text (4) does not include integration step h (at engines work modelling it equals 0,12). This error was due to the calculations „behind the table” - the received transient process did not correspond to physical sense. Similar errors are present in other power-plant parameters calculation executed by Euler's method.

The legacy software (fig. 5) characterises discrete process of modelling with the 60 ms period. This period is used for calculating four simulators parameters and for finishing input-output operations. Thus, necessary speed was reached due to the following factors:

- simplification of the airplane flight dynamics and systems mathematical models;

- replacement of the real (dynamic) processes analytical description by dependences in the form of decision tables;

- application of simple and fast functions interpolation methods;

- use of a simple method of differential equations integration (Euler's method).

After the source code models check the reengineering of the legacy software was carried out in two stages: reverse engineering – creation of the high level algorithmic representation; forward engineering – creation of the new C-code software based on this algorithms. For the reverse engineering the special tool – abstractor was built [11, 12].

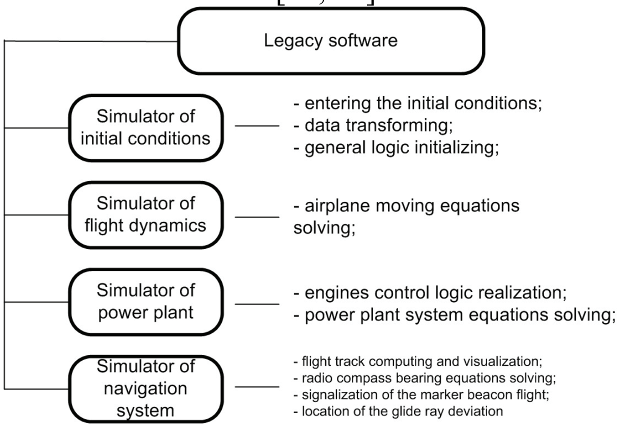

Fig.5 Legacy software structure

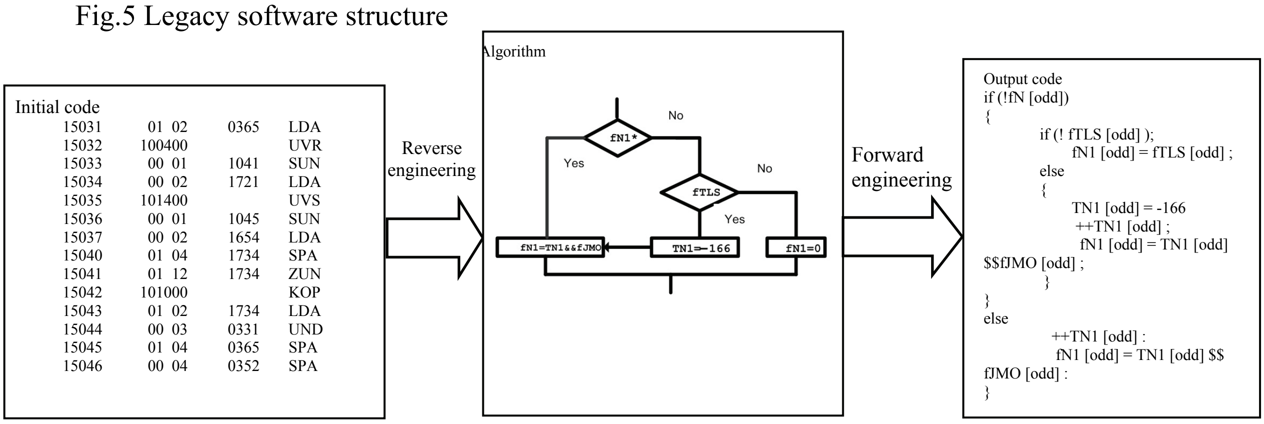

Fig.6. Reverse engineering result (part of the code)

3.1 Data Exchange System

Components and structure of the new software of the simulator computer system is defined by the following:

- object of control is simulator, a real-time system, which requires the defined recall time;

- the computing system of a simulator should provide input and output of plenty of parameters (nearly 120);

- visualization of the simulator flight environment should be realized on the high-speed computer with the special characteristics of a video subsystem.

These factors define the distributed architecture of the simulator computer system, that includes several specialized computers and peripheral devices (fig. 7): an industrial computer for simulator models computing and input-output of data; computer for realization of the visual environment and noise simulators; a computer for the instructor board.

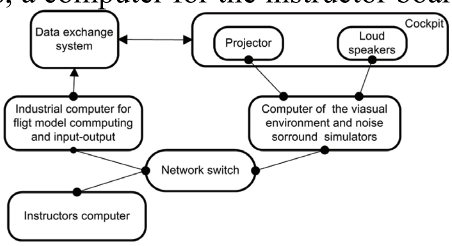

Fig.7. Hardware architecture of the simulator modeling system

Data exchange between computers is organized through a local computer network on the Ethernet and protocol TCP/IP basis. Equipment of the computing system includes the digital-analogue IO-devices, the computer projector and the sound amplifier and loudspeakers. IO-devices are connected with one of the following types: analog-digital converters (ADC); digital-to-analog converters (DAC); logic signals IO-devices. All devices are the boards which are installed on the industrial computer on the ISA system bus.

3.2. The Software Of The Data Exchange System

The software of the data exchange system works on an industrial computer and is designed to provide the exchange of airplane simulators (models) with the simulator cockpit equipment. This software was created by adjustment of the specially developed pattern [13]. The software provides the following tasks:

- configuring of the IO-devices;
- control of the IO-devices;
- realization of network exchange under TCP/IP-protocol;
- provision of the standard interface in normalized parameters for exchange of IO-devices with models of the airplane.

The two-level modular architecture of the software provides the flexibility and scalability of a IO-subsystem (fig. 8). It includes the levels of IO-device drivers and drivers of parameters. Drivers functions provide control of signal and data conversion and digit data delivery. Driver level provides configuring of IO-devices during start and exchange control. The level of parameters drivers provides configuring of parameters which are inputted, outputted and converted - digital values of signals to normalized analogue values of models and vice versa.

The configurator of IO-devices reads the configuration data (numbers of boards, the addresses, numbers of interruptions) for each of configuration files, configures the devices automatically and tests their functioning.

The configurator of parameters stores the configuration and reads the data, necessary for normalization of each parameter. Each analogue parameter has the following configuration sets: parameter number; minimal and maximal values of parameter, minimal and maximal values of signals.

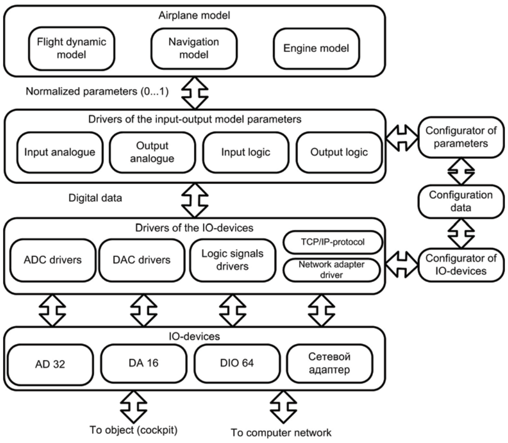

Fig. 8. Architecture of the simulator data exchange system

4.Adequacy Of The Reworked Software

For checking the reworked software functioning adequacy on the real object the quantitative and qualitative estimation are used The quantitative estimation was carried out in such ways:

- point - comparison of values of the calculated operational parameters with reference points in the description of simulator TL-410 by the simulator developer technique;
- interval - comparison of the calculated characteristics with characteristics which are resulted in documents of the real airplane (flight guidance, technical operation guidance, the description of the plant system, the description on the avionics, data of flight record system).

Estimation of a quality of simulator behavior in different flight modes and stages is carried out by experts - pilots. Results of point estimation application are presented in the table, and results of interval estimation - on fig. 9, 10.

There are two approaches to a quantitative estimation of adequacy - determined and statistical [14].

Results of reworked software adequacy check based on the determined approach have shown the efficiency of the developed method of the legacy software reverse engineering.

The statistical approach to an estimation of adequacy is planned to be carried out after statistical experiment.

Table Point estimation of the TL 410M simulator adequacy

Flight part	Controlled parameter	Control value	Defined value
Acceleration	Time from the moment of release of block before achievement of speed V = 150 km/h	t = 14 ± 2 sec	14.7 sec
Ascensional rate	Vertical speed of rise of the plane	V_y = 10 ± 1.5 m/sec	10.72 м/sec
Flight characteristics	Cruising speed, rotation moment, pitch	V = 250 ± 25 km/h; $M_к$ = 49 ± 5 %; υ = 4.5^0	258.7 km/h 45.7%; 4.19^0
Acceleration in flight	Time of increase of the cruise speed of the plane V = 200 km/h, V = 300km/h	t = 32 ± 4 sec	31.44 sec
Braking in flight	Time of decrease of cruise speed V = 300 km/h to V = 200 km/h	t = 29 ± 4 sec	31.14 sec

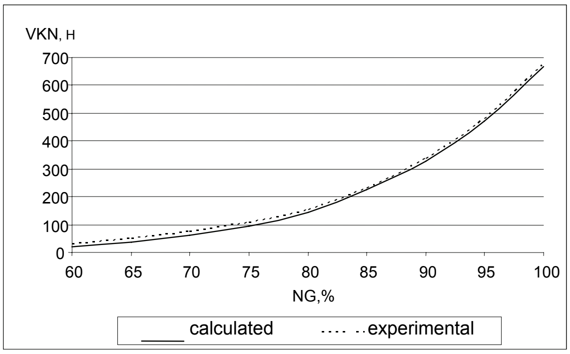

Fig. 9 Engine power (throttle characteristic)

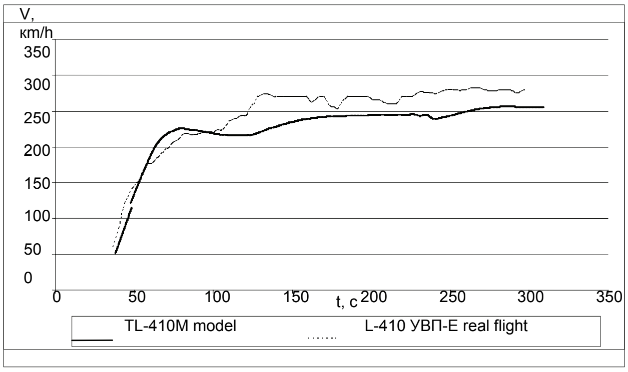

Fig. 10. Flight speed (dynamic characteristics)

The essence of the statistical approach is defined by the following [14]:

- each of compared objects (the airplane and simulator) has the statistical indeterminism;

- the volume of the information registered in flight is limited and is given to the researcher irregularly;

- adequacy is represented as a random variable, which probable distribution is formed consistently (in process of flight information receipt) on the basis of the statistical hypotheses test theory.

A method was developed for the statistical approach realization.

Conclusion

Application of the software reverse engineering allows not only to prolong the out-of-date scientific and technical complexes use, but also to realize its improving support. For example, for a flight-modeling complex the reverse engineering provides the following: an opportunity of new functions addition; perfection of simulators models; application of modern integration methods.

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V.I. Morzhov, Dr. of Tech. Sc., (NAU, Ukraine)
E.I. Romanov, Can. of Tech. Sc., (NAU, Ukraine)
Y.A. Yermachkov (NAU, Ukraine)

MAIN TASKS OF PROFESSIONAL TRAINING COMPUTERIZATION FOR AIRCRAFT PILOTS

The progress in fields of computing and modeling techniques, information processing and the national economy advanced branches computerization has led to radical changes in operator training methods for different complex technical systems (aircraft, atomic power stations, thermal power stations, etc.). A basis of such methods is the concept of computerization for professional training of complex technical systems operators. This concept is based on a wide introduction of different computer-assisted systems and simulators which are developed on universal personal computers fundamentals. These means are used in educational process for aircraft pilots training and retraining both in theoretical and practical study [1].

The computerization of aircraft pilots professional training allows to intensify process of study due to pilots activity increasing, the adaptation of process to its specific features, rendition of the information proposed. All this allows teaching concrete aircraft pilot as the operator that is really necessary in his professional work.

Meanwhile it is possible to assert, that the problem of a highly effective complex computerization of professional training cannot be solved without organic conformity of study process and training to natural structures of cognitive and the human-operator sensomotor activity.

The structure of means which provide realization of aircraft pilots ground training in the aviation organizations of Ukraine can be subdivided in two groups:

1. Computer-based means of theoretical study for aircraft pilots.
2. Computer-based means of practical training for aircraft pilots.

Modern hardware for aircraft pilots theoretical study are developing at different stages of pilots training on the basis of highly productive personal computers with great capacity of main and external memory and combined in local area networks that makes a basis of computerized systems training.

Aircraft pilots theoretical study has a great value while mastering of a professional knowledge, and allows to comprehend practical activities in view of physical processes which are proceeding. In this connection efficiency of educational process essentially depends on methods and means which are used during aircraft pilots training. Computerization of aircraft pilots theoretical study opens wide opportunities due to its universality, flexibility and reliability of systems functioning on digital personal computers basis.

PC application during aircraft pilots theoretical study allows: to use the automated educational systems; to use multimedia manuals; to use systems of the objective control for evaluation a degree of theoretical material mastering; to apply individual methods for aircraft pilots study during training.

All this should promote the best mastering of a theoretical material for experts trained.

Computer hardware for aircraft pilots practical ground training is intended for getting experience and skill for operator aircraft control activity and its onboard systems. During operator aircraft control activity the pilot on the basis of information processing, which influences him, makes controlling actions and enters operating commands by means of corresponding system controls.

Now aircraft simulators of different types are widely used in Ukraine civil aviation subdivisions. An aircraft simulator is a technical mean with the help of which under ground conditions an aircraft real flight conditions and a functioning of its onboard systems by means of which the crew provides piloting of an aircraft are simulated. Such simulators are used for study, aircraft pilots skill increasing, crew members retraining for other types of aircraft, crew professional knowledge and skills regular checks of an aircraft piloting, crew members flight interaction both under normal, and complex weather conditions and others.

An economic parameter which finally determines the cost of crew members training and retraining for aircraft of concrete type is the main and defining criterion for modern aircraft simulators use efficiency.

Application of modern digital computer facilities and new concepts in digital simulators construction allows solving successfully a problem of simulators use efficiency during the aircraft pilots ground training.

New tendencies for hardware designing and upgrading, that are used by aviation enterprises in Ukraine, and among which it is necessary to pay special attention to the modular principle of construction, conceptual unity of all parts computerized professional training for aircraft pilots, new information technologies for creation of databases, knowledge, etc., provide high efficiency of their use.

The computerization of aircraft operators training allows to reduce study cost in some times, as well essentially decrease study terms. However, the highly effective complex computerization of professional training demands greater charges and time cost for intellectual work. The solution of this problem should be finding in utilization of modular principles construction for software and hardware modules of ground training computer system.

The modular principle of ground training means construction will provide an opportunity to their easy upgrade, and also their simulation opportunities increasing, new samples development terms reductions, reliability increasing, decreasing in charges for technical operation of the educational equipment and also the cost decreasing for the production a unit of means.

Thus, the computerization of aircraft pilots ground training allows to achieve not only improvement of educational process quality, but also to provide safety of training at different stages of study, and also to reduce essentially the cost of study.

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I.P. Serdiuk (National Aviation University, Ukraine)

THE METHOD FOR AN ESTIMATION OF FLIGHT CREWS PROFESSIONAL LEVEL ON FLIGHT SIMULATORS

The method of an estimation of the flight crews professional level is proposed on the basis of pattern recognition theory. The flight crews professional level estimate in tasks of 1-st and 2-nd ICAO categories meteorological minimums confirmation on the flight simulator.

The flights safety level of modern airplanes appreciably depends on reliable of crew members actions, as in normal conditions, so in special flight cases. Increase of reliability of crew members actions requires improvement of system of their professional training. The most effective means of crew members professional training - are flight simulators.

For operative evaluation of crew trainings actions on simulators ordinary used algorithms of tolerance control. Insufficient information base of tolerance control, in which basis lay regulated by normative documents of the airplane flight operation limits, forces to use a flight instructor's experience estimation. The instructor's estimation of the flight task quality can be carried out on a several marks scale, or a binary scale. Joint using of tolerance control algorithms and an instructor's mark estimation is possible when the problem of an crews action quality estimation is solving as a problem of the pattern recognition theory.

The pattern recognition problem has next formulation: there is some set of supervision which are set by a vector **X**, they concern to different classes, classification is set by number ω which can have values: 0, 1...., p-1. Having sequence **M** of supervision and their classifications:

$$x_1,\ \omega_1;\ \ldots\ ;\ x_M,\ \omega_M, \qquad (1)$$

it is necessary to construct solving rule $\omega = F(x)$ which will classified new appear supervision with possible smaller amount of mistakes.

The problem of construction of a plane which divides two sets of vectors is reduced to finding a maximum of function:

$$W(\alpha) = \sum_{i=1}^{a} \sum_{j=1}^{b} \alpha_{ij} - \frac{1}{2}\Psi^T \Psi \quad , \qquad (2)$$

where vector $\Psi = \sum_{i=1}^{a} \sum_{j=1}^{b} \alpha_{ij}\left(x_i - \bar{x}_j\right)$.

Theoretical positions and software complex of tools of the pattern recognition theory were used for definition of optimum set of variables, which characterize quality of executing of tasks of confirmation of the given meteorological minimum to pilot-capitan on a flight Tupolev-154 simulator.

The program of checks contains tasks of confirmation meteorological minimum 1-st and 2-nd categories with full flight crew. During checks horizontal and vertical visibility was set by the simulator instructor and depending on conditions of training. The visibility during take-off was 400 – 200 m. Landing approach was carried out in an automatic mode. Visibility on runway was simulated depending on the Pilot-capitan's given minimum. Pilot-capitan determined conformity of actual visibility to the given minimum and carried out automatic leaving on the second circle from height of not less of decision height. Conditions at repeated approach and landing, correspond to the given minimum.

Registration and the analysis of the flight data was carried out with the help of software and hardware complex which registers 64 analog variables and over 100 single commands, with frequency 2, and for some variables - 4 times per second [3]. Flight tasks results can be performed in the form of express cards or as oscillograms lists.

Initial conditions of tasks was identical to all flights: take-off weight 102 t., landing weight 78 т., pressure of airport 746 mm., Vt.off. = 282+15 km./h., Vland. = 258 + 10-5 km. / ч., Vgoaround = 245 + 10 km. / h., V1 = 262+15 km./ч., V2 = 287 + 15 km./h., Vr = 277 + 15 km. / h., Vref = 266 + 10-5 km. / h.

It was 80 flights of the given minimum confirmation of 2-nd ICAO category , results 63 of them satisfy requirements of certification.

For the crews action analysis, distributions of probability density was approximated with a method of structural risk minimization using [1]. Estimate function of density was construct as decomposition on trigonometrical functions system.

In figure 1. show estimated distribution of probability density of the maximal speed of the landing gear extension in tasks of confirmation of a meteorological minimum. The density distribution function - multimodal, as well as functions still some characteristics of actions, it testifies to heterogeneity of the investigated contingent in characteristics of actions coordinates. Heterogeneity of characteristics is consequence of psychophysical distinctions, different techniques of education, individual piloting strategy and allows to use structural research of the data.

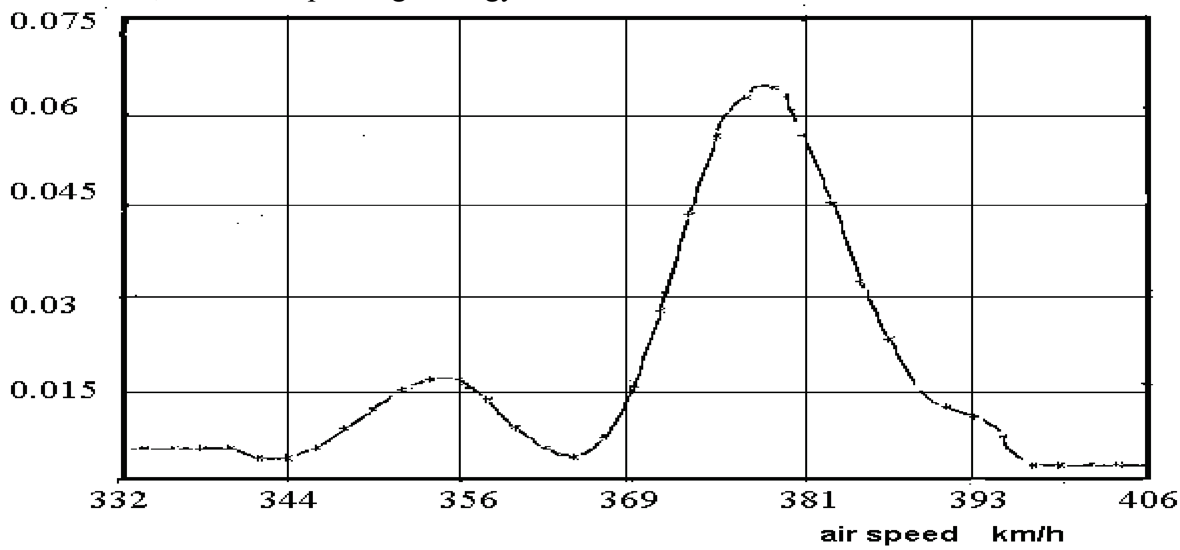

Fig. 1. Distribution of the maximal speed during landing gear extension confirmation of a minimum of landing at a meteorological minimum 2-nd categories.

Factorial analysis is one of data structures methods, which allows to explain correlations between variables by definition of factors which cause these correlations [2]. If to count flights of a minimum confirmation as performance of tests for revealing it is professional - the important qualities, the main equation of the factorial analysis will connect abilities, which necessary for performance of the test, as the expected factors, with volume of these abilities, as factorial loadings:

$$\mathbf{S_{ji} = C_{j1} X_{1i} + C_{j2} X_{2i} + \ldots + C_{jq} X_{qi}} \qquad (4)$$

where **S j i** - an estimation of the examinee **i** at performance of the test **j**; **Cjq** - loading of the factor **q** in the test **j**; **Xq i** - volume of the factor **q** in the examinee.

In table 1. the resulted factorial loadings which exceed 0.4 threshold value, and making dispersions of factors for 80 of confirmation 2-nd categories minimum flights.

The experimental data factorial structure has the dominating first factor with dispersion of 31.5 %. This factor is connected only with the maintaining of flight speeds in the confirmation of a minimum program. The second factor with dispersion of 10.4 % is connected with variables which characterize landing approach and landing. The rest four factors consist 31.3 % of dispersion. The existing of common factors is also testifies the structure of the experimental data and allows to assume existence of a subset of variables - most informative for definition of the pilot's given minimum confirmation quality.

Table 1.

Factorial structure of flight tasks dates of 2-nd ICAO category minimum confirmation.

№	Variables	Factors					
		1	2	3	4	5	6
1.	V of nose wheel up	.88					
2.	V of take off	.90					
3.	V 2	.88					
4.	H initial landing gear retraction				-.72	.41	
5.	H initial of flaps retraction						.77
6.	V initial of flaps retraction	.77					
7.	V final of flaps retraction	.63		.50			
8.	V max. landing gear extension	.85					
9.	V max. of flaps extension beginning	.77					
10.	Roll attitude on the 3-rd turn						-.64
11.	Roll attitude on the 4-th turn		.47				-.49
12.	V approach	.88					
13.	V of landing	.40		-.61			
14.	N y of landing				-.77		
15.	L of landing			.85			
16.	Z of landing					.55	
17.	Max. roll attitude on glidepath		.73				
18.	Lateral landing limit		.81				
19.	N y of go around					-.64	
20.	H of go around					.68	
21.	V of go around	.88					
Dispersion %		**31.5**	**8.6**	**7.6**	**6.9**	**8.3**	**6.8**

From initial set of 21 variables, we shall define a subset of the most informative attributes from the point of view of flight tasks quality. In this set of attributes the dividing plane has the minimal guaranteed probability of erroneous classification. The initial set is reduced up to 14 attributes for which constructed solving rule (2) with a threshold, which is equaled-0.954 and values of the coefficients resulted in table 2. Values of probability of erroneous classification for space with reduction of the size - has decreased

Table 2.

Coefficients values for a solving rule of quality of the given minimum 2-nd categories confirmation tasks on the reduced set of attributes.

№	Attributes	Solving rule coefficients					
1.	V of nose wheel up	.2592	-.3976	.1559	-.0175		
4.	H initial landing gear retraction	.0421	.3102	-.3524			
5.	H initial of flaps retraction	-.2293	.4522	-.2228			
7.	V final of flaps retraction	.0001	-.0637	-.1889	.2525		
9.	V max. of flaps extension beginning	.2054	-.2054				
10.	Roll attitude on the 3-rd turn	.0276	-.1994	.1718			

11.	Roll attitude on the 4-th turn	.0001	.1970	-.1970			
13.	V of landing	-.1019	.2410	-.2117	.0726		
14.	N y of landing	.1196	.2086	-.4644	.1362	.0001	
15.	L of landing	-.1300	-.2259	-.0858	-.1475	.5892	.0001
16.	Z of landing	-.2925	.0117	-.0255	-.0685	.3748	
17.	Max. roll attitude on glidepath	.2407	-.1229	.2521	-.3699		
18.	Lateral landing limit	-.4086	.4086				
21.	V of go around	.0456	-.2320	.2694	-.0830		

The estimation of quality of the constructed solving rule shows, that for all vectors of first class of value of function **W** - positive, the second - negative, full division of vectors of sample into two classes thus is achieved.

The used technique is possible to recommend for engineering of the crew actions control systems for other types of airplanes, and also for operators of other vehicles.

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Oleksandr Zaporozhets, Professor, Vadim Tokarev, Professor, Sergiy Boichenko, Professor, Grigoriy Franchuk, Professor (National Aviation University, Ukraine)

INVESTIGATION AND RESEARCH OF ENVIRONMNETAL AND CHEMMOTOLOGICAL PROBLEMS OF CIVIL AVIATION IN THE NATIONAL AVIATION UNIVERSITY

Investigation and research of environmnetal problems of civil aviation, first of all in fundamental and applied aviation acoustics, has been conducted in National Aviation University at the university since the middle 1960’s in close collaboration with leading scientific organizations in constructions and maintenance of aviation techniques including the Central Aero Hydrodynamical Institute (Moscow), State Scientific Research Institute of Civil Aviation (Moscow), and the Aviation Design Offices of Tupolev, Il’ushin, Antonov, Yakovlev. Later in 1980’s the tasks of aircraft engine emission and local air pollution in airports became of primary concern too. Today NAU is a leading scientific enterprise in the Ukraine in the sphere of environmental protection from civil aviation impact. The subjects of scientific concern includes as dominant factors – aircraft noise and air pollution, so as other important ecological factors like water and soil pollution, wastes, electro-magnetic fields, third party risk, etc. There are many protection measures were designed for the purposes of their reduction and specific strategies with environment, technical and economical efficiency were proposed during the last 40 years.

Research in aviation acoustics were concerned, first of all, with operational methods and measures for aircraft noise abatement - based on modelling of noise generation by engines and the equations of aircraft motion. Optimal profiles of take-off and approach flight stages have been formulated. Decision method have been proposed too using the modified gradient method and solutions of the task according to various criteria have been defined. During the first stage the influence of aircraft flight weights, of control point or control zone placement and of size of control zone have been investigated.

For higher reliability and accuracy it has been found necessary to improve the acoustic models. This has required physical investigations in acoustic chambers of characteristics of the dominant aircraft noise sources including the power unit or airframe noise. For this reason the complex of anechoic and reverberation chambers has been designed and built in the university. The anechoic chamber has total and usable volumes 640 (8x8x10) and 330 m^3 respectively. The treatment of anechoic chambers consists of polyurethane wedges with density 40 kg/cub.m and sizes: length of wedge - 0.8 m, the area of the basis - 0.2x0.2 m. The wedges are supported on punched plywood of thickness 0.01 m with the space between the walls and plywood equal to 0.05 m. The large reverberation chamber had the volume 173.7 m^3 and total area of the reflecting walls 180.6 m^2. Small reverberatiom chambers have total volume of about 4 m^3 and total area of the reflecting walls of about 8 m^2. The design of the large chambers enables precise measurements above the 100 Hz in the anechoic chamber and above 125 Hz in the reverberation chamber. The equivalent area of sound absorption in reverberation room was equal to 30.1 m^2 and reverberation times varied between 9.32 s at 125 Hz and 1.39 s for 8000 Hz. Both chambers have been certified for precise measurements and investigations. Research on aerodynamic sources is instrumented with specialized equipment of “Bruel & Kjer”, “DISA”, RFT (East Germany) and of native production.

The great number of acoustic investigations on aerodynamic noise sources have been carried out including turbulent sources, jets, co-axial jets and jets leaking in screen, ejected jets, and airflows around the wing models. The results of the investigations have provided improved calculation models for the main aviation noise sources, including jets and by-passed jets, fans, turbines, combustion chambers, and airframe noise sources. A complex model of acoustic sources has been designed to take into account the influences on noise levels produced by the aircrafts under the flight path and in the vicinity of the airports of many kinds of operational parameters (ambient atmosphere, runway and airport conditions, operational modes, etc.). These numerical investigations have defined the influence of operational factors on the noise levels and efficiency of optimal flight modes of particular airplanes.

At the end of 80-s, a method of choosing the optimal modes of operation of the air fleet around the airport region have been designed. Algorithms of optimal distribution of the aircrafts among the routes of approach-departure were based on entropy modelling of the system as a whole. In addition this method enables forecasting of environmental capacity features (particularly for noise, fuel burn and air pollution criteria) for every airport.

Since the beginning of the 70's, new tasks for the acoustic laboratory have included the assessment of noise fields inside the airplane cabins. Besides the traditional noise sources like the power unit, turbulent boundary layer, and the airframe noise sources, noise sources associated with the air conditioning system (ACS) are been taken into account. The resulting model of noise generation by inboard ACS is based on the method of energy conservation taking into the account acoustic characteristics of the ACS units and aggregates. As the first stage the acoustic characteristics of the air distributing units were measured. The accuracy of resulted noise models for the ACS has been assessed by comparing predicted assessed and measured data inside the cabins of airplanes. These models have shown to give good agreement with measured data in frequency bands above 300 Hz.

Currently researches in environment protection (EP) field in the university are connecting with the necessity to develop the national system of control of aviation impact on the environment. So, as well as carrying research in particular aspects of separate important ecological factors, the NAU co-ordinates the whole nationwide system of EP with mutual assistance of the State Civil Aviation Administration of the Ukraine and with the collaboration between the organizations in the Ministry of Health Protection and of Ministry of Environmental Protection. For this purpose the Center of Environmental Problems of Airports has been established in 2006. The main components of these system take into account the particular laws concerning the control of this problem in the Ukraine, new national standards for EP needs, new calculation methods for aircraft noise, electro-magnetic fields (EMF), engine emission/air pollution, risk assessment around the airports, and the design and implementation of various kinds of abatement procedures and measures - operational, technical, technological, economical, etc. Even though the investigations of the EP legislation is only at the beginning, the great part of work on EP standards have been done in accordance with the main Environmental Programs of EU and ICAO. The policy of ICAO is supported and in fact the ICAO noise and emission standards are implemented in Ukrainian practice of civil aviation.

Various international practices for EP regulation have been examined as well to design new proposals for EP standards. It has been concluded that the previous standards for EP in the USSR and Ukraine were directed mostly by hygienic imperative than by technical feasibility and economical efficiency. For this reason there has been relatively poor observance of various abatement procedures in practice. For example, the noise limits at the boundary of the protection zone, inside which any kinds of residential and public buildings are forbidden, are of the order of 10 dBA more rigid than in many other countries where there is a greater financial potential to solve the problem. Analysis of the situation shows that a majority of buildings are placed inside the protection zone in the vicinity of the airports without any protection measures, so that the aircraft noise problem is out of control. New proposals for zoning and land-use in the vicinity of the airports in the Ukraine are more realistic and are enabling better priorities and decisions in respect of the EP problem.

The new zoning and land-use rules, as for aircraft noise, so as for electro-magnetic fields, air pollution and third party risk, stipulate new calculation methods for assessments of noise, EMF, air contamination and individual risk contours around the airports with necessary accuracy and reliability. The new methods prescribe and use the individual flight paths and characteristics for any type of aircraft under consideration or at least for specific groups of the aircraft. All the methods include influence and effects of atmosphere and ground conditions, screen reductions, etc, so the accuracy and reliability of the new methods are much higher and are in a good agreement with the international requirements, particularly of ICAO. Of course the new method is more tedious to calculate but it has been realised in PC programs: **IsoBell'a** for aircraft noise, **PolEmiCa** – for aircraft engine emission and air pollution, **EMISource** – for EMF, **3Prisk** – for individual risks around the airports.

At the beginning of the 60-s of the XX century the prerequisites of a new science formation appeared as a result of increased requirements to the level of fuels, lubricants and technical liquids operating properties due to the improvement of technique and technologies of the petrochemicals use and also due to the mastering of new reactive air crafts, specific fuels, lubricating materials and technical liquids for Civil aviation. The range of issues related to those mentioned above lead to a new field of knowledge, new fundamental scientific direction initiation – chemmotology. The date of the new science beginning is considered to be 1964. It was formatted and formulated by professor Papok Kostyantin Karlovych, author and scientific leader of complex researches of aviation fuels properties influence on processes, which take place in engines systems of airplanes. The term «chemmotology» is made of «chemistry», «motor» and «logos».

Scientific researches of Kiev institute of engineers of Civil Aviation (later its name was changed: Kiev international university of civil aviation (1994), National aviation university (2000)) were closely connected with the processes of formation of chemmotology as a sciences, in particular, in aviation industry.

Papok K. K. supported the initiative of group of Kiev institute of engineers of Civil Aviation researchers to create scientific direction of aviation chemmotology in the institute.

In the mid 60-s the group of researches, headed by candidate of engineering sciences, assistant professor Aksyonov Olexander Fedotovych, was formed in the Kiev institute of engineers of Civil Aviation. In 1964 based on the initiative of Aksyonov O. F. a research group was created on the chair of Aircraft and Engines Technical Exploitation (the head of the chair was assistant professor Sukharnikov Vladimir Mikhaylovych) to work on the questions of fuels, lubricating materials and technical liquids usage. In 1968 the independent chair of Chemistry and Technology of Fuels and Lubricants was created. And in a year the Department of fuels and lubricants was created too.

Up to the mid 70-s researches in the field of chemmotology were carried by other departments of institute: physicists, hydraulics, electrical engineering and other.

To co-ordinate these researches and integrate resources the complex scientific direction was created in Kiev institute of engineers of Civil Aviation – the Chemmotology of Aviation Fuels and Lubricants. The rector of the institute headed this direction, corresponding member of NAS of Ukraine, professor Aksyonov O. F. The research groups of professors Solovyov A. M., Chernenko G. S., Vasilenko V. T., Nikitina G. A., Grokholsky A. L. worked in this direction.

The research works were ordered by Ministry of Civil Aviation, Ministry of Aviation Industry of USSR, Aviation Design Offices Tupolev, Aviation Design Offices Ilyushyn, Aviation Design Offices Antonov, Aviation Design Offices Miel and others.

Concept of development of chemmotology scientific direction with the NAU is orientated on innovative model, which will allow keep and promote achievements of past and present NAU researchers, to improve quality and compatibility of developments and inventions in order to implement them in a short period under the conditions of crisis situation on the market of fuels, lubricants and technical liquids, and also it will allow to create grounds for the improvement of working conditions of scientific-pedagogical staff of chemmotological direction, implement their teaching and scientific, finding and development of talented creative personalities among student young people, training of personnel with higher qualification.

The main organizational, administrative, structural principle of formation, functioning and development of chemmotology scientific direction must be the presence of central structural subdivision (department, center, institute, research and development complex) in the general structure of the University.

The target of chemmotology scientific direction is stimulation of research and development works, designing work and also personnel training (including qualification enhancement, in-plant training, internship) in accordance with international regulations and standards to solve actual and perspective tasks of chemmotology in the field of fuels, lubricants materials and technical liquids testing and admittance to production and use, in particular, in aviation industry, and also nature protection and energy saving innovations.

The strategic task of chemmotology scientific direction (school) activity is the achievement of modern level of research conduction and scientific-pedagogical personnel training.

The basic task is conduction of fundamental, searching and applied researches, research and development works in accordance with scientific directions of the university, namely: chemmotology, tribochemistry, tribology, natural environment protection and living safety, certification and quality management, testing, diagnostics, admittance to production and use of fuels, lubricants and technical liquids, in particular, in aviation industry, with the purpose of solution of topical jobs of science and practice.

The tasks of chemmotology scientific direction also include:

1. Use and development of existent scientific-pedagogical potential to develop and introduce innovative environmentally sound technology in the field of petrochemicals supply.

2. Organization of production of competitive highly technological scientific and technical production for the world market in order to increase efficient use of fuels, lubricants and technical liquids. Wide collaboration with foreign partners in this task.

3. Creation of necessary conditions for the highly skilled personnel training (retraining, internships, practical workers) for those industries of economy, where fuels and lubricants and technical liquids are used, named chemmotologists.

Chemmotolgy creates the necessarily "basement" for providing the optimal conditions of fuel deployment, modern qlaity of fuel requirements, and efficient fuel use in technics.

The generalized function of oil products utility as the ones of civic utility products can not be described by some amount of corresponding engineering documents and charts (as opposed to the generalized function of transportation devices utility). This principle difference between oil products and machinery products objectively induced a science of chemmotology and partly tribotechnics appearance.

To know fuels, lubricating materials and technical liquids is to have have a clear understanding of interdependence of quality characterizing parameters and physical, chemical and energetic processes occuring during their use under definite conditions, and, also, the interdependence with their chemical and group constitution.

The knowledge of engineering means not only the knowledge of construction, kinematical, dynamic and temperature characteristics but also the knowledge of physical and chemical properties of constructing materials essential for analysis and forecasting of physical and chemical processes during the use of particular fuel or lubricating material.

The task (problems) of chemmotology are the following:

1. optimization of fuels, lubricating materials and technical liquids quality;

2. increase in efficiency of fuels, lubricating materials and technical liquids use;

3. creation and improvement of a system and methods for fuel quality assessment.

The main ways of these problems solving are:

1. Increase in sources of different oil fuels;

2. Decrease of the expenditure of fuels in engines and nonrecoverable losess during technological processes with fuel operation "from the dwell tot the gas station";

3. Use of alternative fuels.

The economical essence of chemmotology is ahievement of a maximum economy of raw material sources, fuels, lubricating materials and technical liquids through the optimization of a balance, quality of products and their efficient use.

Olena Konovalova, Assistant Professor, (National Aviation University, Ukraine),

AIRCRAFT NOISE MAPPING IN THE UKRAINE – THE FIRST STEP TO THE NATIONWIDE AIRPORT NOISE IMPACT MODEL

The airport land use compatibility concerns four broad environmental headings, all identified in Ukrainian and International laws or rules: noise, electro-magnetic radiation, air pollution and safety. Noise is one of the most basic airport land use compatibility concerns. Moreover, at major airline airports, many busy general aviation airports and most military airfields noise is usually the most geographically extensive form of airport impact. The number of people affected by noise around airports depends of the way in which land surrounding an airport is planned and managed.

The Committee on Aviation Environmental Protection (CAEP) has long focused on the goal of reducing noise through aircraft noise stringency requirements, operational procedures, land-use planning and policy that restricts certain types of aircraft. The purpose is to mitigate the adverse effects of aviation noise on the health and welfare of people living near airports. These benefits however may be lost if population subsequently grows in land near airports that has been relieved. Further development of that land, if not coordinated with the expansion plans of an airport, can lead to additional costs both to the community and to aviation.

In ICAO Assembly Resolution A35-5, Appendix F is dedicated to land use planning. States are urged to avoid inappropriate land-use or encroachment whenever possible in areas where reduction noise levels have been achieved. Noise sensitive activities as residences, schools, hospitals must be controlled, and the development of the airport has to take into account these activities. ICAO Noise-Balance Approach to aircraft noise control consists of identifying noise problem at an airport then analyzing various measures, which in the frames of this paper are divided into four elements:

- noise at source;
- land-use planning and management;
- operational measures;
- operational restrictions.

For the purposes of formulating airport land use compatibility policies and criteria, further dividing these basic concerns into functional categories is more practical.

Basic definition: As defined by cumulative noise exposure contours describing noise from aircraft operations near an airport. Exposures are ones affected by high concentrations of aircraft takeoffs and landings. The calculation of cumulative noise levels depends upon the number, type, and time of day of aircraft operations, the location of flight tracks, and other data described elsewhere [1, 2]. For airports with airport traffic control towers, some of these inputs can be derived from recorded data. Noise monitoring and radar flight tracking data available for airports in most metropolitan areas are other sources of valuable information. At most airports, though, the individual input variables must be estimated.

Compatibility objective. The clear objective of noise compatibility criteria is to minimize the number of people exposed to frequent and/or high levels of airport noise capable of disrupting noise-sensitive activities. In the Ukraine, as objectives of strategic noise mapping it was proposed to use the following:

(a) determination of exposure to environmental noise, through noise mapping, by methods of assessment;

(b) ensuring that information on environmental noise and its effects is made available and taken into account by local authorities / community;

(c) adoption of action plans, based upon noise-mapping results, with a view to preventing and reducing environmental noise where necessary and particularly where exposure levels can induce harmful effects on human health and to preserving environmental noise quality where it is good.

Basis for setting criteria. Compatibility criteria related to cumulative noise levels are well-established in state and international regulations.

The Day-Night Average Sound Level (DNL) metric used elsewhere in the U.S., and recommended by ICAO Doc 9184-AN/902, publ. 2, 2004 and ICAO Doc 9829 AN/451, 2004, but adds the evening weighting not included in DNL, like it is done for metric DENL in the EU Directive 2002/49/EC. The basic international criterion sets a DNL of 75 dBA as the maximum noise level normally compatible with urban residential land uses. For many airports and many communities, 75 dBA DNL is too high for land use planning purposes, even 65 dBA somewhere is too high.

In the Ukraine the equivalent noise level metric is established by state regulations, including for airport noise different norms for day and night period of time. To reflect the greater community sensitivity to noise during night, the norms or this time are up to 10 dBA less than for daytime.

Compatibility strategies. The basic strategy for achieving noise compatibility in an airport vicinity is to limit development of land uses which are particularly sensitive to noise. The most acceptable land uses are ones which either involve few people (especially people engaged in noise sensitive activities) or generate significant noise levels themselves (such as other transportation facilities or some industrial uses). On occasion, local considerations outweigh noise impacts and result in decisions by local land use jurisdictions to allow residential development in locations where this use would normally be considered incompatible. In such circumstances, approval of the development should be conditioned upon dedication of an aviation easement and requirements for sufficient acoustic insulation of structures to assure that aircraft noise is reduced to an interior noise level of 45 dBA or less.

Measurements. For the purposes of airport land use compatibility planning, noise generated by the operation of aircraft to, from, and around an airport is primarily measured in terms of the cumulative noise levels of all aircraft operations. Cumulative noise levels are usually illustrated on airport area maps as contour lines connecting points of equal noise exposure. Mapped noise contours primarily show areas of significant noise

Airport Noise Compatibility Planning, which currently is established in national Ukrainian legislation in aviation branch as a part of aerodrome certification, provides procedures for developing airport noise exposure maps and noise compatibility programs.

***Conclusions*:** If an airport operator submits a noise exposure map, the map must be revised when operations changes are significant. Such changes include an increase in day-night noise level of 1.5 dB or more that creates substantial new incompatible land uses or occurs within an already incompatible land use area. Currently, the Centre of Ecological Problems of Airports proposed to the airports to calculate three variants of noise exposure map for different number of aircraft operations:

1. Number of aircraft operations equal to the present-day intensity.
2. Forecast number of aircraft operations (usually for next 10-15 years).
3. Maximum number of aircraft operations possible to operate ensuring flight safety rules

Exceptions include a significant change in airport layout, flight patterns, etc.

Actual land use responsibility rests with local authorities. Zoning and other types of planning for compatible land use are most appropriate in undeveloped areas. Airport noise compatibility planning is difficult in developed regions, such as Kyiv, Kharkiv, Dnepropetrovsk, Donetsk, Odessa. As advanced researches the Centre of Ecological Problems of Airports defines:

- Estimation of population within zones of impact (in quantity)
- Estimation of density and dispersion of population within zones of impact

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Chushikina Olga, Researcher, Oleg Kartyshev, Researcher,
(Center of ecological safety of civil aviation, Russia, Moscow)

GAINING INFORMATION METHODOLOGY FOR AIRPORT'S SANITARY-HYGIENIC ZONE PROJECT DEVELOPMENT

Introduction

Today in Russia we have globally started the airport's sanitary-hygienic zone (SHZ) project development. Airport is a complex source of negative influence on environment either inside territory's borders or beyond its bounds as along the aircraft flight track. The great number of different organizations can be located on the airport's territory and near it. They can be both the airport's services and leaseholders. These organizations have a lot of various sources of negative impact on environment and the human. Therefore the airport's SHZ is per se the mutual affected area for a number of organizations mentioned above.

First of all the problem consists in environmental impact assessment from a bundle of sources located on huge airport's territory. Secondly it is difficult to estimate the environmental pollution from moving aircraft, when measures for pollution reduction are impossible in source itself. And organizational measures such as using «noisy» aircrafts limitation, especially in the nighttime, a substitution for aircraft fleet, placing the aircraft's noise and emission monitoring system, are very expensive.

Task formulation

In the meantime these projects were done only for 13 of 351 civil airports that are numbered in Russia. At present such projects of 4 airports undergo an examination in Russian federal supervisory agency for consumer goods quality and for 9 airports projects are developing. Gaining experience showed a whole number of differences in developer's methods. The first stage of airport's SHZ project development imply the gaining information about all airport's services and compilation of requirements specification (RS) on this project. If RS is made competently and completely, it already directly shows to customer, developer and matching instance the full spectrum and properties of infrastructure units, which influence is necessary to take into account in SHZ. The RS also reflects volume and complication of work, and by that makes it possible to set a term and cost to execution of such project, and except the «losses» as well, when developer doesn't take into account some data.

Incomplete information creates the additional or repeated researches and so much the worse when it is happened already on final stage of development or project appraisal. This fact finally leads to increase in term and cost of project development.

Usually developers compile RS, which doesn't image the situation in whole: it doesn't show volume and order of research, and availability of regulatory documents too. It subsequently makes difficulties for development and leads to serious mistakes.

For the purpose of support to the correctness and uniformity of airport's SHZ project development and decision of above-listed problems, it is necessary to arrange a methodically correct gaining information and compilation of RS for project development.

The customer (airport) and developer must understand and be responsible for that their information must be full and reliable, and they must timely give the changes in this information. Especially it is concern of anthropogenic impact on the environment addition, which wasn't included in RS.

Sometimes developers use the information from existent projects of airport's organizations in the capacity of input data in SHZ project development. It can be project of maximum permissible emission (MPE), project of wastes generation limits (WGL), project of maximum permissible sewage discharge (MPSD) and etc. But at times these projects go out of data because at the present time some facilities in airport was closed down or reconstructed, or environmental equipment has worn out and thereafter it's operating efficiency decreased.

Methods of solution

The suggested sequence of the input data collection for airport's SHZ projects development, from my point of view, will be effective for rigorous formation of the complex approach to the SHZ-project implementation. It will allow to reduce the costs and the possibility of the accidental errors and defects, detectable on the last registration stages and expert examination in the instances.

On the pre-project stage and during RS development the advice is that an execution of research will be in turn:

1. The list of authorized persons of the ecological, planning, technical services and organizations based on the airport's territory and near it is created (airfield, combustive-lubricating materials, supply services, etc.). One must get into contact with these services in order to obtain the detailed information about the considered infrastructure units.
2. On the basis of the airport maps and the information about the located in the airport and near it services the up-to-date airport located services scheme is developed. For the each single organization on the detailed map the explication of all the buildings and constructions with designation of the technological areas attached is implemented. All the above mentioned objects are considered as the potential sources of the negative affection on the environment.
3. The service perspective data are collected, including the temporal gradation: reconstruction, temporary closing-down, productive capacity modification for either the land-based or aircraft exploitation).
4. The new scheme of the prospective situation in the airport is developed as needed. In a similar manner as in the section 3 the new objects are marked on the airport scheme-map, including the technological areas – the possible sources of the negative affection on the environment.
5. For either up-to-date or prospective airport located objects the sources of the negative affection on the environment and population health are singled out severally for every type of this affection: air pollution, noise pollution, electromagnetic emission, water pollution, wastes generation, etc.
6. The data about town planning on the airport responsibility area are collected and the scheme of nearest resident area is developed. The special attention should give to resident objects, which situated in close to airport's borders and established tracks of aircraft departure and arrival, because it'll be necessary to develop the measures for negative affection reduction from airport's sources in the direction of this residential area.
7. For every up-to-date airport source qualitative and quantitative rates of negative affection are taken from existent projects of airport's organizations and the last departmental control of limit keeping results (see above-listed project MPE, WGL, MPSD, water use and disposal contracts with specialized organizations). Meanwhile, it's necessary to check the real state and function of every source, especially when there wasn't the departmental control of the airport.
8. For every prospective and also up-to-date airport located object, if above-listed projects are absent, its technological characteristics are requested. This information is needed for calculation of negative affection level on environment. For up-to-date airport located objects an inventory can be made in common with airport services.
9. As a result, the summary schedule of input data for each kind of negative affection on environment and every source including planned perspective with designation of the its realization period is created.
10. On the basis of the fulfil research RS on SHZ-project is created. It must include some parts: the list of input data at present time and prospective situation in the airport; due date of project development; requirements made to project structure, order of calculations and measurements and execution of graphic materials; normative base of existent methods and acts needed for research. RS must include also the staging of project realization: the preparation, calculation, execution of document, expert examination and approval in the matching instances.

The suggested sequence of the input data collection and RS creation for airport's SHZ projects development helps to control the project execution and correctly set tasks and time for its performance, when a lot of developers make this large-scale project.

Inna Gosudarska, assistant, (National Aviation University, Ukraine, Kyiv)

DEFINITION OF PUBLIC SAFETY ZONES IN THE VICINITY INTERNATIONAL AIRPORT “KYIV” (ZHULYANY)

Municipal airport “Kyiv” (Zhulyany) is situated almost in the city, just eight kilometres from the Kyiv’s downtown. The area of the airport is 265 hectares (655 acres). It has one runway 1800 meter. Airport serves to general aviation maintenance shop.

Including in calculation the crash rate of aircraft category the public safety zones (PSZs) is defined in the vicinity International airport “Kyiv” (Zhulyany) that based on present air traffics in 2007, forecasts air traffics in 2017, maximum capacity airport in 2017.

The first calculation scenario of definition PSZs based on present air traffics in 2007 in the vicinity International airport “Kyiv” (Zhulyany), Tab. 1.

Table 1

The results of risk contours that based on present air traffics in 2007 at the International airport “Kyiv” (Zhulyany)

Risk	Distance, m
10^{-4}	0
10^{-5}	226
10^{-6}	2481

The public safety zones are performed concerning magnetic course landing of the air traffics 081° and 261° that based on present air traffics in 2007 at the International airport “Kyiv” (Zhulyany), fig. 1 and fig. 2. The summarised risk contours of PSZs in both directions that based on present air traffics in 2007 at the airport, fig. 3.

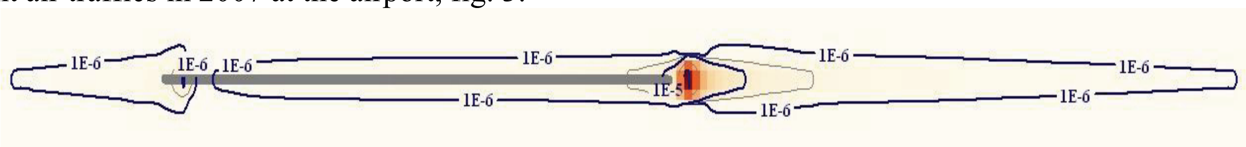

Figure 1 - Magnetic course landing 081°

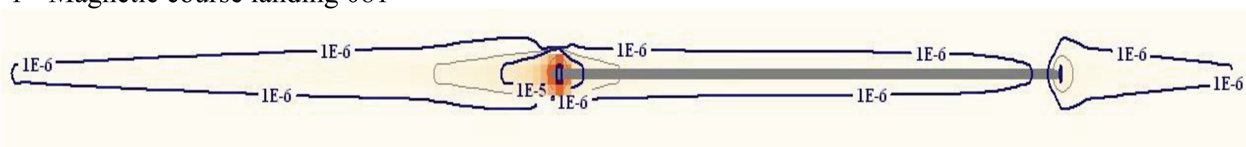

Figure 2 - Magnetic course landing 261°

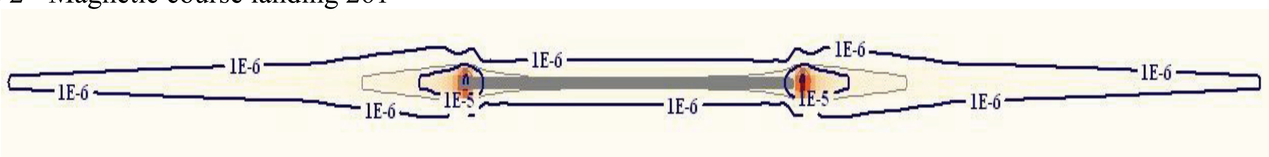

Figure 3 - Summarised risk contours

The PSZs in the vicinity airports have to remodel at intervals of about ten years, based on forecasts about the numbers, types and generations of air traffics ahead. Consequently the second calculation scenario of definition PSZs based on forecasts air traffics in 2017 in the vicinity International airport “Kyiv” (Zhulyany), Tab. 2.

Table 2

The results of risk contours that based on forecast of air traffics s in 2017 at the International airport “Kyiv” (Zhulyany)

Risk	Distance, m
10^{-4}	29
10^{-5}	548
10^{-6}	4118

Also the public safety zones are performed concerning magnetic course landing of the air traffics 081° and 261° that based on forecasts of air traffics in 2007 at the International airport “Kyiv” (Zhulyany), fig. 4 and fig. 5. The summarised risk contours of PSZs in both directions that based on forecasts air traffics in 2017 at the airport, fig. 6.

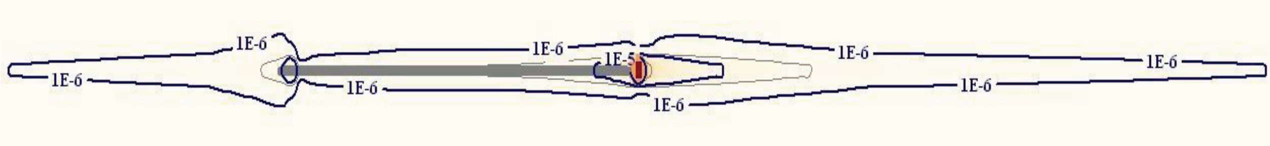

Figure 4 - Magnetic course landing 081°

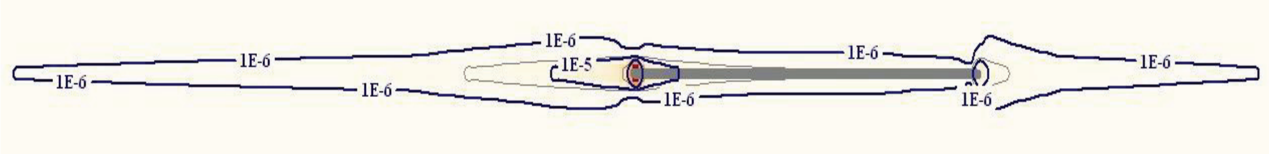

Figure 5 - Magnetic course landing 261°

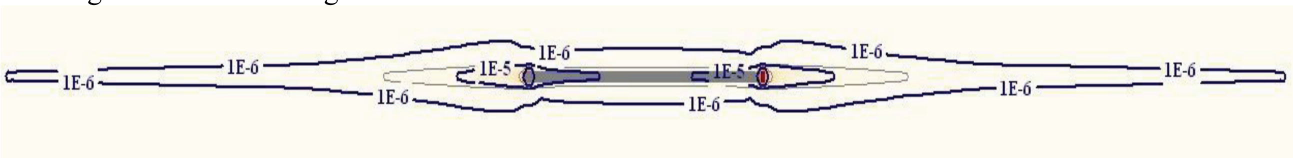

Figure 6 - Summarised risk contours

The PSZs in the vicinity airports have to remodel considering of the maximum airport capacity. Consequently the third calculation scenario of definition PSZs based on maximum capacity International airport "Kyiv" (Zhulyany) in 2017, Tab. 3.

Table 3

The results of risk contours that based on maximum airport capacity in 2017 at the International airport "Kyiv" (Zhulyany):

Risk	Distance, m
10^{-4}	127
10^{-5}	1829
10^{-6}	8658

Also the PSZs are performed concerning magnetic course landing of the air traffics 081° and 261° that based on maximum airport capacity in 2017 at the International airport "Kyiv" (Zhulyany). The summarised risk contours of PSZs in both directions that based on maximum airport capacity in 2017, fig. 7.

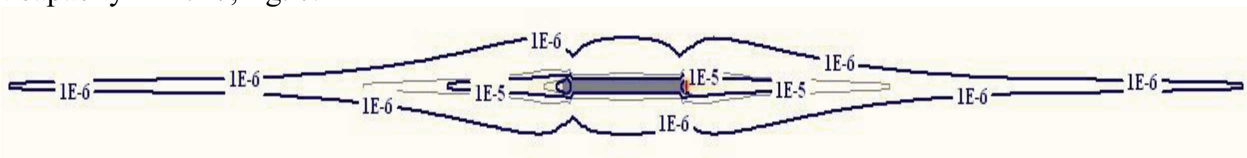

Figure 7 - Summarised risk contours

As a result of calculations it was recommended to establish the PSZs at the level maximum airport capacity in 2017 in the vicinity International airport "Kyiv" (Zhulyany), Tab. 4.

Table 4

The recommendation for creating PSZs at the level maximum airport capacity to 2017 in the vicinity International airport "Kyiv" (Zhulyany)

Risk contours of public safety zones	Maximum longitudinal distance *Y*max , m	Maximum lateral distance *X*max , m
10^{-5}	1829	140
10^{-6}	8658	500

Grigoriy Golembievskiy, Assistant Professor (National Aviation University, Ukraine, Kyiv)

ACCURACY AND UNCERTAINTY OF AIRCRAFT NOISE MODELLING

Two approaches to analysis of aircraft noise phenomena have been defined and implemented in computer programs. The first approach is based on l/3-octave band spectra noise analysis of any type of aircraft in any mode of flight or during maintenance activities in the vicinity of an airport. The approach is implemented in a model and appropriate software ***NoBel****. The second approach is based on the concept of "noise radius" and provides calculations of aircraft noise exposure units around the airports or at any noise monitoring point. The basic "noise radius"- relationships may be obtained from experimental data as well as by calculation (for example, by using the* ***NoBel*** *program). The second modelling approach has been utilized in software* ***IsoBell'a.*** *Here, the basic acoustic models for aircraft of any type wil be examined on its accuracy and uncertainty.*

The acoustic model of an aircraft

An aircraft is represented by a set of noise matrices, each dependent on flight mode and consisting of sound pressure level *(SPL)* spectra (in a l/3-oclave band form) for a defined number of directions of sound propagation from the acoustic source. In some cases the noise matrices are obtained experimentally, in others they are obtained by means of calculations based on the models for the particular acoustic sources of interest for the aircraft under consideration. It is impossible to define the characteristics of all phenomena by means of analytical and semiempirical models only. The most common phenomena determining or influencing the accuracy of noise matrices are the engine installation effects and noise abatement treatments.

The sound pressure level spectrum *{*SPL_{jk}*)* of aircraft noise of any type in spectral bands N_j, j=1,N_j, and in some k-th direction of sound propagation, where k = 1, N_k , with reference to previous considerations, can be defined by:

$$SPL_{jk} = SPL_{jkp} + \Delta SPL_{jk} \qquad (1)$$

where SPL_{jkp} is the predicted value of SPL_{jk} resulting from a sum of particular models SPL_{jki} for characteristic (or dominant) noise sources, i = 1,..,N_s; and *ΔSPLjk* are spectral corrections for differences between the predicted SPL_{jkp} and measured values SPL_{jk}. For each aircraft of interest, SPL_{jkp} is defined by:

$$SPL_{jkp} = \sum_{i=1}^{N_S} SPL_{jki} \qquad (2)$$

Spectral corrections are defined as the spectral transfer functions for the total acoustic model of the aircraft as follows:

$$\Delta SPL_{jk} = SPL_{jko} - SPL_{jkp} \qquad (3)$$

where SPL_{jko} are the experimentally observed values of SPL_{jk}. The observations must be carried out either during flight testing in accordance with noise certification requirements or during noise engine testing at the outdoor testing facility. In the latter ease, of course, various flight effects and airframe acoustic sources are excluded.

In general, SPL_{jko} and SPL_{jkp} are functions of many parameters, so the transfer functions ΔSPL_{jk} are functions of these parameters too. The main parameters are the flight mode (engine type and thrust) and the direction of noise propagation from source to receiver. If the results of engine noise testing are presented in the form of noise matrices, then it is possible to define the directional relationships for the transfer functions ΔSPL_{jk}. *SPL*-spectra for flight noise testing in the direction of maximum magnitude of instantaneous sound levels $L_A(t)$ or *PNL(t)* (or *PNLT(t))* are the more accessible data in practice. The flight mode relationships can be defined for them and then generalized for any direction of noise propagation.The following equations are useful: the vector of total spectral differences E is defined by

$$E = \left\{ \sum_{jk} W_j \left[SPL_{jkr} - SPL_{jko} \right] / \sum_j W_j \right\}^{1/2} \qquad (4)$$

so that

$$E^2 = \Delta SPL_{jk} + E_{jk}^2$$

and the relative error index of agreement d is defined by

$$d_j = 1 - \frac{\sum_j \left\{ W_j \left[SPL_{jko} - SPL_{jkp} \right] \right\}^2}{\sum_j \left\{ W_j \left\{ \left[SPL_{jkp} - SPL_{jkor} \right] + \left[SPL_{jko} - SPL_{jkor} \right] \right\} \right\}^2} \qquad (5)$$

where $SPL_{jkor} = \Sigma\ (Wj\ SPL_{jko})\ /\ \Sigma Wj$ is an average estimate for the observed data[1]. The index of agreement d_j is nondimensional and varies between 0 and 1. If $d_j = 1$ the resulting prediction model is reliable and compliant to the observed data in the j-th band under consideration.

Thus the basic acoustic model of an aircraft of any type is derived from the noise matrices and the value of each component of the matrices is defined by formula (1). The models are represented in terms of the parameters of aircraft flight (engine) modes and of the stale of ambient environment, so they can be used for any aspect of the aircraft noise problem. This method for deriving an acoustic model of an aircraft has been validated by means of flight testing data obtained from preliminary noise certification results for the Yakovlev-40 aircraft. Measurements are available for both take-off and approach stages, so the transfer functions are defined for two flight modes. In all cases (of course, without No 11 flights) the index of agreement d_j varies between 0,88 and 0,96 over the spectral bands. The averaged value of index d_j for No 11 flight = 0,62. For most of the spectrum bands, the probability P that the assessed χ^2-statistic is higher than the χ^2-distribution law is between 0,92 and 1,00, so the reliability of the resulting acoustic model is quite high. Small deviations from these good results are observed in a few low-frequency bands (for which $d_j = 0.77$). The ground effects here are substantial and higher accuracies in the overall spectrum have not been achieved despite application of a ground interference model in the prediction procedures, since accurate data about the type of rejecting surfaces and their characteristics were not available.

Spectral weighting function

A spectral weighting function W in equations (4, 5) may be dependent of spectral correction implented for noise criteria, used in particular task of noise impact assessment. For example, for L_{Amax} definition correcting filter of type "A" must be used, with highly decreased low frequency and little bit decreased high frequency octave or third-octave spectral levels and increased spectral levels between 1 and 4 kHz. Thus spectral weighting function W may account on significance of the spectral component and its spectral elements must be differ from 1 as in linear case of noise level assessment:

$$W_j = \frac{10^{0,1(SPLj + \Delta SPLjA)}}{10^{0,1SPLj}} \qquad (6)$$

where ΔSPL_{jA} - spectral correction for filter of type "A".

For perceived noise level PNL assessment the spectral weighting function W may be used in same way as in equations (6), but with spectral correction ΔSPL_{jD} for filter of type "D", which is used sometimes to model the noisiness scale of the PNL or directly by assessing the noisiness of the spectrum under consideration in relation to the pink noise spectrum of the same *OASPL*.

For noise event assessment the, where distance to noise source and directivity angle of noise radiation are changed a huge influence on results of the noise directivity patterns of separate acoustic sources exists, so as of the sound propagation effects. It means that index of agreement d during noise event assessment may change considerably due to inaccuracy of noise directivity patterns modelling or due to inaccuracy sound propagation effects modelling. In other words spectral transfer function ΔSPL_{jk} of the Basic Acoustic Model (BAM) of the aircraft for noise event is a results of identification task solving including the influence of the directivity of sound radiation (sound matrix) and sound propagation effects.

Olena Bondarenko, Student (National Aviation University, Ukraine, Kyiv)

SIMPLIFIED METHODS OF AIRCRAFT NOISE MODELLING AND ASSESSMENT

The given graph-analytical method of aircraft noise assessment is an improvement of the method, which is resulted in «Recommendations on establishment of limitation areas for dwellings in the vicinity of airports from the terms of noise» (M., GosNIIGA, 1992).

In the given method the groups of airplanes, resulted in Tab. 1, are used. In the table the following abbreviations are used: DRA – distant-route airplanes, SMA – middle- route airplanes, RJ – regional jets, BC – business-class airplanes. Distributing of existent airplanes' fleet into the groups is carried out by criteria – maximal flight mass of the airplane, accordance to the norms of noise (the proper Chapter of the Appendix 16 of ICAO), type and number of engines in the power plant, maximum distance of executable flights.

Table 1

Groups of the airplanes

<table>
<tr><th>Groups</th><th>Airplane types</th><th>ΔL_1 dB(A)</th><th>ΔL_2 dB(A)</th></tr>
<tr><td rowspan="2">DRA
4 engines
uncertified</td><td>jets Ан-224</td><td rowspan="2">+10</td><td rowspan="2">+15</td></tr>
<tr><td>props Ан-22</td></tr>
<tr><td rowspan="2">DRA
4 engines
Chapter 2</td><td>jets B-707, B-707-QN, DC-8-20, DC-8-QN
Ил-86, Ил-96, Ил-76T, Ил-62б, Ил-62M, Ан-124-100</td><td rowspan="2">+5</td><td rowspan="2">+12</td></tr>
<tr><td>props</td></tr>
<tr><td rowspan="2">DRA
4 engines
Chapter 3</td><td>jets B-747-400, B-747-200, A-340-200, BC-9/10/20/30/40/50, Ту-154Б, Ту -134, B-727-200, B-737-100/200</td><td rowspan="2">0</td><td rowspan="2">+10</td></tr>
<tr><td>props</td></tr>
<tr><td rowspan="2">DRA
2 engines
Chapter 3</td><td>jets Як-42, B-767-300, B-767-400, B-777-300, A-330, A-300, B-757-300, Ту-214, MD- 80</td><td rowspan="2"></td><td rowspan="2">+8</td></tr>
<tr><td>props Ан-12, Ил-18, Ан-70, Lockheed Hercules (C130), L188C</td></tr>
<tr><td rowspan="2">MRA</td><td>jets Як-40, Ту-204, B-737-300, B-737-400, B-737-500, B-737-700, B-737-800, A-320, 757-PW, MD-90</td><td rowspan="2"></td><td rowspan="2">+5</td></tr>
<tr><td>props Ан-24, Ан-26, CVR580, Ил-114, Fokker 50, FH227, F27 (Fairchild), Fokker F27/ FK27, NAMC YS11, Convair 600/640, Gulfstream I, BAe Advanced Turboprop(ATP), ATR72, DeHavilland Buffalo, Saab 2000</td></tr>
<tr><td rowspan="2">RJ and BC</td><td>jets Ан-74, Ан-72, Ан-148, CL-600, CL-601,
L-35, CNA-550, E-135, E-145, MD-90
Gulfstream -2/3/4</td><td rowspan="2"></td><td rowspan="2">0</td></tr>
<tr><td>props Ан-140, ATR 42, Dornier 328, EMB-120, SD330, Nord 262; Shorts SF340, SD360; Ayres Loadmaster; Beech Starship 2000, DHC6, CASA Nurtanio CN-235, Bae Jetstream 41б F90 (BE9F), Twin 18 (BE18 & C45), King Air 100
Cessna: 300, 340, 401, 402, 441
Grumman: Gulfstream Commander
Piper: Cheyenne/PA42
Rockwell: Aero commander, Jet Prop Commander</td></tr>
</table>

By the most representative types of the airplanes in the groups are following: DRA4 - Boeing 747; DRA2 - Boeing 767; MRA - Boeing 737-300; RJ – CRJ; piston BC - Beech 1900.

For every group of the airplanes the dependences of maximal noise levels are set for the stages of takeoff/climbing from the distance from the point of startup of the airplane on runway and descending/landing from the distance to the front edge of the runway.

The resulted dependences are got for the terms of reflection from an acoustically hard covering in absence of screening and vertical reflecting surfaces. Absorption of noise in atmosphere is accounted in accordance with the requirements of the ICAO Appendix 16.

For every group of airplanes, indicated in Tabl. 1, the maximum sound levels L_{Amax} are determined for the stages of takeoff/climbing (along the axis of flight depending on distance from the beginning of running on runway) on a Fig. 1 (for jets) and Fig. 2 (for airplanes with propeller engines) and similar - for descending/landing.

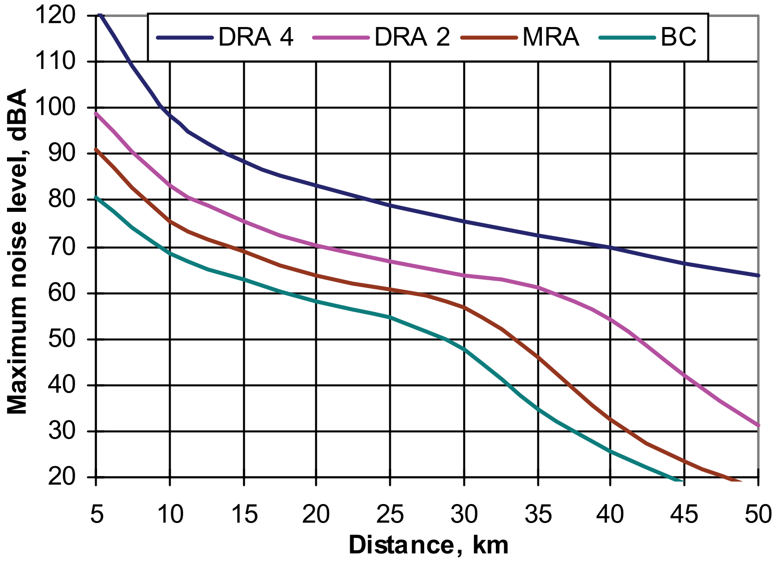

Figure 1. Maximum sound levels L_{Amax} for jets at takeoff/climbing

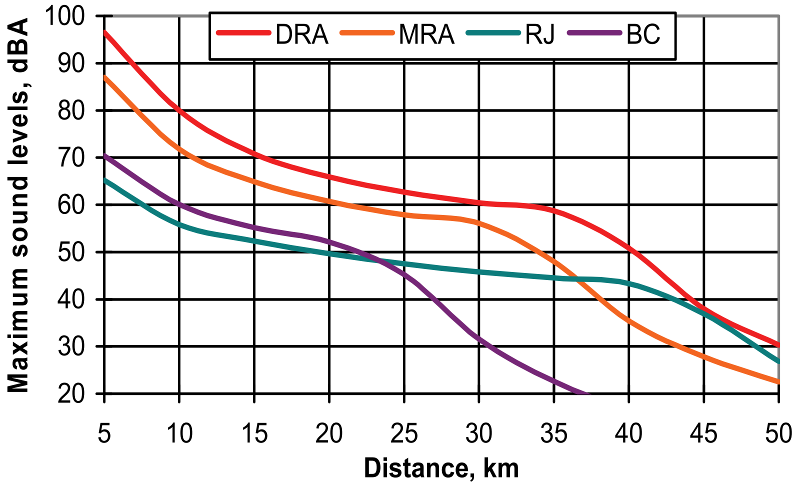

Figure 2. Maximum sound levels L_{Amax} for props at takeoff/climbing

The maximum sound levels for the airplanes of the groups DRA4 (noise levels equal to requirements of Chapter 2 of the ICAO Annex 16) and DRA4 (uncertified airplanes on noise) are determined by addition to the values of maximum levels L_{Amax} for the group of the DRA4 of the correction $\Delta L_{gr}=\Delta L_1$, the values of which are resulted in tabl. 1:

$$L_{Amax} = L_{Amax\,DRA4} + \Delta L_{gr}.$$

Conclusions

Improved simplified method is almost harmonised with existing recommended integrated noise model. Uncertainty of the received estimations of noise levels is found in limits ±5 dBA.

Valentyn Glyva, Doctorant, Andriy Lukjanchikov, Aspirant,
(National Aviation University, Ukraine, Kyiv)

ASSESSMENT OF ELECTROMAGNETIC FIELDS INSIDE AIRPORT AREA

In RF plane wave propagation (far-field), the power crossing a unit area normal to the direction of wave propagation is usually designated by the symbol *S.* As power density S corresponds also to the quotient of the total radiated power and the spherical surface area enclosing the source, it is inversely proportional to the square of the distance from the source, and can be expressed as:

$S = P/(4\pi r^2)$,

where P is the total radiated power and r is the distance from the source.

If the exposure takes place in the far-field of a well characterized antenna in free space, then S (W/m^2) is calculated by the formula:

$S = G\, P_t /(4\pi r^2)$,

where G is the far-field power gain, P_t is the power transmitted (W) and r is the distance (m) from the antenna. If G is not known, a useful approximation of S can be obtained by substituting the physical area A for A_e. This gives a somewhat larger value for S, since A is generally larger than A_e. Although the equations are far-field relationships, i.e., correct for distances greater than approximately $2L^2/\lambda$ (L >λ), they can be used with an acceptable error for distances greater than $0.5L^2/\lambda$.

Assuming theoretically perfect free-space radio signal propagation conditions, the maximum range of a radar, R_{max}, is given by the so-called radar equation:

$$R_{\max} = \left[\frac{P_t G_t A_e \sigma_0}{(4\pi)^2 L_s S_{\min}}\right]^{1/4}$$

where P_t - transmitted power, watts; G_t - gain of the transmitter antenna, linear term; A_e - effective aperture of the receiving antenna, m^2; σ_0 - nominal (specified) target cross section, m^2; L_s - system loss between transmitter/receiver and antenna, linear dimensionless quantity; S_{min} - minimum detectable signal, watts. R_{max} is a theoretical maximum that is never realized due to practical engineering and design limitations of field-deployed equipment and unanticipated losses within radar systems. Actual values of R_{max} are typically half of the theoretical value.

Universally used sources with moveable antennas and/or beams, such as scanning or rotating radars, introduce an additional complication from the safety viewpoint. The concept of mean (average) power emitted may be introduced, which is averaged for pulse length or per unit time, according to:

$P_p = P_a/tf_r$ or $P_a = P_p f_r\, t$

where P_p is the peak power, P_a the average power, f_r the repetition frequency, and t the pulse length.

Exposure limits for the general population

Exposure limits for the general population should be lower than those for occupational exposure. Recommended derived limits in the frequency range of 100 kHz-300 GHz are provided in Tab. 1. Huge investigations were done in airports in direction of measurement of AMF from airport navigation facilities. Some measured data are shown in Tab. 2.

Table 1

General population exposure limits for RF fields

Frequency range, MHz	Wave length	Limits, V/m	WHO recommendations
0.03: 0.3	10:1 km	25	87
0.3:3	1:0.1 km	15	$87/f^{0.5}$
3:30	100:10 m	7.43 - 3lg f	$87/f^{0.5}$
30:300	10:1 m	3	27.5

Table 2

Measured values of EMF

Radiation source	H, V/m	L, m	Limits
LMM (дальній приводний радіомаяк)	5780-0,62	0-100	15 В/м
LOM (ближній приводний радіомаяк)	4470-0,15	0-100	25 В/м
Radio station „Полоса” Р-140	146-1,12	0-200	3 В/м
Radio-navigational means for flight and aerodromme supply	46360-0,01 мкВт/см^2	0-5000	ОРЛ - 15 мкВт/см^2 інші - 2,5 мкВт/см^2
LLZ (СП-80М КРМ)	1,77-0,2	0-400	3 В/м
GP (СП-80М ГРМ)	9,0-0,16	0-400	2,5 мкВт/см^2

Calculations are made by using the method [2] and appropriate to it software **EMISource.** For example, for БПРМ with radiation frequency 0.257 MHz, (λ = 1167.3 m) results are shown in Tab. 3. For the limit = 25 V/m an radius of sanitary zone is equal to r = 4.3 m.

Table 3

Calculated values of EMF

Distance, m	H, V/m
10.0	8.390
50.0	3.248
100.0	1. 697
150.0	1.140
200.0	0. 856
250.0	0.685
300.0	0. 571
350.0	0.489
400.0	0. 427

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Kateryna Kazhan, Post-graduate (National Aviation University, Ukraine)

COMPLEX ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF NOISE AND POLLUTANT EMISSIONS IN THE AIRPORT VICINITY

The article is directed on substantiation of the environmental airport capacity model. Two factors – noise pollution and local air quality – is under consideration as the most affected on environment in the airport vicinity. Approach allow to assess influence of operational procedures on noise and emission levels in the airport vicinity; forecast flight schedule.

In addition to the increasing traffic demand, new constraints on the flow of traffic have been imposed and limited the capacity and efficiency of air transportation. This influences the European economy on the broader scale [1]. Apart from airport and airspace capacity issues that need to be resolved to accommodate further growth, the air transport industry is also facing increasing constraints with respect to environmental pollution. More and more airports within Europe, as well as world-wide, are faced with noise and emission restrictions imposed by government or local authorities. Thus, the use of means of reducing noise and emissions to increase airport capacity is a very topical. And at levels which are close to regulatory, or they are exceeded it is often difficult to determine which of the factors require reduction first. This is especially true for operational procedures of noise and emissions reducing.

The interrelationships between noise and emission could significantly intensify the problem of choice of the operational procedures for reduction aviation impact on environmental [2]. We meet the problem twice – first time when we determine the most harmful factor in the airport vicinity, which is necessary to decrease – noise or emission. And the other time – we can lead to rise of one of the factors, trying to decrease another. This interdependency connected with operational features of aircraft. Many of the noise abatement procedures are capable to increase fuel burn, and particularly emission of unburnt combustibles and NOx. Inverse dependence is similar. That's why the problem can not be solved in general case.

So, the task is not classical, because it has some target functions, which need to be optimized. In this research it was proposed to structure the task. The first stage of the task consists of the determination of the priority contribution of aircraft movements in total.

The basic idea of this method is the ranking of hazards, which includes first of all determination of the geometric probabilities of critical zones intersection. There are three types of critical zones: noise contour K_{noise} (normative level of the noise – maximum noise level Lamax or equivalent noise level Laeq), air pollution contour K_{aq} (maximum permissible concentration, MPC or multiple value) and contour of the city perimeter K_c. The noise contour and the air pollution contour are allowed to move and depend on operation conditions, meteorological parameters etc. The contour of the city perimeter is the fixed set.

The form of criteria can vary depending on modelling goals, national features. Full event set for some point T includes:

$-T \in K_c$, $T \in K_c \bigcap K_{noise} \neq 0$, $T \in K_c \bigcap K_{aq} \neq 0$ - concurrent intersection of the city, air quality and noise contours;

$-T \in K_c$, $T \in K_c \bigcap K_{noise} \neq 0$, $T \notin K_c \bigcap K_{aq} \neq 0$ - intersection of the city and noise contours;

$-T \in K_c$, $T \in K_c \bigcap K_{aq} \neq 0$, $T \notin K_c \bigcap K_{noise} \neq 0$ intersection of the city and air quality contours;

$-T \in K_c$, $T \notin K_c \bigcap K_{aq} \neq 0$, $T \notin K_c \bigcap K_{noise} \neq 0$ noise and air quality contours don't cross the city perimeter.

So, the ranking of involved events allows to estimate necessity and order of hazards reduction methods. The next step of the complex assessment includes opportunity of short-term and long-term forecasting of noise and/or air pollution impact on aircraft fleet, the optimal distribution of the aircraft between the routes, reduction procedures and to compose an annular flight schedule in the airports taking into account noise and air pollution level restrictions in critical zones around airports. The approach is based on entropy method with the use of analytical models.

Algorithm of the considered method consists of definition of the criteria form, and the data preparation; the model formation for optimization; the definition of the task for optimization; obtaining the results of the optimization and translating them into resulting controls. The algorithms and application programs designed using an informational data for local circumstances [3,4].

The method, algorithm and application software are obtained for short-term and long-term forecasting for operational aircraft fleet in the airport 'Boryspil'.

The first stage of the complex assessment shows that the noise pollution in the area of the airport is the most dangerous factor and first of all demands reduction**.** The probability of the concurrent intersection of the city, air quality and noise contours is 0.01, the intersection of the city and noise contours is 0.34, the intersection of the city and air quality contours 0.04.

The entropy method allows to choose the most efficient noise abatement operations procedures and approved route.

During period under consideration there are 22 aircraft types used on 12 routs in the airport. Total amount of aircraft is 196. It is also possible to use 2 types of noise abatement procedures (1 for landing and 1 for take-off). Three critical zones with noise levels upper that normative limits were determinated.

The results of the optimizing are shown that using in 23% cases of noise abatement procedures allow to reduce noise in critical zones to normative levels. The area of the environmental protection zones decreases on 15 %. After optimizing the control assessment of the air quality was implemented. Insignificant increasing of emission NOx and CO was fixed without exceeding limits. The proposed approach allows to prepare information, which is necessary for decision-making needs during the airplane fleet formation, noise and pollution reduction in critical zones.

The method will be obtained for short-term and long-term forecasting of aircraft noise for operational aircraft fleet. The assessment of aircraft noise and emissions are being carried out using the analytical models and the corresponding zones are being derived for dwelling-house usage taking in account of national circumstances and requirements.

The model that is under development will allow to:

- influence assessment of aircraft fleet structure, operational procedures on noise abatement and emissions in vicinity of airport;
- plan flight schedule by means optimal distribution of aircraft between the routes for arrival and departure with use of noise criteria;
- assess influence of environmental factors on aircraft noise and emissions abatement;
- forecast an annular flight schedule at the airport taking into account noise level restrictions in critical zones around airport.

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Olena Konovalova, Assistant Professor, (National Aviation University, Ukraine),
Salah Khardi, PH.D. - HDR, (INRETS, Bron, France)

OPTIMIZATION STRATEGIES TO REDUCE AIRCRAFT NOISE

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Among environment concerns, excessive aircraft noise and its control has become a major objective of airport authorities. The capacity of airports, particularly in Europe, is eliminated by noise impact, and it can be increased only with the implementation of effective transport management system, which reduces this impact on the local community. During recent decades, aircraft noise levels have been successively reduced up to 20 dB. Nevertheless, the large numbers of people who live in communities near airports are affected by aircraft noise which has increased tremendously in scope. Decisions have been made to enable the choice of possible solutions of aircraft noise control around airports. Several procedures have been used in the worldwide aircraft operation such as low-noise during the take-off and landing flight procedures, optimal route distributions, flight route optimization around airports, etc. Nevertheless, the noise in the vicinity of airports, in particular under the take-off and landing flight paths remains high disrupting the quality of life of local residents. Complaints are increasing despite the withdrawal of the noisiest aircraft, the fleet renewal, and the vote of international resolutions recommending that airports, faced with the problem of noise, introduce restrictions of operations. In the frames of this work it is proposed to consider the following types of operating restrictions:

- *Global*: to all traffic;
- *Aircraft specific*: restriction on aircraft type or a group of aircraft based on individual noise performances.
- *Partial*: restrictions applied for an individual time period or specific days.
- *Progressive*: gradual decrease in the maximum level of traffic or noise energy:
    - number of movements per period;
    - quotas expressed as a combination of movements and aircraft noise characteristics.

Technology solutions and the positive measures taken by airport authorities (restrictions on use of land, procedures for takeoff and landing, operating restrictions, compensating residents, …), failed to reduce their impact near airports because of the growth in air traffic.

The aircraft manufacturers foresee a demand for aircraft to cope with the increased traffic and fleet renewal in the coming years. The proportion of heavy-lift is progressing towards almost half the fleet. This growth will differ by two essential characteristics: 1. mass transport anticipating the scarcity of take-off slots; 2. transport playing on the increasing frequency and flexibility of operations continuing despite the anticipated shortage of oil.

All the experts agree that around 2020, taking into account the known oilfields and the potential extraction, the production of oil will reach a maximum level and then decrease especially with the growing economic power of China and India. Whatever the efforts to conserve energy and promote renewable energy, air transport will continue to grow, even with very expensive oil. This problem can only be solved within the framework of a global vision for sustainable development involving new technology engines and fuselages (Julliard, 2003), breakthrough technologies, the design of new procedures and flight paths (Zaporozhest and Tokarev, 1998; Zaporozhest and Khardi, 2004), airspace management, new regulation rules and certification (ECAC, 1997). Sustainable air transport development necessitates the implementation of measures aimed at reducing the aircraft noise nuisance at airports with particular noise problems.

ICAO Balanced Approach to aircraft noise control consists of identifying noise problems at an airport, then analyzing various measures. Long-term measures must force the solutions at regional level: reduction of noise at source and certification; phase-out of non-certificated airplanes; noise charges; and land-use planning and management. Short-term measure must facilitate the solutions at local level, like noise abatement procedures and mitigation of aircraft operation. It is a major challenge for the future of air transport in the context of economic development linked to compliance with the conditions of people living near airports. In recent years, increasingly strict regulations on aircraft noise have imposed large economic penalties on aircraft companies and airlines that fail to comply. As engine technology leads to quieter engines, airframe noise – defined as the non-propulsive component of aircraft noise which is due to unsteady flow around the airframe components– has become a major contributor to the overall aircraft noise levels. The physics behind airframe noise generation is still not fully understood and must be characterized before reduction techniques can be implemented. R&D projects confirmed that research in this field is active, and that current technological developments can help to reduce aircraft noise levels. The current challenge is to establish an objective assessment taking account of the evolution of air traffic, and a permanent control of noise. This control is complementary to the actions initiated by the government as the mastering of urban planning in the vicinity of an airport, assistance for soundproofing, optimization and control of operational rules. In any case huge relationship between them must be provided, because of reaching more efficiency and advantages. Currently it is proposed to make more deep analysis of operational procedures, grounding on solving of optimization tasks for flight paths at take-offs and approaches.

Departure procedures. Prior 2001 the PANS OPS guidance contained only two recommended procedures: ICAO A and ICAO B. In 2001 revision of PANS OPS development of noise abatement departure procedure (NADPs):

- engine thrust reductions cannot be made below 800' above the runway;
- the thrust reduction cannot be below the thrust level required by the certificated aircraft flight manual or approved manufacturers' operations manual;
- procedures for Air Navigation Services – Aircraft operations (PANS OPS) Volume 1 – Flight procedures (Doc 8168), Part 1, Section 7:
  - NADP 1 - For noise areas sensitive near the airport;
  - NADP 2 - For more distant areas.

Approach procedures. Operationally, the Continuous Descent Arrival/Approach (CDA) procedures can produce significant reductions in noise and emissions. The results of some specific unrestricted CDA demonstrations resulted in 5 to 6 db reduction in peak noise levels along some portions of the flight path (reduction of 30% in noise contours area)

CDA is based on the following operational concept:

- Replace the alternation descent/ stable flyover/ descent… by a continue descent during the arrival phase in VFR.
- Delete engine thrust variations , so decrease noise , fuel flow and emissions.
- Use modern avionics (FMS) to manage the trajectory in vertical plan.

For that an improved complex of models for particular dominant aircraft noise sources was developed. Among them the dominant sources of the engine – jet (including co-annular with by-pass ratio till 12-15), fans at inlet and outlet, combustion chamber, turbine, and the dominant sources of the airframe – wing with flaps and slats, landing gear. All improvements are reached on latest results of theoretical, numerical and experimental analysis of the sources from European and American aircraft noise programs. Particularly in European program "Silencer" the National Aviation University contributed in aspects of the modelling of noise propagation and engine installation effects.

But a compromise should be found between environmental acceptability, the lower cost of design, development, production and exploitation, and increasing the operational capacity of the airspace. Furthermore, the known absence of a clear link between the certified noise levels and noise levels measured on the ground justifies the experimental work undertaken by research and development. Indeed, at the end of each certification, changes have taken place, due to technological leaps facing the aviation industry (Oishi and Nakamura, 2000; Kenzakowski et al., 2002; Hunter and Thomas, 2003; Kannepalli et al., 2003). In flight, commercial jet aircraft sources are active (Smith, 1989; Hubbard, 1994; Michel et al., 1998). Their relative importance depends on the flight segment and the airframe-engine combination. There are many components in aircraft noise - different parts of the air-frame (flaps, under-carriage etc.), engine fan, and engine jet etc. - whose relative importance changes according to which aircraft is considered and with the aircraft's operational configuration and mode of flight. Thus, directivity has a much greater contribution in aircraft noise source characteristics.

New models for the acoustic sources, their propagation and installation effects must be used for searching of the new or improving of currently used flight procedures. For that the optimization tasks must be formulated and solved. Criteria of optimization must include the flight event evaluation and overall scenario evaluation as well. Due to inclusion of propagation effects the routine meteorological and topographical conditions influence on results of optimization may be investigated.

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Dmytriy Babejchuk, Researcher, Olga Veklenko, Student
(National Aviation University, Ukraine)

CNS/ATM SUPPORT FOR AIRCRAFT NOISE IMPACT REDUCTION AROUND THE AIRPORTS

Environmental benefits of the CNS/ATM implementation

CAEP's Working Group 4, Emissions — Operational Issues, initiated a study of the environmental benefits made possible through the implementation of CNS/ATM systems [1]. Within the time frame under consideration (1999–2015), global air traffic is expected to increase by approximately 61% (FESG). In the same time period, fuel consumption and CO2 emissions are projected to increase by just 37%. Fuel burn and CO_2 emissions are growing less quickly than traffic because of the introduction of more efficient engine technology, aircraft retirement and fleet expansion. The preliminary results of this study show that by 2015 there will be an additional benefit of approximately 5% fuel burn and CO_2 emission savings.

For local environmental issues CNS/ATM implementation may contribute to noise reduction problem in the way, which is outlined below. Recently, however, support to ICAO through its CAEP has been expanded to include the topic of Continuous Descent Approach (CDA), for which EUROCONTROL provides the CAEP Focal Point.

Approach noise abatement procedures

During descent and approach, the aircraft has to lose speed and altitude in a controlled manner to arrive at the final stabilisation point on the final approach with the correct speed and in the landing configuration. In addition, the aircraft changes its aerodynamic configuration and engine thrust setting. The variables on the flight path that can influence the noise footprint on the ground are: In the vertical plane: Height at a given position; Speed, influencing airframe noise; Aircraft configuration: position of slats/flaps, spoiler and landing gear), influencing airframe noise; Thrust level, driving engine noise level; Descent angle or gradient, determining profile height, deceleration distance and thrust requirement; Threshold displacement is considered as a solution to move of the noise footprint closer to the airport. In the horizontal plane: Accurate RNAV versus conventional navigation capability from current aircraft. An improvement of precision in navigation can reduce this spread of noise; Radar vectoring or (strictly) prescribed arrival/approach routes. If substantial vectoring by air traffic control occurs for arrivals, much larger dispersion should be considered.

Continuous Descent Approach (CDA) procedures are the most common noise abatement approach technique. They are designed to eliminate level segments present in conventional "step down" approaches, keeping aircraft at higher altitude and lower thrust for longer, thereby reducing noise impacts and reducing fuel burn and emissions. The basic concept is illustrated in Fig. 1.

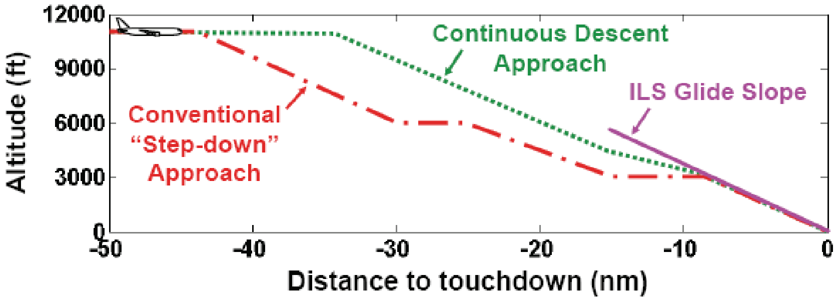

Figure 1 - Basic concept of Continuous Descent Approach

An Advanced Continuous Descent Approach (ACDA) is enhanced with future infrastructure, ATC/ATM tools and crew cabin tools in order to meet demands of capacity and safety. During an ACDA, the requirements for ATC/ATM speed control may be relaxed, or even removed, and additional constraints may be added; for example to execute a part of the approach with thrust idle or to follow a certain fixed vertical flight path. The "ideal" noise abatement approach procedure enables the entire descent and approach phase of flight to be flown as high as possible for as long as possible with no level segments, at flight idle engine thrust and with clean aerodynamic configuration for as long as possible. This involves a combination of the CDA, RNAV and LP/LD techniques [2]. Fig. 2 shows the result of this comparison for an aircraft of the A319 family (it is in operation in the Ukraine).

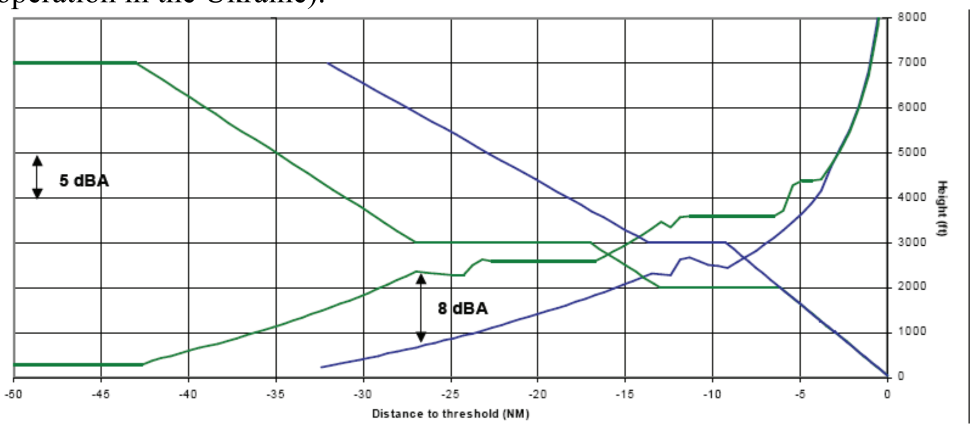

Figure 2. Comparison of the ACDA approach procedure and typical current practice approach

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Aleksandr Korolkov (Center of Ecological Safety of Civil Aviation, Russia, Moscow)

CURRENT INTERNATIONAL PRACTICE FOR AIRCRAFT ENVIRONMENTAL LEVIES AND PENALTIES IN AIRPORTS. RECOMMENDATIONS FOR AIRPORTS IN RUSSIAN FEDERATION

Nowadays Western European countries pay more and more attention to the problem of environmental effects of aviation. As commonly known major effects among these are noise and aircraft engine emission of harmful gases to the atmosphere.

Analysis of foreign aviation enterprises' experience on lowering the environmental impacts shows that there are different ways of control and means of lowering aircraft noise. In market economy conditions the means of economic coercion, or in some cases, encouraging of using of modern low noise aircrafts by airlines and specially developed low noise flight routes and techniques, should be considered as the most effective. For airlines in different countries special economic levies so called "environmental charges", that take into consideration the ecological characteristics of aircrafts, shall be underlined. Also some countries already utilize systems of noise related penalties for airlines, whose aircrafts do violate certain set, low noise flight techniques and flight routes optimized to lower noise effect on populated areas around airports. The other countries are planning to do so. Implementing of airport charges for ecological characteristics of aircrafts is governed by ICAO Doc 9082/7 and is allowed only for airports where the problem of excess noise effect on population really exists. Also according to the same document any of such charges shall be connected to the landing charges. This rule does apply to ecological charges. Noise penalties are not covered by this rule.

Variations in systems of applying and calculation of airport ecology related charges are caused by the different factors of evaluating of aircraft noise, which include but not limited to:

-Evaluation based on certified noise characteristics of certain aircraft type;

-System of noise quota count;

- Results of noise control in specific airport implementing special automatic and automated means of noise control;

-Aircraft ICAO noise chapter

-Take – off or landing aircraft weight

- System of encouraging means, so called "Bonuslist" for using low noise aircrafts.

-Surcharges for night time operations.

It is needed to be said that the utilization of factors is or their combinations differs from country to country. For example in German airports the basis for calculating ecology charges is combined division of aircrafts into different noise categories: aircrafts of ICAO chapter 2 and 3 are separately divided into 7 categories each. The fixed tariff of base charge is set for each category. Extra surcharge is implemented based on actual landing weight and time of certain aircraft

In Swiss airports aircrafts are divided into 5 different noise classes. For the least noisy aircraft of 5^{th} class noise charge is not applied, except for use of such aircraft during nighttime, when the special nighttime surcharge is applied. In addition to the noise characteristics charge special charge for engine emissions is applied in Swiss airports. All engines are divided into 5 groups according to their emission characteristics. For the most ecologically advanced group 5 no emission charge is applied.

In United Kingdom airports the system of noise quota count based on certification noise level of aircraft is implemented. This system allows the encouraging of airlines to use low noise aircrafts instead of noisy ones.

In UK the practice of implementing penalties for exceeding certain noise levels by aircrafts is widely used. Penalties are set according to noise monitoring system data, for the noise event determined on exceeding the certain threshold noise level by aircraft in certain designated areas (For example for Manchester airport the level of 83dBA in 6.5km from start of roll). The actual penalty amount depends on the value of exceeding the threshold and calculated as sum of fixed part of penalty for exceeding threshold itself and variable part for number of dBA of threshold exceeding. It shall be underlined that use of such system is highly dependable on the reliable operation of noise monitoring system.

Today it seems rather difficult to determine which factor or combination of factors need to be used to get better results from ecology related airport charges in Russian Federation. There are different reasons for that. Besides the lack of statistical data on the degree of the aircraft operations influence on the environment in airports vicinity, there are number of other factors, which differs airport operation in Russia and Western Europe. Among these are the following: the high share of old noisy aircrafts in operation, which do not comply with ICAO chapter 3 and above. To stop operation of such aircraft will cost significant amount of both time and money. The implementation of ecology related charges not necessarily will lead to the same consequences as in Western Europe, when the aircraft operators began to increase the share of modern low noise aircraft. Many Russian airlines will probably prefer to continue to use noisy aircrafts and pay high charges. It can be economically effective for them to pay charges that to pay even more for modernization of their fleet.

The other typical factor for aircraft operators in Russia is frequent violation of flight routes, which not always can be justified be means of flight safety. These violations are most common for small and business aviation. With contemporary development of city infrastructure and new construction of residential buildings in the vicinity of airports such violations will lead to increased effect of aircraft noise on population.

International airport Domodedovo (Moscow) is the pioneer in Russian noise monitoring and flight routes violation control systems. During the project of reconstruction of runway #1 Domodedovo is installing the noise monitoring system, which will allow to find, track and investigate the exceeding of threshold noise levels for aircraft operations as well as find out the standard flight route violation cases. This system can also be the basis for implementing airport ecology related charges, as well as penalties for exceeding noise level in residential areas. These day airport faces the following problem: which method of airport charges shall be brought into force. For this purpose, specialists of Domodedovo airport in close cooperation with Center of ecological safety of civil aviation is doing the deep analysis of foreign experience in using the systems of environmental related airport charges and penalties as well as operating automated and automatic control systems. It is done for the first time in Russia with the purpose of development of complex approach to the management of airport environmental influence.

Oleksandr Zaporozhets, Professor, Marina Gordeeva, Aspirant
(National Aviation University, Ukraine, Kyiv)

GROUNDS FOR AIRCRAFT NOISE LEVIES IN THE UKRAINE

Environmental tax is the source of financing of the measures directed on the protection of natural environment, the rational use of natural resources, rise of ecological safety of vital functions of the human beings.

In case of the aircraft emission of contaminating matters into the atmosphere the object of taxation is maximal flight mass of the aircraft and number of carried out by them landings. Proposed rate of tax for the emission into the atmosphere of contaminating matters by aircraft – 5 hryvnyas per ton of maximal aircraft flight mass per one landing-takeoff cycle. Key strong recommendation from the ICAO Council Resolution (2007) “that any environmental levies on air transport, which States may introduce, should be in the form of charges rather than taxes and that the funds collected should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions”. Secondly, a State that had chosen to proceed with a local charge on aircraft emissions would have undertaken the necessary analysis to confirm that such a charge is an appropriate policy measure to address the local air quality (LAQ) situation [1].

Airport studies confirm that aircraft continue to be a relatively small contributor to regional pollution, although aircraft-related NO_x contributions could increase as air traffic increases and other non-aircraft emission sources become progressively cleaner. Airports and their associated activities are sources of an assortment of gaseous and particulate emissions. This information is determined through the completion of an emissions inventory. Ukranian guidelines for aircraft emission inventory [3] are in good accordance with new ICAO guidelines [4]. Moreover, all the improvements, which were made during last decade, are fully implemented in new Russian guidelines [5], in which the Center of Environmental Problems of Airports of the National Aviation University has contributed.

Existing airport emission inventory guidelines [3,5] are agreed almost with requirements of existing ICAO policies on aircraft emissions or noise charges. On emphasizing the use of ICAO policies on aircraft emissions or noise charges it is necessary to make the distinction between a local emissions/noise charge and a tax, as well as a discussion of the application of ICAO's existing policies in the context of LAQ or noise impact in the vicinity of the airports.

These policies pertain to: 1) Non-discrimination; 2) Potential impacts on the Developing World; 3) Transparency; 4) Cost-basis; 5) Cost-effective measures; 6) Minimize competitive distortion; 7) No fiscal aims; 8) Charges rather than taxes.

Dominant environmental factor in airports – aircraft noise is still not covered for ecological taxation or charging in the Ukraine, but this task is of great concern. It must be performed in one way as for other environmental noise sources – transportation sources of noise first of all.

ICAO policy with respect to noise charges was first developed in 1981 and is contained in ICAO Policies on Charges for Airports and Air Navigation Services (Doc 9082/7). ICAO policy consider that airports with noise problems may levy such charges in order to recover the costs incurred for the alleviation or prevention of noise. In the context of noise-related charges, this can include the costs of: noise monitoring, noise insulation for housing, and purchasing houses and land in areas adversely affected by noise. The recommended by ICAO process before the implementing the charges involves four steps as follows:

Step 1: Identify Relevant Local Air Quality and Noise Standards and Regulations.

Step 2: Determine Current Airport Air Quality and Noise Impact.

Step 3: Verify Compliance and Conduct Impact Assessment.

Step 4: Quantify the Relative Contribution of Aircraft.

There are different ways in which a State (or its delegate) might levy an aircraft emissions/noise charge. ICAO guidance describes [1] some of the concepts and possibilities - including a direct charge, a modified landing fee, etc.; in practice schemes may be a hybrid of these. If a State wishes to adopt and implement such charges, it should do so in a manner consistent with ICAO policy.The systems of airport charges related to aircraft noise are founded on approaches that are based on the most different initial criteria, such as:

- the results of noise/emission certification testing of specific types of aeroplanes/engines for compliance with the requirements established in the ICAO Standards in Annex 16, Volume I (aircraft noise) and Volume II (engine emission);
- the national systems of categorizing aircraft in operation according to the characteristics of the noise/emission created by them at ground level for individual categories or specific types;
- the results of the measurements of actual concentrations in air of the airport and of noise levels at the take-off and landing of aircraft at a specific airport, using automatic systems for the 24-hour monitoring of aircraft noise;
- the actual time of day, calendar days of the week, seasonal periods of time;
- the class of aircraft in operation, as well as the nature of the air services being performed;
- a mixed system using some of the criteria listed above.

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Yuriy Medvedev, Aspirant (Center of Ecological Safety of Civil Aviation, Russia, Moscow)

NUMERICAL MODELING OF AIR POLLUTION DISPERSION FROM THE AIRCRAFT AND OTHER AIRPORT POLLUTANT SOURCES

Introduction

The problem of air pollution dispersion is considered. The exact solution of the diffusion equation is used. The motion of the aircraft is modeled numerically. The additional problem of the submerged jet is investigated numerically. The obtained information is applied to the correction of the main problem. The obtained results are used for the modeling of the real processes. While developing the ICAO recommendations [1] were taken into account and implemented.

Dispersion modeling

Since the dispersion is caused by the turbulent diffusion and the wind transfer, the model equation takes the following form:

$$\frac{dc(\vec{r},t)}{dt} = \left(\nabla, D\nabla c(\vec{r},t)\right) + f(\vec{r},t); \tag{1}$$

here $c(\vec{r},t)$ is the pollutant concentration in the space point $\vec{r}\left(x,y,z\right)$ at the moment t, $f(\vec{r},t)$ is a source function, D is the diffusion coefficient function and $\nabla = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$.

The frame of reference is set so that the wind velocity vector u_w and the *x*-axis are collinear. The *z*-axis is directed upwards and the *y*-axis completes the right-hand triple. Thus, the dispersion equation takes the form (no sources are expected) [2]:

$$\frac{\partial c}{\partial t} + u_w \frac{\partial c}{\partial x} = k_x \frac{\partial^2 c}{\partial x^2} + k_y \frac{\partial^2 c}{\partial y^2} + k_z \frac{\partial^2 c}{\partial z^2}; \tag{2}$$

The solution for the equation (2) has the form, [2]:

$$c(x,y,z,t) = \frac{M}{4(\pi t)^{3/2}\sqrt{k_x k_y k_z}} \exp\left(-\frac{(x-x_0-u_в t)^2}{4k_x t} - \frac{(y-y_0)^2}{4k_y t}\right) \times$$
$$\times\left[\exp\left(-\frac{(z-z_0-H)^2}{4k_z t}\right) + \exp\left(-\frac{(z+z_0+H)^2}{4k_z t}\right)\right]; \tag{3}$$

where H is the corrected source height, obtained from the problem of submerged jet (see below). The function (3) gives the instantaneous concentration value for the point (x,y,z) from a single exhaust event. In order to obtain the averaged concentration value the integration for a specific time period is used.

The atmospheric turbulent diffusion coefficients $\left(k_x, k_y, k_z\right)$ for all directions differ and depend on the atmospheric parameters. Thus the considered solution (3) for each point in the space has the specific values for the $\left(k_x, k_y, k_z\right)$ [5].

Problem of submerged jet

The additional single source parameters, the corrected height H and the jet fading distance L, are obtained by solving the problem of submerged jet. In the initial cross-section the engine jet and the atmospheric air are mixing (Fig.1).

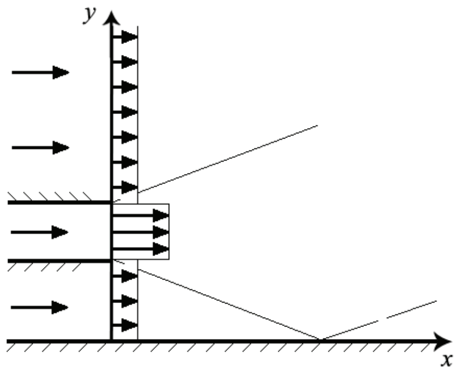

Fig. 1. The mixing of engine jet and the atmospheric air with the formation of the flux, reflected from the runway surface

This process is governed by the system of equations (4)-(7) [3]:

$$\frac{\partial \rho}{\partial t}+\frac{\partial\left(\rho U_i\right)}{\partial x_i}=0; \tag{4}$$

$$\frac{\partial U_i}{\partial t}+U_j\frac{\partial U_i}{\partial x_j}=-\frac{1}{\rho}\frac{\partial p}{\partial x_i}+\frac{1}{\rho}\frac{\partial\left(-\rho\overline{u_i u_j}\right)}{\partial x_j}+g_i; \tag{5}$$

$$\frac{\partial \Phi}{\partial t}+U_j\frac{\partial \Phi}{\partial x_j}=\frac{1}{\rho}\frac{\partial\left(-\rho\overline{u_i\varphi}\right)}{\partial x_i}+S_\Phi; \quad (6) \qquad \rho=\rho(\Phi); \quad (7)$$

Solving this problem provides the value for corrected source height *H* and the distance *L*. The assumptions used are: The problem is 2-dimensional; Molecular transport terms are equal to zero; Mass forces are neglected; The viscous boundary layer is considered infinitely thin; The problem is stationary.

Weighting factors for the emission segments

Since the emission rate for the individual pollutant is irregular during the LTO cycle and depends on the engine operating mode, the weighting factors are applied. The factor values lie in the range between 0 and 1 and are the ratios of the corresponding pollutant emission on the current regime to the overall emission. For instance, the weighting factors for the aircraft type IL-76 are presented in the table 1, calculated on the basis of [4].

Table *1*

Weighting emission factors for IL-76

Weighting factors for the pollutant emission rates on different operating modes for aircraft type IL-76		Pollutant				
		CH	CO	NOx	C	SO2
Operating mode	Take-off	0,010	0,007	0,210	0,294	0,100
	Climb	0,031	0,023	0,459	0,327	0,267
	Approach	0,065	0,079	0,135	0,270	0,167
	Idle	0,894	0,891	0,196	0,109	0,466

Numerical modeling results

The numerical modeling was carried for the Eurocopter landing pad in St'Petersburgh (Russia) and Ufa Airport (Russia). The input data are: the atmospheric conditions, the total pollutant emission, the aircraft type, the aircraft tracks and the standard LTO cycle description. The output data set was visualized on the TecPlot-software, Fig. 2 and 3.

Conclusions

The described method allows to compute the pollutant concentration field. The numerical method utilizes the measurement results and makes possible the refinement procedure. A number of problem parameters are considered. The ICAO recommendations are taken into the consideration. The computed concentrations reveal the dispersion mechanism.

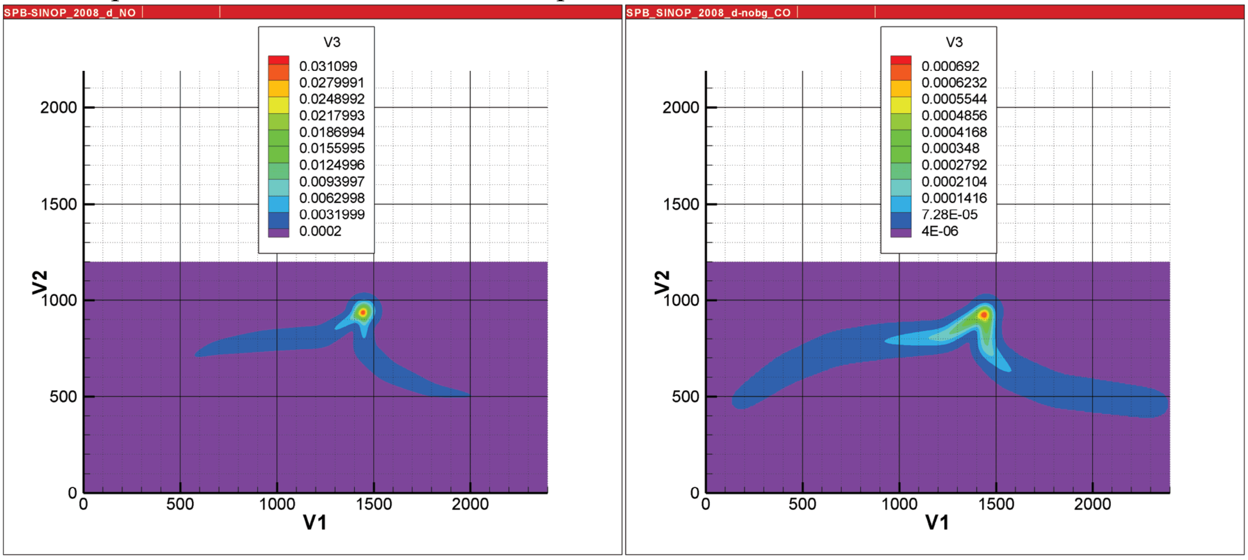

Fig. 2. Eurocopter landing pad in St'Petersburgh (Russia). The average 20-minutes (maximum single) concentration fields for NOx (left) and CO (right).

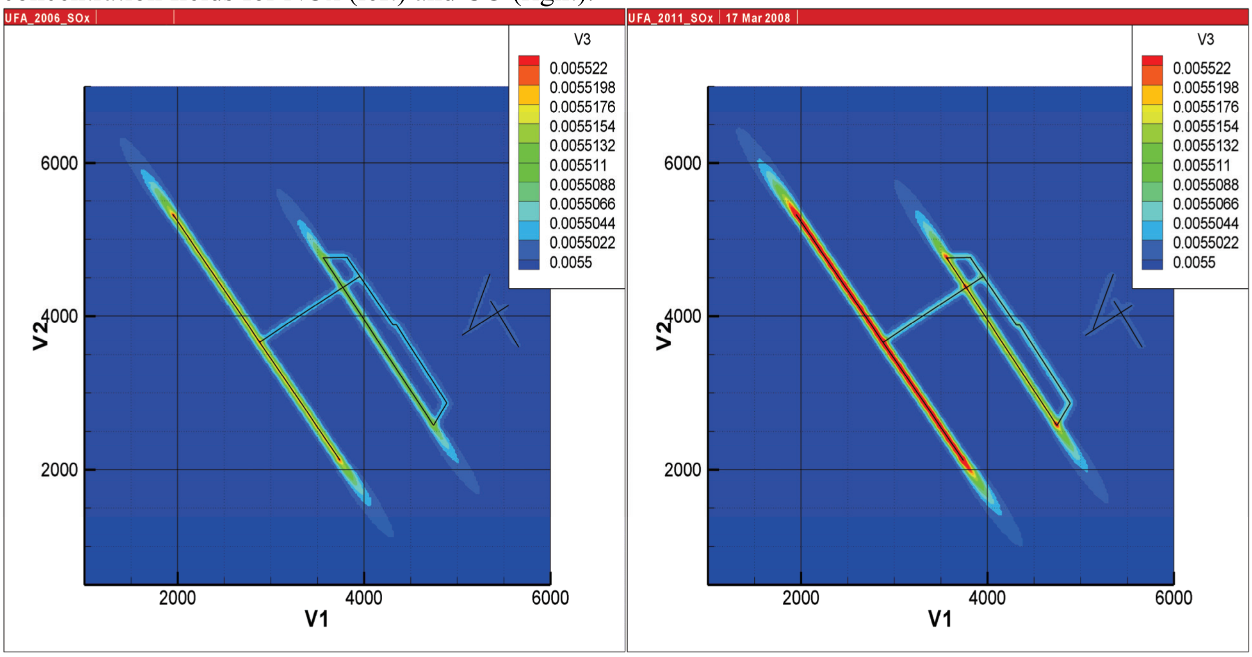

Fig. 3. Ufa (Russia) Airport. The average daily concentration fields for SOx for years 2006 (left) and 2011 (right).

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Kateryna Synylo, Aspirant (National Aviation University, Ukraine, Kyiv)

NUMERICAL SIMULATIONS OF DESPERSION BY JETS OF THE AIRCRAFT ENGINE GASEOUS EMISSIONS

A number of models have been developed for the assessment of air pollution produced by aircraft activities inside airport area. It consists of the following basic components: engine emission inventory calculation; transport of the contaminants by engine jets; dispersion of the contaminants in atmosphere due to wind and atmospheric turbulence. CFD simulations has become an alternative to those complicate and laborious wor, producing more accurate simulations and predictions to regulation air quality.

Backgound

Airport operations affect the environment in several ways – the impact of increasing air traffic on the environment and growing public awareness of local air quality around airports. According to international practice many models were developed for accurate assessment of local air quality inside the airport. There are 3 well-known emission tools for conduction of emission inventory and dispersion modelling in the vicinity of airport [1-3]:

- LASPORT - Emission Calculation and Dispersion Model System, based on Langragian dispersion model LASAT [1];
- EDMS - Emission and Dispersion Model System developed the FAA [2];
- ALAQS-AV - Emissions Inventory was developed by EUROCONTROL [3].

For dispersion calculations these modelling system consider aircraft as a point source of exhaust (on apron) and as area (line) source (during taxing, queuing, accelerating on the runway).

In ALAQS-AV [4] a CFD software package was developed, which characterise the plume dynamics and flow structure of turbulent jets. Results of CFD calculations produce more accurate simulations and predictions to regulation air quality [4].

Modeling results of non-buoyant and buoyant free jets

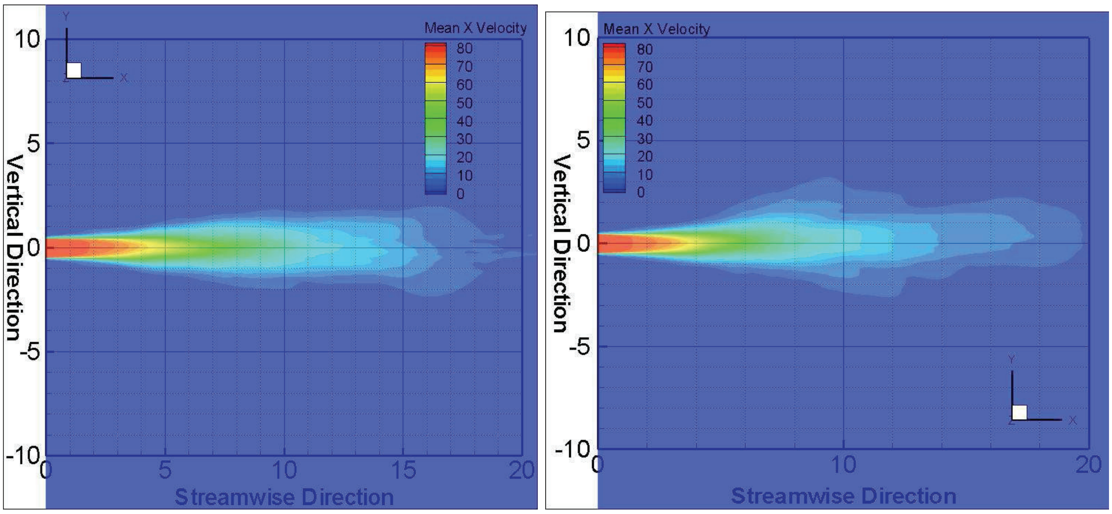
In basis initial data and boundary conditions for considered research in ALAQS document [4], modeling of buoyant free and wall jet was performed due to Fluent 6.3 [5]. The model LES was used for solving basic equations of CFD simulations. For investigation buoyant free jet mesh of cylindrical shape was created by Gambit:

- Total mesh density comprises 1 653 890 cells;
- Geometrical parameters of mesh: length (height of cylinder) extend to 70m, width (radius of cylinder) extends 50m, jet diameter – 1m.

The boundary conditions for this research are follows:

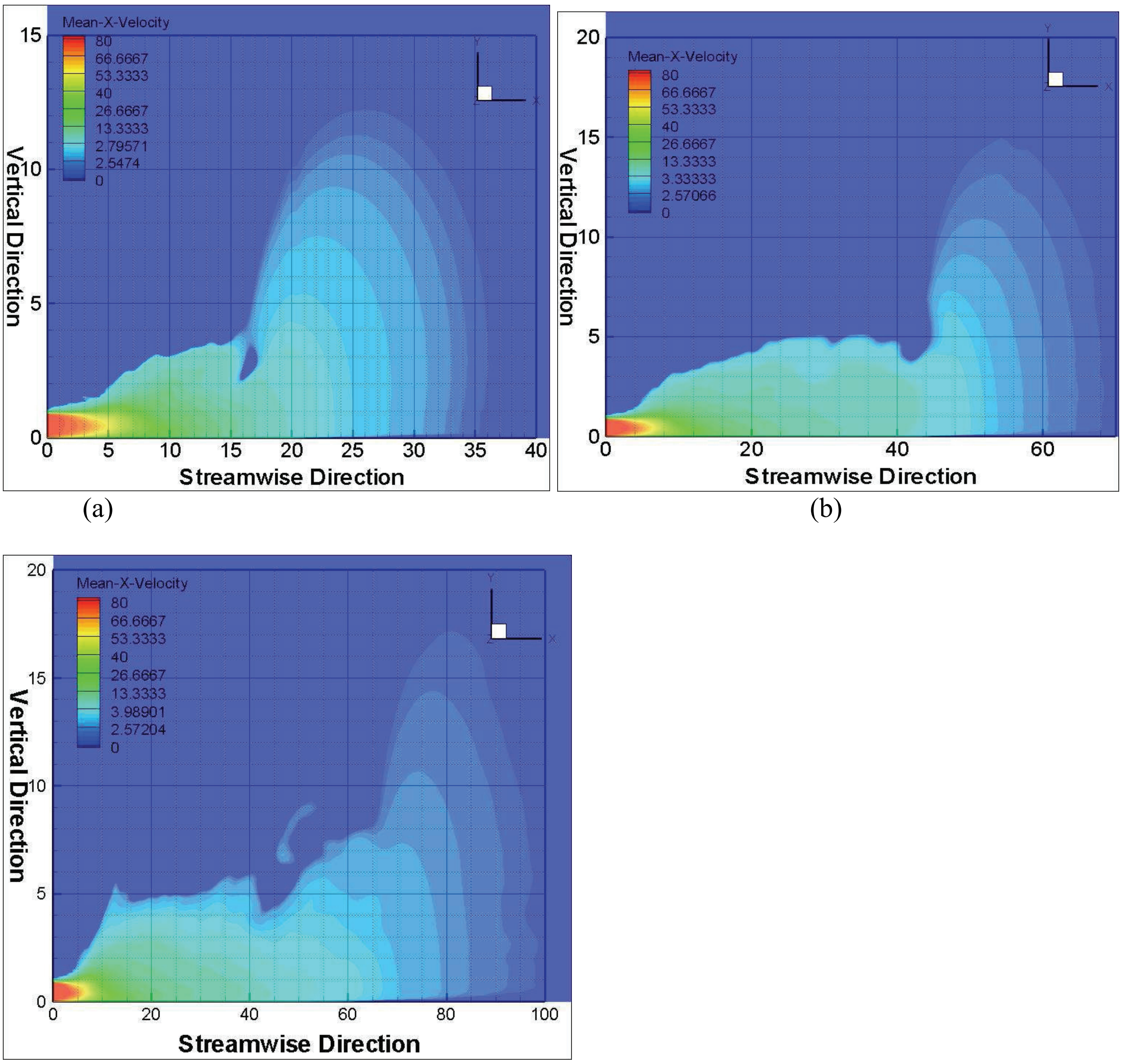
- The jet exhaust is set up as a velocity inlet with velocity magnitude 80 m/s, releasing hot gases 690 K;
- The co-flow is across the domain with temperature 300 K wind velocity2.5 m/s;
- The circular boundaries are defined as wall, located far away from the jet;
- The face opposite to the jet is set up us pressure-outlet of control volume.

Fig. 1 shows a comparison of the mean velocity profile for the simulations of the buoyant free jet due to Fluent 6.3 [5] (a), buoyant (b) and non-buoyant free jet (c) due to CFD numerical simulations of ALAQS report [4]. It can be seen that for the non-buoyant jet has the symmetrical pattern, whereas the buoyant jets show a break in the symmetry and point out buoyancy effect, which cause to rise of centerline axis jet. With aim to compare the results for buoyant wall jet due to Fluent 6.3 with free and wall buoyant jets in ALAQS simulations results and assess the effects on the fluid mechanics, when the wall is added, mean velocity profile for buoyant wall jet was created by TecPlot for different times: 1, 5, 10 s (Fig. 2). It can be seen that at the moment t = 1s a much further penetration for the wall jet exists than for the free jet. The free jet still exhibit an almost symmetrical pattern. The wall jet, on other hand, shows a different pattern with fluid rising at some distance behind the jet exhaust.



(a) (b)

Figure 1 - Mean velocity profile for non-buoyant (a) and buoyant free jet (b), transient decision for the moment 1 s after release of the jet



(c)

Figure 2 - Mean velocity profile for buoyant wall, transient decision: 1s (a), 5 s (b) and 10 s (c)

Buoyancy effects can clearly be seen after 5 s, when the free jet velocity profile shows a deviation from centerline axis. The wall jet has approximately the same pattern as in the previous time step, with the flow rising much higher than for the free jet situation. The flow penetration is also much deeper for the wall jet than for the free jet simulation.

Results of the 3-D simulations due to Fluent 6.3 [5] and ALAQS computations (Fig. 2) confirm, that decay rate for the free jet is greater than the for wall jet. On the other hand, the potential core is much shorter and its decay rate is much greater for the free jet simulation than for the wall jet simulation. Mean velocity and temperature profiles show, that fluid dynamic of buoyant jet is more close to buoyant free jet. Certainly, Coanda and influence wall exist, but distance 3m from jet exhaust is not sufficient for essential clinging phenomenon due to Coanda effect. Whereas distance approximately 1m from jet exhaust, allow represent comprehensive clinging and lift-off property of wall jet (results of ALAQS report [4]).

Comparison of CFD simulations by Fluent 6.3 and complex model "NAU"

For this simulation, turbulence model LES was used for solving general Navie – Stokes equations of fluid flow. The basic concept of the LES concept is to solve explicitly the larger eddies of the control volume, whereas the smaller eddies are modeled through a filtering process.

In basis initial data (velocity and jet temperature, wind velocity, air temperature, diameter of engine nozzle) for considered research, calculations of height plume were implemented due to complex model "NAU" for fulfilled gases from aircraft engine. The NK-8-2U jet engine at idle operation mode was selected (velocity jet = 98 m/s, temperature jet=423 K). Atmospheric conditions: air temperature = 298 K, wind velocity – 2m/s. Wind is directed along the aircraft engine jet, which is corresponding to slipstream. The simulation involves a round jet of 1 m in diameter closely to a ground (3.0 m).

Height of buoyancy effect "h_A" and longitudinal coordinate of buoyancy effect site "X_A" due to CFD (Fluent 6.3 [5]) modeling and complex model NAU (***PolEmiCA***) are represented in Tab. 1.

Table 1

Comparison of height of buoyancy effect "h_A" and longitudinal coordinate of buoyancy effect site "X_A" due to CFD simulations and complex model "NAU"

	Simulations	Height of buoyancy effect "h_A", m	Engine height, m	Vertical coordinate of jet, m	Longitudinal coordinate X_A"
1	mesh1	21.54	3.5	25.04	210
2	mesh2	20.62	3.5	24.12	175
3	com. NAU	42.53	3.5	48.03	250

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Volodymyr Pavlysh, Assistant Professor, Oleksandr Zaporozhets, Professor,
(National Aviation University, Ukraine, Kyiv)

WATER POLLUTION BY ANTI-ACING LIQUIDS AND THEIR TREATMENT IN AIRPORTS

Certain winter weather conditions cause icing up of aircraft. This can leave flight-related surfaces and technical equipment in a critical state. For the air safety it is essential that wing surfaces are fully cleared, which means clear of snow, ice, slush or frost. The most common technique for deicing/anti-icing of aircraft is the application of chemical deicing/anti-icing fluids (ADF), which nowadays are composed primarily of ethylene or propylene glycol. In Europe there are almost exclusively propylen glycols in use, since the environmental impact is a most important concern. The new equipment (spraying units) entailed the development of new procedures of using a mixture of hot water and glycol for the de-icing /anti-icing in order to apply a protective film afterwards. Most airports still dump the de-icing/anti-icing agents into the irregular sewage system, where the glycols completely biodegrade within a short time. The biodegradation will be even increased in flowing water.

Four types of deicing/anti-icing fluid are used on aircraft, and vary by composition and holdover time. Type I fluids, which contain glycol and less than one percent additives, are most commonly used for deicing and have relatively short holdover times. Types II, III, and IV fluids are used for anti-icing protection because they contain higher concentrations of additives (two percent or less) in addition to glycol. Larger airlines use both Type I and Type IV fluids for deicing and antiicing. Because longer holdover times are not as important a consideration at smaller airports, smaller airlines typically use Type I and II fluids, which contain smaller amounts of additives, or no anti-icing fluids at all.

Toxicity of the ADF

Glycols are not poisonous, but they are dangerous for natural waterways, because they consume oxygen in the water during the process of biological and chemical deterioration, bringing oxygen levels to a point where water-based organisms can no longer be supported. Ethylene and propylene glycol can have harmful effects on aquatic life due to their high biological oxygen demand (BOD). A summary of BOD and COD results for Type I, II, and IV ADFs is shown below in Tab.1. The results indicate that ADFs are readily and rapidly biodegraded. Note that the Type I data presented are for concentrated fluid and not as applied fluid. It is recognized that the propylene glycol-based Type I fluid has a lower BOD than the ethylene glycol-based Type I fluid. In general, Type II and Type IV solutions should have a higher BOD concentration than Type I solutions (as applied) because they contain a higher concentration of glycol.

Table 1

BOD and COD results for Type I, II, and IV ADFs

Fluid Type	**COD (mg/L)**	**BOD, Day 5 (mg/L)**	**BOD, Day 10 (mg/L)**	**BOD, Day 15 (mg/L)**	**BOD, Day 20 (mg/L)**
Type I - EG based (concentrate)	1,260,000	873,000	1,070,000	NA	1,210,000
Type I - PG based (concentrate)	1,400,000	840,000	NA	NA	NA
Type II - PG based	NA	730,000	NA	NA	NA
Type IV - EG based	945,000	463,000	576,000	775,000	935,000
Type IV - PG based	794,000	520,000	NA	NA	785,0

NA - Not available; EG - Ethylene glycol; PG - Propylene glycol COD - Chemical oxygen demand.

Although pure ethylene and propylene glycols have low aquatic toxicity, ethylene glycol exhibits toxicity in mammals, including humans (with the potential to cause health problems such as neurological, cardiovascular, and gastrointestinal problems, serious birth defects, and even death when ingested in large doses). Additionally, ethylene glycol is considered a hazardous air pollutant (HAP), and is subject to reporting requirements.

Additives in deicing/anti-icing fluids can be significantly more toxic to the aquatic environment than glycols alone. Corrosion inhibitors are highly reactive with each other and with glycols; reactions can produce highly toxic byproducts. Other additives such as wetting agents, flame retardants, pH buffers, and dispersing agents also exhibit high aquatic and mammalian toxicities.

Protection management measures

Airport's primary water quality goal is to prevent or minimize pollutant discharges, thus limiting adverse water quality impacts associated with airport activities. The airport's environmental programs pertaining to water quality and environmental compliance and management include: Stormwater management; Water quality management; Contingency Plan compliance; Storage tank compliance; Compliance auditing and inspections; Environmental Management System (EMS) implementation; State Sustainability Program participation.

The following measures were taken to improve water protection and to minimise the pollution levels of the waste water resulting from airport operations: Minimisation of precipitation run-off from the runway and apron through the construction of rainwater reservoirs; Minimisation of the pollution levels in the waste water through the sparing use of environmentally less harmful de-icing agents for aircraft and runway, and by feeding the rainwater polluted with de-icing agent into the public sewage system; Reduction of drinking water consumption – construction and operation of a rainwater utilisation system; Removal of soil contamination from the abandoned airport tank farm.

Harmful de-icing agents for aircraft and runway are of basic concern. There are four basic approaches to pollution prevention for aircraft deicing/anti-icing operations: (1) elimination of glycol-based fluids through the development of an environmentally benign alternative fluid; (2) minimization of the volume of fluid applied to aircraft through the development of better fluids, improved application methods, and innovative aircraft deicing technologies; (3) development of collection and disposal strategies that prevent the release of ADF-contaminated wastewater to the environment; and (4) development of glycol recycling methods.

Approaches to pollution prevention for airfield pavement deicing/anti-icing operations include: (1) adoption of alternative pavement deicing/anti-icing chemicals that are less harmful to the environment; (2) reduction or elimination of pavement deicing/anti-icing chemicals through the implementation of alternative deicing/anti-icing technologies; and (3) minimization of the amount of agents applied through the use of good maintenance practices, preventive anti-icing techniques, and runway condition monitoring systems.

Airports are required to obtain permit coverage for storm water discharges from vehicle maintenance, equipment cleaning operations, and airport deicing operations. Airports must develop and implement Storm Water Pollution Prevention Plans (SWPPPs) that include the following elements: Description of potential pollutant sources and a site map indicating the locations of aircraft and runway deicing/anti-icing operations and identification of any pollutant or pollutant parameter of concern; Description of storm water discharge management controls appropriate for each area of operation; Consideration of alternatives to glycol- and urea- based deicing/anti-icing chemicals to reduce the aggregate amount of deicing chemicals used and/or lessen the environmental impact; Evaluation of whether deicing/anti-icing over-application is occurring and adjustment as necessary; Employee training on topics such as spill response, good housekeeping, and material management practices for all personnel that work in the deicing/anti-icing area.

Olena Rudenko, assistant, Acja Solovejkina, researcher,
(National Aviation University, Ukraine, Kyiv)

NEW ECOLOGICALLY-SOUND ANTI-ACING LIQUIDS FOR AIRPORTS

Modern aviation transport demands a considerable quantity of ecologically-safe anti-acing liquids. Icing control at airdromes is made in the chemical way by means of preventive anti-acing liquids treatment of pavements.

In Europe solutions of chloride magnesium or crystal chloride sodium are used as anti-acing liquids.

The solution of chloride magnesium is a by-product of the potash industry. Economically it is substantiated, because liquidation of this by-product is considerably cost- and time-consuming.

Crystal chloride sodium is especially extracted. Crystal salts have such advantage - their use remains an airdrome pavement to be relatively dry.

In the Ukraine it is routine to use technical salts of sylvinite dumps as an anti-icing material. There are potash ores fields and mines in Prikarpatye, Kalush in Ukraine. It is cheap and readily accessible raw material.

Liquids on the basis of salts of alkaline metals, salts of alkaline-earth metals, acetates, inorganic and organic acids are broadly described in the patent literature as anti-acing means.

In the American patents liquid and solid anti-acing means on the basis of salts carboksylic alkaline metals, chlorides of alkaline metals are described. There are combinations of several salts in combination with compounding materials for different function.

Instead of chlorides, which negatively operate on aerodrome pavements (runway, taxiways and apron, etc.), it is better and, in some cases, necessary to use other substances, the first requirement for which is that they need to be ecologically safe.

Anti-acing means while thawing penetrates to ground; therefore they should meet requirements of biological safety for people, animals and plants. The basic requirement for such kind of anti-acing means is ability to thaw ice and snow rapidly. It is very important to consider that anti-acing liquids should not operate aggressively on metal parts of planes and the equipment.

Currently at National Aviation University on the basis of Chair of Safety of Human activities the scientific working group is engaged in this problematic. There have been made samples of new special liquids on a basis of least ecologically dangerous compounds. These are carbonates, acetates of alkaline metals, glycerin, propilenglycol. It is possible to add them in a mix of anticorrosive compounding materials.

To develop given solutions of composite mixes the technical characteristics of initial raw materials and methods of its preparation for use have been defined. The optimum qualitative and quantitative structure, temperature and technological parameters of processes have been defined. Also performance monitoring point during all stages and final point of control and observation, some indicators of compounding materials mix were fulfilled. Physical properties and chemical properties of compounding materials mix have been studied.

According to preliminary results it became concluded that the developed specimens of anti-icing liquids satisfy requirements of efficient use concerning its physical and chemical properties and characteristics.

As advanced researches working group consider investigation of possibility and aspects of using such kind of liquids not only in the region of aviation, but also in other branches of national economy. It is possible both in the Ukraine and beyond its boundaries.

S. Madzhd, assistant, G. Franchuk, Professor, I. Smelskiy,
(National Aviation University, Kyiv)

MODELLING OF THE TOXICITY DEPENDENCE ON THE SUBSOIL WATER QUALITY IN THE AIRPORT AREA

Literature's analytical review has shown that increased attention is paid now to the studying of surface water in the territory of airports but such attention is still insufficient; no attention is paid to the studying of subsoil water which is polluted by the airports. It should be noted that multiple-vector cybernetic ecological models are created only for the limited number of simple ecosystems at present. Environmental state thorough observation шт. airport area is a complicated task, and it can be solved given the general task is split into several secondary tasks.

The object of this research is the studying of the air-transport processes effect on drinking water wells near the airports, creation of the subsoil water state database, statistical analysis of the results, making database analysis by way of mathematical methods and system working up for taking measures as to increasing subsoil water ecological safety in the territory of the airport.

Hydrochemical methods have been used to analyze water environment quality; toxicity level has been determined by way of biotesting methods. For the assessment of relative water toxicity level laboratory culture *Daphnia magna* has been used recommended by the national standard documents. For the drinking water analysis *Daphnia magna's* death rate during 48 hours was taken as Y effective index (%). X factor index values are: X1 – petroleum product content, mg/dm³; X2 – oxidation index, mgO/dm^3; X3 – phosphates content (PO_4^{3-}), mg/dm³; nitrite content (N/NO_2^-), mg/dm³; X5 – distance to the wells from the runway, m.

Calculation table 1 and picture 1 show aggregate characteristics of the comparative correlation and regression analysis of the polluting substances effect on the toxicity level of the drinking water wells in the affected area of the air-transport processes.

Table 1

Initial characteristics of the polluting substances effect on the toxicity level

Y, %.	X1	X2	X3	X4	X5
23,0	0,70	16,60	0,80	12,00	20,0
21,0	0,60	22,20	0,70	16,00	250,0
20,0	0,40	20,60	1,10	13,70	500,0
14,0	0,30	26,90	0,56	19,00	1000,0
17,0	0,30	15,00	0,60	7,70	1500,0
Partial correlation coefficients	0,8015	0,2461	0,3106	0,0772	0,6724

The aggregate effect of the drinking water factor indexes on the percentage of the experimental testing objects death rate can be described as a multiple model correlation where equation coefficient is shown in Table 2.

Table 2

Coefficients of the drinking water multiple regressions

X5	X4	X3	X2	X1	b
-0,045741	1,361247	1,092321	0,742135	0,043711	26,71523

Thus, we have the following model equation Y = 0,043711*X1 + 0,742135*X2 + 1,092321*X3 + 1,361247*X4 - 0,045741*X5 + 26,71523.

The analysis of the influence degree of the drinking water toxicity level on daphnids' death rate presented on the basis of the multiple regression coefficients' comparison has shown that heavy metals and petroleum products have the biggest impact on the testing objects' death. Multifactor correlation model that has been created to test subsoil water in the affected area of the air-transport processes is shown in Table 3.

Estimated adequacy of the developed model according to Fisher criterion which is 7.38 according to the results shown in Table 3 and which is more than 1.7 tells that the developed model corresponds to the research process. Model's precision is estimated in Table 3 by way of quadratic coefficient of determination R2=0,9664 and multiple correlation coefficient which is 0,8421. Proximity of these coefficients to the figure of one tells about considerable precision of the developed model. Graphic illustration (Figure 1) of the modeling results and actual data comparison shows that modeling corresponds to the processes under study to a great extent.

Table 3

Multifactor correlation model of the drinking water tests

Water model	X1	X2	X3	X4	X5
Correlation coefficient	0,84214755	0,7452154	0,412741	0,81215031	0,1012456
Estimated precision according to the average quadratic inaccuracy	1,98545655	12,145869	2,1565712	5,1475845	10,780124
Relative inaccuracy, %	0,421	1,512	0,543	1,184	1,651
Estimated certainty according to Fisher criterion	7,38	2,02	6,98	1,74	1,04

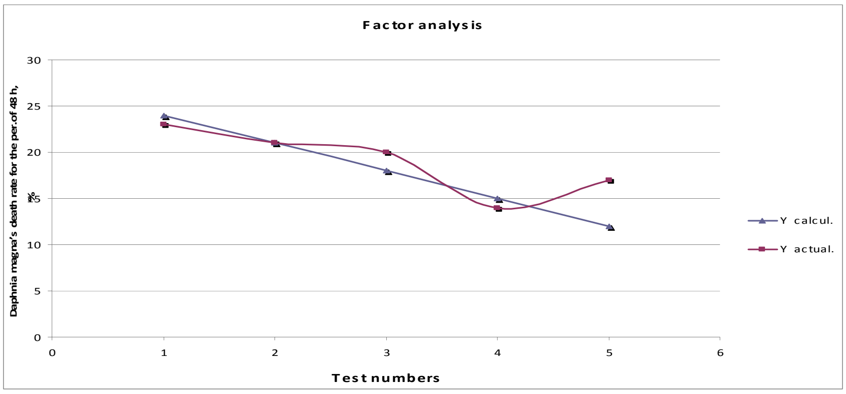

Figure 1. Modelling of the aggregate effect of the drinking water factor indexes on the crustaceans' death rate

The results of the elasticity coefficient calculations for the subsoil water taken in the affected area of the air-transport processes are shown in Table 4.

Table 4

Elasticity coefficient indexes of the subsoil water tests

Elasticity Coefficient Indexes	X5	X4	X3	X2	X1
	1,427	0,054	0,057	4,125	1,431

Elasticity coefficient X1: $E1_{water}$ = 1,431%, i.e. when X1 changed to 1% (oil carbohydrate, mg/dm^3), Y (Daphnia magna's death persentage) increased to 1,431%. Elasticity coefficient X2: $E2_{water}$ = 4,125%, – when X2 (oxidation index, mgO/dm^3) changes to 1%, Y increases correspondingly to 4,125%. Elasticity coefficient X3: $E3_{water}$ = 0,057%, – when X3 (Pb, mg/dm^3) changes, Y will increase to 0,057%. Elasticity coefficient X4: $E4_{water}$ = 0,054%, – when X4 (N/NO_2, mg/dm^3) changes to 1%, Y will increase accordingly to 0,054%. Elasticity coefficient X5: $E5_{water}$ = 1,427%, – when X5 (distance to the wells, m) changes to 1%, Y will increase to 1,427%. Summarized elasticity E for the drinking water ΣEi = 7,094%. Thus, when all X for the drinking water change simultaneously to 1%, Y will increase accordingly to 7,094%.

The majority of factor indexes for all environment constituents have correlation coefficients more than 0,67 and that proves the fact that indexes under study are closely connected. Regression equation coefficients show complete change of Daphnia magna's death percentage with the corresponding factor index change to 1 and others remain unchanged. Variation coefficients of the binate models for the drinking water are almost identical and they are following (according to factors' numbers): 29,37; 31,14; 30,07; 29,96; 32,37, i.e. they are less then 33% and that indicates to the fact that the information under study is homogeneous enough.

Yanovskiy L.S., Professor, Baykov A.V., Varlamova N.I.
(Central Institute of Aviation Motors, Moscow, Russia)

AVIATION ENERGETIC UNIT BASED ON FUEL CELLS WITH THERMOCHEMICAL HEAT REGENERATION

The report represents new opportunities of efficiency increase of aviation power units with fuel cells on board of aircraft. It is shown that application of the solid oxide fuel cells (SOFC) with membranes for gas-synthesis generation from liquid fuel is the most suitable technical proposal for aviation. Autothermal reforming with water adding or power unit exhaust gases can be used for the gas-synthesis generation. MEMS technology with nanotechnology for catalytic nanoparticles penetrating on internal surface of the membrane channels can be used for the membrane manufacturing.

The report results experimental data confirming opportunity of thermochemical heat regeneration in SOFC unit with gas-synthesis generation from liquid hydrocarbon fuel. Results of theoretical analysis show that high efficiency of the process can be obtained by combination of membranes generation with SOFC in common electrical generation channel. In this case efficiency of the combined power unit with SOFC and gas turbine unit can exceed 80%. The report contains estimations of the mass and dimensional characteristics of perspective power unit with SOFC in comparison with traditional sources of electrical energy for passenger aircraft such as B–787 ("Dreamliner").

Sergiy Boychenko, Professor,
Olexandr Aksyonov, Correspondent member of Academy of sciences of Ukraine, Professor,
National Aviation University, Ukraine, Kyiv, Ukraine

THE PLACE AND THE ROLE OF CHEMMOTOLOGY AS A SCIENCE IN THE GENERAL SYSTEM OF KNOWLEDGE

Development of all types of technical equipment is necessarily followed by the rise of their endurance capability and infallibility in-process. Fuels are energy sources for engines and machines, and lubricants are means of friction decrease and device deterioration; technical fluids are substances used for absorbing (depreciations) or transmission of energy from its source to the place of use or into the environment in machines and devices .

Improvement of engines, machines and devices is impossible without the improvement of operational abilities of fuels, lubricants and technical fluids in-use.

Therefore in economy there not only a continuous rise of fuel and lubricant consumption volume is observed bu, also a rise of demands to their quality and improvement of major characteristics.

The number of problems resulted in the development of a new scientific branch, a new scientific direction – chemmotology. The appearence of the new scientific direcrion dates back to 1964. The founder of chemmotology is professor **Konstantin Karlovich Papok**.

Chemmotology is on the edge between fundamental sciences and is based upon them; those include physics; organic chemistry, physical chemistry, colloid chemistry, energetics, thermodynamics, technology, mathematical science, economics, ecologym ergonomics and others. A term "chemmotology" has been formed out of "chemistry", "motor", and "logos" terms.

At present chemmotology is a theory and practice of rational use of fuels. lubricants and technical liquids. Chemmotolgy creates the necessarily "basement" for providing the optimal conditions of fuel deployment, modern qulaity of fuel requirements, and efficient fuel use in technics. The generalized function of oil products utility as the ones of civic utility products can not be described by some amount of corresponding engineering documents and charts (as opposed to the generalized function of transportation devices utility). This principle difference between oil products and machinery products objectively induced a science of chemmotology and partly tribotechnics appearance.

The general scheme of bonds between development stages, quality assessment producing, multi-stage testing and the use of fuel and lubricating materials and techincal liquids is as presented on chart # 1.

The successful solving of this problem is only possible under two conditions: oil products of appropriate quality choice; their correct and think-through use.

For example, the decrease of temperature of automobile gasoline boiling end point from 225^0C to 200^0C causes 5-8 % of gasoline economy with simultaneous 2-3 times engine wear decrease.

The more complicated machine is, the more strict and many-sided requirements to the quality of fuel, lubricating materials and technical liquids there are. Their quality was characterized in the technical standards set for aviation fuels by only two factors: density and fractional composition. There are more then 10 of them today.

The universal four-chain chemmotological system representing the meaningful structure of chemmotology exists in any kind of technics and machinery that use fuels (chart #2). This system includes the mutual connection between the quality of fuels and lubricating materials, equipment reliability and its operational conditions.

A professional labour activity of specialists oriented on oil refinery, organization of trade products storage, transportation and distribution, and ensuring the correspomdense of properties of fuels and lubricating materials with engine and machinery working conditions with the goal of producing the maximum technical, economical, ecological and social effects, is called the **use** of fuels, lubricating materials and technical liquids.

To know fuels, lubricating materials and technical liquids is to have have a clear understanding of interdependence of quality characterizing parameters and physical, chemical and energetic processes occuring during their use under definite conditions, and, also, the interdependence with their chemical and group constitution. The knowledge of engineering means not only the knowledge of construction, kinematical, dynamic and temperature characteristics but also the knowledge of physical and chemical properties of constructing materials essential for analysis and forecasting of physical and chemical processes during the use of particular fuel or lubricating material. The lack of this kind of analysis and forecasting creates conditions of impossibility of solving the problem of fuels and lubricating materials with the maximum effect use.

Theoretical basement for an efficient and rational use of fuels and lubricating materials is in the development of a general theory and the determination of rules connecting together their quality, reliability, economy and efficiency of machinery operation; substantiation of optimum quality requirments; new sorts choise (or development); sorts unification; providing quality preservation; physical, chemical, operational and ecological properties in the processes of storage, transportation and distribution research; specific costs and fixed losses decrease; the shrotening of quality control works; methods of qulity regeneration development; the solving of problem of interchange of fuels and lubricating materials sorts of different producing countries; the development of methods and systems for the test of operational properties and quality parameters determination; the effect of the "engine – fuel - lubricating materials - technical liquids" system (chart #3) environmental protection.

The determination of the general rules that reflect the inderdependence of fuels, lubricating materials and technical liquids properties with longevity, reliability, economy and ecological compatibility of technics operation is one of the most important problems of chemmotology.

The processes of interdependence and intercation of chemmotological system chains (see chart #2) are the main objects for research and the essence of chemmotology.

Operational properties of fuels, lubricating materials and technical liquids are the subjects of chemmotological research.

The task (problems) of chemmotology are the following:

1. optimization of fuels, lubricating materials and technical liquids quality;

2. increase in efficiency of fuels, lubricating materials and technical liquids use;

3. creation and improvement of a system and methods for fuel quality assessment.

The main ways of these problems solving are:

1. increase in sources of different oil fuels;

2. decrease of the expenditure of fuels in engines and nonrecoverable losess during technological processes with fuel operation "from the dwell tot the gas station";

3. use of alternative fuels.

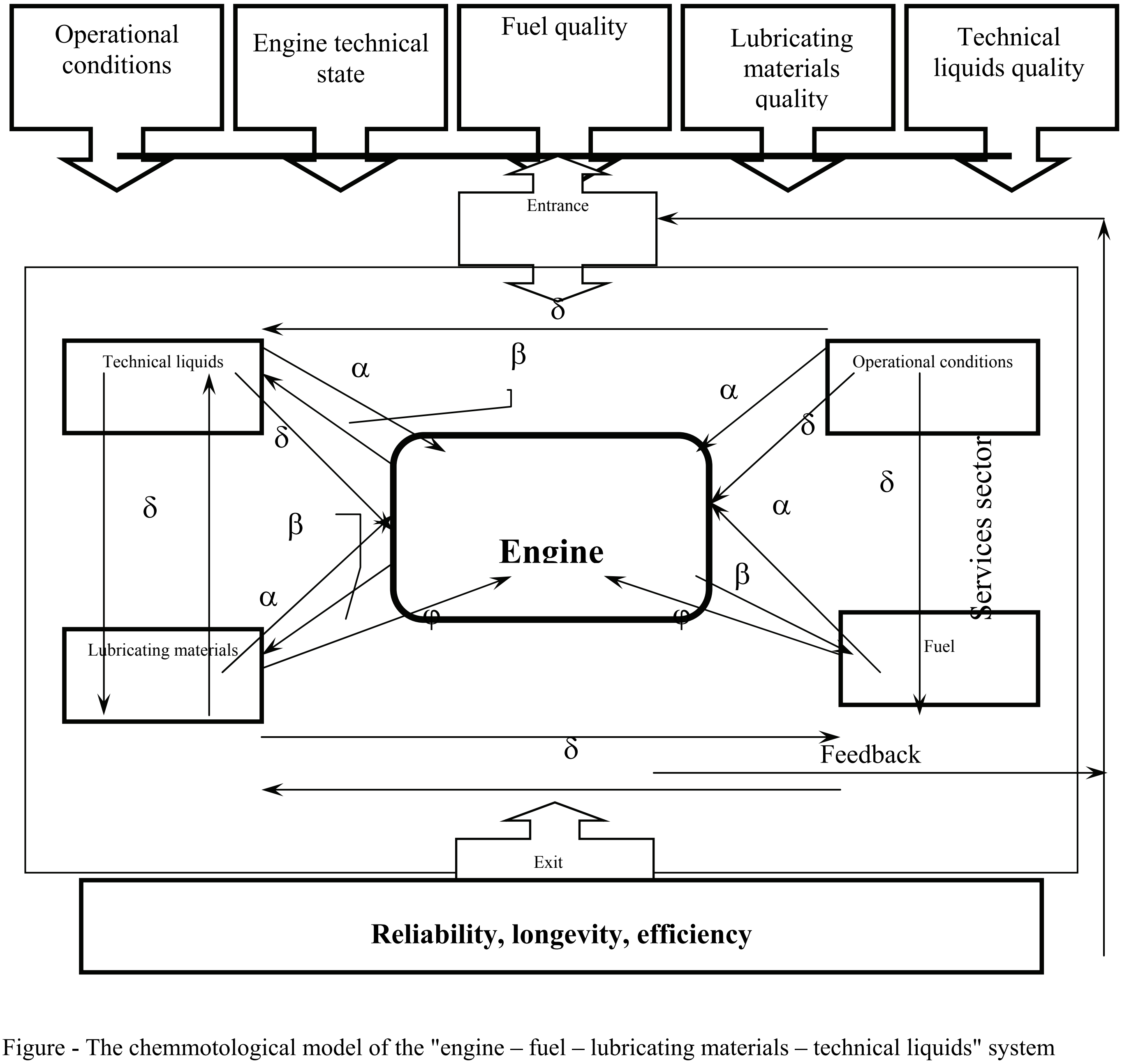

Figure - The chemmotological model of the "engine – fuel – lubricating materials – technical liquids" system functioning during the transportational devices operation:

α – fuel, lubricatin material, technical liquid impact on engine operational characteristics;

β – engine requirments for fuek. lubricating material or technical liquid quality;

δ – operational conditions influence on engine characteristics, fuel, lubricating material or technical liquid quality; φ – fuel-lubricating material or technical liquid influence on engine efficient operation.

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Chernyak L., Akinina K. National Aviation University, Kyiv, Ukraine

QUALITY AND ECOLOGICAL SAFETY OF AVIATION FUELS

Analyzing of fueling situation in transport section such conlusion can be done, ecologically-energetic problems of such branch has to be solved in one complex system «human – environment – fuel – trnasport».

Energy ecological problems and aspects of its rational development are very urgent today (Fig. 1).

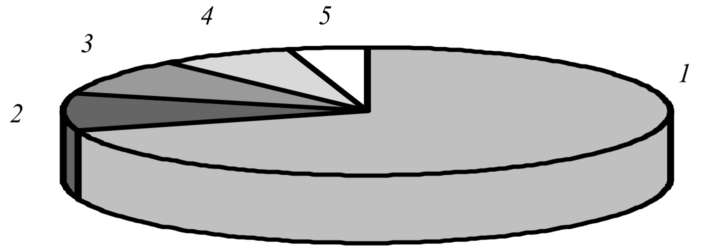

Figure 1 - Harmful substances emission balance during transport exploitation: *1* – automobile transport (70 %); *2* – agricultural (9,4 %); *3* – railway (9,2 %); *4* – air (7,3 %); *5* – water (4,1 %).

Fuel for transport engines is well-known toxically harmful substances, which can cause industrial injury, diseases or health problems of people who work in specific area. Environment pollution by oil products is caused by its evaporation or leakage and fuel combustion emissions into atmosphere during engine working.

High atmospheric air quality providing is one of the most important aspects. Ukraine with other industrialized countries signed and performs Montreal protocol (1988) about ozone depletion protection, Convention of Organization of United Nations at New-York (1992) about climate change and Kiyoto Protocol (1997), which assigned decreasing of harmful substances emissions to the whole country and separately to each branch of economy, where energy is individual part. The main goal is to prevent global consequences from carbon dioxide and other emissions, which cause ozone depletion. Requirements for harmful substances emissions regulate by rule 49 EEC OUN and directive 88/77 EU (Table 1).

Table 1

Regulations for transport ecological compatibility

Directive EU and rules EEC OUN	Harmful substances emissions, g/кw			
	CO	CH	NO_x	Particular matter
Rule 49 EEC OUN	14,0	3,5	18,0	—
Directive 88/77 EU	11,2	2,4	14,4	—
Euro-1 (from 1993)	4,5	1,1	8,0	0,36
Euro-2 (from 1996)	4,0	1,1	7,0	0,15
Euro-3 (from 1.10.2000)	2,0	0,6	5,0	0,1
Euro-4 (2003–2005 years)	1,5	0,5	3,5	0,08
Euro-5 (2006–2009 years)	1,0	0,5	2	0,05

European countries from the year 2000 implemented new specification on automobile petrol's. Ecological requirements to European automobile petrol according to EN 228 specified benzol content decreasing from 5,0 to 1,0 % rev., and total aromatic hydrocarbons from 42,0 to 30,0 % rev.

These requirements reflected in european standards of series Euro-2, 3, 4, 5 (Table 1), requirements of World Charter of fuel producers and Directive of European Union 2003/17/EU (instead of Directive 98/70/EU), assigned ecological requirements to fuels (Table 2). Automobile transport development perspectives are very broad, which indicates level of anthropogenic influence increasing on atmospheric air purity, flora and fauna. Diesel fuel producing and consumption is increasing with parallel automobile petrol large volume producing. Diesel transport is one of the main sources of environmental pollution by sulfur oxides, nitrogen, soot particles and toxic aromatic hydrocarbons. Aviation engine fuel production is one of the most developing branches in oil refining industry of the world.

Table 2

Ecological requirements for petrol
(Directive of European Union 2003/17/EU)

Parameters	Unit	Limits	
		Min	Max
Octane number - research method - motor method		 95 85	 - -
Vapor pressure, summer period	kPA	-	60,0
Distillation: - % evaporation at 100 °C - % evaporation at 150 °C	 % v/v % v/v	 46,0 75,0	 - -
Hydrocarbon analysis: - olefins - aromatics - benzene	 % v/v % v/v % v/v	 - - -	 18,0 42,0 1,0
Oxygen content: Oxygenates - methanol (stabilizing additives) - ethanol (stabilizing additives possible) - iso-propyl alcohol - tret-butyl alcohol - iso-butyl alcohol - ethers containing five or more carbon atoms per molecules - other oxygenated	% m/m % v/v % v/v % v/v % v/v % v/v % v/v % v/v	- - - - - - - 	2,7 3 5 10 7 10 15 10
Sulphur content	mg/kg	-	150
Lead content	g/l	-	0,005

Automobile emissions contain more then two hundred types of toxic elements, such as: carbon oxide, nitrogen, sulfur, heavy metals, carcinogens and mutagens, hydrocarbons, aldehyde, aerosols, sulfurous anhydride, etc. (Table 3). Every year automobile imbibe 4350 kg of oxygen from atmosphere, and emitted 3250 kg of carbon and 530 kg carbon monoxide, 90–150 kg unburnt hydrocarbon, 40 kg nitrogen oxide, up to 1 kg of lead. Also 96% carbon oxide, 30% nitrogen oxide, 68% hydrocarbons are emitted into atmosphere through exhaust pipe of automobile. Wrong exploitation of transport can be the reason for toxic substances emission increasing CO, C_nH_m – up to 25–30%, NO_x – up to 15%.

Intensity of harmful substances emissions by one diesel locomotive is an analog to 15–20 trucks or 40–60 automobiles. One aircraft ТУ-154 during take off and landings is emitting into the atmosphere 100 times more harmful substances then car. 2-4 mg/min of carcinogenic substances (benzopiren) is emitted into atmosphere during the work of turbo jet and turboprop engines. Air plane is emitting 3,7 t carbon oxide, 2 t hydrocarbons (unburned fuel) and 1,7 t nitrogen oxide per day by take offs and landings. In 1985 world aviation emitted into atmosphere more then 1,2 (100) mln tones of CO, 0,8 (25) mln tones CH, 1,4 (15) mln tones NO.

Table 3

Specific loss of petrol and diesel engine

Harmful substance	Specific loss, g/kg fuel	
	Petrol engine	Diesel fuel
CO	37,8	20,8
NO_x	21,0	41,0
CH	30,0	10,5
Particular matter	1,5	7,6
SO_x	1,5	5,6
Aldehyde	0,93	0,78

Hydrocarbons are the most harmful substance, which pollute atmosphere and have dangerous impact on human. Hydrocarbons are indicators of carburetion and combustion process poor organization or major lack of air in engine fuel mixture. Tetraethyl lead (TEL) $(C_2H_5)_4Pb$ and tetra methyl lead (TML) $(CH_3)_4Pb$ are very toxic components, used for petrol octane number increasing contains lead. For removing of combustive products effluxes are used (lower bromide, chloride); decrease lead content in 3-5 times in combustive chamber. It means that 90-98 % of lead contained in ethyl petrol is emitted in atmosphere. Lead forms aerosols with automobile gases, which absorbed by lungs with air and stored with food and water in stomach and causes disorder central nervous system, fainting, injury of liver, kidney, decreasing of vision, genetic disfunction. Because of definite element toxicity most countries forbid its content in petrol’s and require automobile exploitation on non-ethylene petrol.

Another reason of atmosphere contamination – is fuel evaporation during transportation, storage, technological discharge operations, loading, refueling and from transport fuel systems. From all types of losses this one have class «irretrievable», part of them protected and regulated by oil products losses (kg/t) according to “Norms of oil products natural loss during storage, distribution and transportation” reflects natural loss of various types of oil products in different technological operations.

To realize statements of Kiyoto protocol and used article 2 (iv and vii, IPCC method) we have done calculation of greenhouse gases into equivalent of CO_2. Initial data is daily emissions from regular refueling station in amount of 60 kg particular volatility organic compounds (VOC); we have to consider potential of global warming defined by 100 years term. Emissions on such term are 2 160 000 kg. Transferring of received amount of VOC into CO_2 (in regard to potential of global warming indexes for CH_4, that at UNFCCC evaluation is 23) we got 0,00506 Tg equivalents to CO_2.

Conclusion

Analysis shows to solve ecologically energetic problems of energy, connected with transport exploitation and motor fuel application, optimal complex approach applied to system «human – environment – fuel – transport», granting all technological chains specifications from the moment of oil extraction to product transformation of unburnt gases and fuel.

Main directions of ecologically energetic problem solving of system «human – environment – fuel – transport» are: 1) motor fuel quality increasing with ecologically safe characteristics; 2) engine construction improvement with purpose of combustion efficiency and harmful substances emission transformation in unburnt gases increasing; 3) alternative fuels application; 4) environmental procedures on the object of oil products complexes, system of transportation, refueling stations, petroleum storage depot; 5) organizational procedures including harsh regulations (standards), which control harmful substances emissions in unburnt gases and volatile hydrocarbons, which evaporate into atmosphere.

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Oksana Vovk, Assistant Professor,
Kseniya Akinina, Student, National Aviation University, Ukraine, Kyiv,
Natalia Shevchuk, Assistant Professor, NTUU «Kiev Polytechnic Institute»

PET-BOTTLES RECYCLING TECHNOLOGY AS A WAY OF WASTE MINIMIZATION

Recycling of PET Bottles is the activity whereby bottles made out of PET are collected, sorted and processed in order to reuse the material out of which they are made. In many countries, PET plastics are coded with the number 1 which is found inside the universal recycling symbol, usually located on the bottom of the container.

Polyethylene terephthalate (sometimes written poly(ethylene terephthalate), commonly abbreviated PET, PETE, or the obsolete PETP or PET-P), is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers; beverage, food and other liquid containers; thermoforming applications; and engineering resins often in combination with glass fiber. It is one of the most important raw materials used in man-made fibers.

PET is used as a raw material for making packaging materials such as bottles and containers for packaging a wide range of food products and other consumer goods. Examples include soft drinks, alcoholic beverages, detergents, cosmetics, pharmaceutical products and edible oils. PET is one of the most common consumer plastics used.

The empty PET packaging is discarded by the consumer after use and becomes PET waste. In the recycling industry, this is referred to as "post-consumer PET." Many local governments and waste collection agencies have started to collect post-consumer PET separately from other household waste. The collected post-consumer PET is taken to recycling centres known as materials recovery facilities (MRF) where it is sorted and separated from other materials such as metal, objects made out of other rigid plastics such as PVC, HDPE, polypropylene, flexible plastics such as those used for bags (generally low density polyethylene), drink cartons, and anything else which is not made out of PET.

Post-consumer PET is often sorted into different colour fractions: transparent or uncoloured PET, blue and green coloured PET, and the remainder into a mixed colours fraction. The emergence of new colours (such as amber for plastic beer bottles) further complicates the sorting process for the recycling industry.

This sorted post-consumer PET waste is crushed, pressed into bales and offered for sale to recycling companies. Transparent post-consumer PET attracts higher sales prices compared to the blue and green fractions. The mixed colour fraction is the least valuable. Recycling companies will further treat the post-consumer PET by shredding the material into small fragments. These fragments still contain residues of the original content, shredded paper labels and plastic caps. These are removed by different processes, resulting in pure PET fragments, or "PET flakes". PET flakes are used as the raw material for a range of products that would otherwise be made of polyester. Examples include polyester fibres, a base material for the production of clothing, pillows, carpets, etc., polyester sheet, strapping, or back into PET bottles.

Worldwide, approximately 1.5 million tons of PET are collected per year. Petcore, the European trade association that fosters the collection and recycling of PET, forecasts that in Europe alone, collection will exceed one million tons by 2010.

UDK 66.040.27: 628.4.032 (045)

Vlasyuk I., Student, Akinina K., Student,
National Aviation University, Ukraine

TECHNOLOGY OF THERMAL PROCESSING OF SOLID DOMESTIC WASTES

Problem of solid domestic wastes (SDW) is very relevant,decision of normal vital functions providing to population, sanitary cleaning of cities, guard of environment, related to the necessity and energy saving.

Utilization of biomass in many countries of the world is one of the leading directions in energy receiving from renewable sources. The volumes of biomass power potential is about 22 million tons/year, from which technically accessible power potential is estimated in 13,2 million tones/ year which makes near 7% of general consumption of primary power resources in Ukraine in 2005 year.

Every day family from three-four persons throws out the bucket of garbage on the average. Thus on every inhabitant of our city there are approximately 100 buckets or 180 220 kg of solid domestic wastes per year. To this amount of SDW follows to add wastes, which appear in shops, hotels, on the stations, markets and in other public places, their amount makes cities from 30 to 50 percents of all of domestic wastes. Presently in the cities of our country more than 40 million cubic meters accumulate for year only domestic garbage, which makes approximately 27 million tones of solid domestic wastes which are taken out on 770 grounds of SDW, and the general volume of their accumulation arrives at 3 milliards of m3.

According statistic only about 4% of wastes utilize in Ukraine. It is result of the origin of so-called petroleum acid-tar lakes, which poison environment and inhabitants of villages which are located near disposal tip.

As an analysis shows, there is no universal method of SDW utilizing, what would satisfy modern ecological and economic requirements. Most acceptable is combined method. Exactly the complex processing SDW, which includes sorting, heat treatment, fermentation and other processes, provides maximal ecological and economic efficiency. In Ukraine methods of the complex mechanized processing of SDW with the purpose of basic scrap components exception in practice so far are not realized.

Method of heat treatment of wastes is used at incineration factories allow to decrease their amount in 3 times, but toxic emission in an atmosphere, muddy flow water, appear at incineration, and slags and ash are more toxic, than SDW, and need the subsequent special treatment. On the grounds of burial place of SDW in Ukraine plenty of second raw material among which paper accumulates annually - to 2,7 million tones, black metals - to 405 thousand of tones, coloured metals, - to 27 thousand of tones and plastic - to 450 thousand of tones, which potentially can be withdrawn the mechanized method and reutilizable. The cost of this second raw material makes an about 1 milliard of UAH.

Unfortunately, to this day there is no unique system of regulating documents for SDW and wastes equated with it. To this day degree and class of danger of SDW is not certain depending on components which are contained in it. Control the system SDW in Ukraine is in the engendered state. Basic directions of activity are certain Laws of Ukraine "On the guard of natural environment", "About wastes".

Now there are five methods of utilization of SDW: an export in dumps; incineration of garbage; processing is biofermentators; pyrolysis is after the chart of decay/burning; electro-pyrolysis.

Ground burial place of domestic wastes, which is practiced in our country, is not decision of problem. Garbage is taken out on city dumps is laid out, products methane, literally poisoning people life. Not by chance Euro commission gave out Directive which forbids in Europe from 2010 year fully to give up ground burial place, but in July, 2002 Euro parlament made decision to examine biomass from SDW and industrial wastes as renewable energy source. The method of fire incineration of SDW is utillized in world practice.

With hard requirements to the norms of emissions into atmosphere of incineration products and pyrolysis after the chart of decay/burning incineration factories became unprofitable everywhere. The cost of cleansing buildings is high, and without them plenty of toxic matters is thrown out into atmosphere. Protocol completes the action of Kiotskiy in 2012 years.

Thus, from five methods of wastes utilization of introduction prospects in the real life have methods which utillize technological processes absolutely isolated from an environment, and it is processing in biofermentators for insignificant volumes in rural locality and in high-energy electrical pyrolysis. Electro-pyrolysis is flameless method of wastes processing, and its advantage, — above all things in prevention of contamination of environment. Electro-pyrolysis does not abandon after itself biologically active matters, a well-educated ash has a high closeness which diminishes its volume sharply, at pyrolysis there are no emissions of heavy metals in an atmosphere. Easily to keep the products after pyrolysis and transport, and for work of equipment which carries out pyrolysis, the heavy tolls of energy are not needed, and all of process on the whole needs less capital investments.

From the other side, SDW is valuable raw material for the receipt of alternative types of fuel. Therefore, development of deserving replacement is unrefurbishable energy sources an relevant task.

Analysis results of SDW utilization methods that application in electro pyrolysis will allow fully decide the problem of urban wastes with simultaneous receipt of chemical raw material which provides profitability of SDW processing comparing to another ways.

Synthesis-gas got in the electroarc reactor of SDW processing is free of sulphur admixtures which it gives as to chemical raw material, considerable advantages in comparing to fossil chemical raw material and to send expedience in the fluidizers of organic synthesis production of chemical products which have the wide use in national economy, or at options of direct receipt of electric power in fuel elements. Thus the depth of feedstock processing considerably anymore than in the methods which are the mortgage of receipt of universal high-quality chemical raw material known on this time.

Thus, summarizing job performances, it is possible to draw conclusion, that on this time there is technology of processing of solid domestic wastes, which is able in root to change city environment from saturated garbage on an environmentally clean environment of life of city inhabitants.

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M.M. Radomska (National Aviation University, Ukraine),
V.D. Myndyuk (National Technical University of Oil and Gas, Ukraine),
G. Franchuk(National Aviation University, Ukraine)

ENVIRONMENTAL SAFETY OF AIRPORT FUEL SUPPLY SYSTEM

The article contents the environmental impacts analysis of major airport objects, in particular fuel supply service. The main source of environmental pollution related to these objects is considered to be products losses within the linear part. The most important causes of pipeline failure and leakages are defined as well as non-destructive methods applicable to control fuel transportation system integrity.

The main sources of environmental danger within an airport is buildings and structures of aircraft technical maintenance, ancillary facilities (warehouses, garages, heating plants and etc.), hangars, runways and fuel and lubricating materials (FLM) storages. All the above mentioned sources affect the environment via air emissions and household and industrial wastewaters discharges and only FLM storages bring specific contamination with light petroleum products and lubricating materials to the environment.

The principal reason of environmental pollution caused by FLM storages is the loss of hydrocarbon materials, which takes place during transport operations and exploitation of imperfect equipment. The volumes of acceptable losses are limited by regulative acts and on the whole depend on the period of year, type of works and type of the equipment used in given production processes, fuel composition and means of its delivery to storage. Considerable amount of FLM is lost as a result of violation of technical regulations for tank loading operations, in the process of fuel transport, storage in reservoirs, reservoirs cleaning and unloading. These losses can be avoided by installing closed fuel vapors circulation systems, following technical safety rules, and due time technical maintenance. Apart from exploitation losses certain amounts of fuel stored in the reservoirs are lost as a result of failures, contributing to soil, underground and superficial waters pollution, as well as indirect atmosphere pollution. The installation of modern reservoir equipment and safe double-wall reservoirs minimizes probability and potential consequences of such losses. Nevertheless, if there is a pipeline 20 km long, which transports 10000 tones of kerosene per month, it releases to the environment 0.35 t at the ejection point, 0.22 t at the main and 0.23 t at the intermediate pumping station and 0,075 at the delivery point, this means 0.875 t of kerosene lost within the system.

Thus, the linear part of any FLM service, which is used for pumping fuel over the airport territory, turns to be one of the basic sources of pollution. The losses take place through leakages and vapors on the pump stations and piping system. The use of metallic compressions and the „pump in a pump" pumping method reduces the losses by more than 60% [1]. The FLM losses occur directly in the pipeline linear part through the compression of bolts and compensates, as a result of failures, and also through the openings of isolation, which arise up under the influence of corrosion. The systematic failures caused by reduction of thickness and perforation of pipeline walls are typical during the exploitation period. Although the losses of FLM through the openings are insignificant in separate areas of pipelines, the overall volumes may reach 50% of general losses for the whole pipeline. Research shows that the second most important reasons of pipeline failures is corrosion and defects of structures and materials - 15 and 18% accordingly (external influences count for 50% of common amount and soil changes and errors of exploitation – 5-6%) [2]. Therefore definition of crippling reasons and conditions, determination of leakage points, their estimation and localization are the most important tasks on the way to airport pipeline systems environmental safety enhancement.

A range of factors influences the impermeability of pipelines. Metallic pipelines of airports are laid underground in thin isolating sleeves, therefore seasonal soil temperature and humidity changes influence them adversely. The pipeline surface expands under the influence of heating and diminishes when cooling. It results in the origin of pipeline material fatigue, which shows up especially strongly in the places of welds and knees. The additional pressure is created by twisting and bends caused by changes of external environment (slides, washout etc.). Soil acidity and alkalinity also adversely affect the condition of pipe insulation and results in formation of insignificant cracks, which enables pipeline contacts with the surrounding soil and leads to pipe walls corrosion in the place of contact.

All the above mentioned factors cause cracks and openings formation, where intensive tensions, fatigue or corrosion are, and let the working body (petroleum product, kerosene, lubricants, technical liquids etc.) get into the environment. Parent metal break, dent with the break of pipe wall, through corrosive openings, local crack, parent metal circular crack, pipeline walls thinning, flange joint screw-bolts break are basic damages of pipelines linear part.

The study of underground pipelines exploitation conditions proved that their destruction was the result of compatible action of corrosive environment and repeated-variable loadings with relatively small frequency of recurrence [3]. There are two types of loadings typical for pipelines: static (single) and small-cycle (repeated-static). Destruction as a result of small-cycle loading starts with formation of fatigue cracks in the area of tensions concentration. As a rule, it takes place along the defects location. The most widespread concentrators of tensions are: spills, penetrations, welds strengthening and adjoining areas. It is set during researches, that the internal defects of welding diminish durability of welded connections by the factor of 3, and superficial defects - almost by one order. Working life reduction both at presence of internal and external defects takes place due to shortened period of cracks development.

The experiments show that the possible lost of fuel through the corrosion induced openings can account for 0.39 l/year for pipelines older than 3 years and 0.1 l/year for those which are less than 3 years old per each kilometer of pipeline. However the study dealt with the pipelines not older than 8 years, whereas pipeline systems of many airports are much older. In order to avoid significant environmental harm and losses of valuable material it is necessary to conduct periodic control of pipelines condition and remove the detected defects. The pipeline walls integrity control is carried out by the means of nondestructive control methods, which perform remote diagnostics without violation of pipe integrity.

Visual control is the simplest and cheapest method of damage location. Oil spots appear on the ground surface in the place of pipeline break. However, if this break is old, and pipeline diameter and pressure are considerable, the fuel spill can take considerable area and the exact localization of the break is impossible.

One of perspective control techniques is thermal nondestructive control. Pipeline, which lies underground and transports any material with temperature different from soil temperature, is the source of heat. It forms a temperature anomaly on the soil surface, which is registered by special devices (thermal imagers, radiometers). A lot of defects in pipelines (especially wall thinning and insulation openings) are also heat sources, which give additional temperature gradient. The use of special methods of temperature field analysis allows interpreting the underlying structure of controlled object and identification of thermal sources.

It is set, that the temperature rise on the surface of soil above a pipeline, caused by fuel flowing in it, can make a few degrees difference, and the temperature anomaly created by leakage can reach 2-3 times higher values, that is enough to define pipeline position and its defects, and also determine their parameters. Following the defect localization and its nature determination it is possible to define the amount of fuel, leaking out of the pipeline:

$$V = \frac{\int_S \text{б} \cdot (T(x,y) - T_{air})dS}{c \cdot c \cdot (T_p - T_{soil})} \qquad (1)$$

where T(x,y) - temperature of soil surface above a source; T_p - temperature of flowing product, T_{soil} - mean soil temperature, T_{air} - air temperature, c - heat capacity of soil, ρ - soil density, α - heat emission index of soil, S - two-dimensional area.

Using remote electromagnetic measurements it is possible to determine the current losses and transitional resistance of pipeline isolating coverage, which is a parameter of insulation integrity. All measurements of this kind are based on taking magnetic field strength, which appears as a result of current flowing within the underground pipeline. The analysis of current distribution enables determination of the locations with damaged insulation cover, as the testing current is lost at the point of any defect.

The acoustic methods of nondestructive control of pipelines are very popular as a result of being easy to do and highly applicable to different tasks, including pipelines impermeability control. There are 2 approaches to the use of acoustic methods of pipelines diagnostics. The first is the use of ultrasound to control welds and structural elements of pipelines, which are assembled, and the second is the location of defects by the sound of liquid leaking out of a pipeline.

Ambient (air and soil) temperature, soil humidity, presence of mechanical and electromagnetic interference sources, depth of pipelines affect accuracy of control techniques and possibility of their application. Therefore it is necessary to consider specific conditions in order to recommend research method for a certain air enterprise. On the whole, it is necessary to accept that the acoustic and electromagnetic methods of control can be applied after determination and taking into account the existent background noise level in the area of airports; the use of thermal methods is impossible, when temperature of soil is similar to the temperature of transported fuel.

Data obtained during defects detection are used to estimate remaining resource and its durability continuation. The procedure of pipeline capacity and remaining life estimation at presence of cracks or crack-like defects involves successive implementation of the following stages [4]: estimation of the area deformation mode; approximation of initial crack-like defect to the database of calculated defect analogues; calculation of relevant maximum (destroying) values of tensions and/or deformations; calculation of defect critical sizes for the current deformation mode; estimation of construction durability under the current set of defects; calculated and experimental prognosis of defects development rate and remaining resource of pipeline construction. This way the remaining pipeline working resource estimation for the area with corrosive defects includes such stages: calculation of wall thinning; estimation of mean corrosion rate; estimation of remaining life. The mean corrosion rate, v_{cor}, used here, is determined experimentally. Thus, the remaining pipeline life, that is an approximate duration of its safe exploitation, is determined as the time necessary for a pipeline wall to thin from an actual size, x_{act}, to the minimum permissible value, x, by the formula:

$$T_{life} = ([x] - x_{act}) / v_{cor} \qquad (2)$$

Similar algorithms are developed for pipelines with the defects of crimps, dents, cracks. Based on the total results of the analysis the following variants of decisions are made: continuation of exploitation without the change of the mode till the complete remaining working resource exhaustion or till the next term of inspection; exploitation under the lowered working pressure; exploitation suspension to conduct repair or replace defected area.

Airport fuel supply service poses considerable environmental impacts due to fuel lost within its facilities especially pipelines. The reason is that pipeline systems are subjected to intensive corrosion induced by different natural and technical processes, which result in local corruption of pipes. Non-destructive control techniques allow making prognosis about the decline of fuel pipelines working quality and thus prevent or help with fast localization of fuel leakages. This is the necessary condition of environmentally sound work of FLM service and enterprise on the whole.

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M.M. Zakharchuk, Student,
O.O. Vovk, Assistant of Professor,
N.V. Zakharchuk, Assistant, The National Aviation University

PROBLEM OF OBTAINING OF HYDROGEN FROM COAL

Many of the issues and technologies associated with making hydrogen from coal are similar to those of making power from coal. These subjects are closely linked and should be considered in concert - particularly with respect to clean coal technologies. These technologies will be required for making hydrogen, and they also offer the best opportunity for low-cost, high-efficiency, and low-emission power production. The lowest-cost hydrogen coal plants are likely to be ones that coproduce power and hydrogen.

Coal is a viable option for making hydrogen in large, central station plants when the demand for hydrogen becomes sufficient to support an associated, large distribution system. Ukraine has enough coal to make hydrogen far into the future. The major consideration is that, because of the high carbon content in coal, the CO_2 emissions from making hydrogen from coal are larger than those from any other conversion technology for making hydrogen. This underscores the need to develop carbon sequestration techniques that can handle very large amounts of CO_2 before the widespread implementation of coal to make hydrogen should occur.

Coal Transportation. If coal is to be a major source for future hydrogen production,

the infrastructure for delivering it to the future hydrogen plants will need to be expanded enough to handle these future requirements. Coal is a viable option for making hydrogen in large, central station plants when the demand for hydrogen becomes large enough to support an associated transport, storage, and distribution system.

Most bulk coal transportation is by rail, with trucks used for local transport. For reasons of economics, most of the world's coal consumption is in power plants located nearby coal mines, which minimizes the necessity for long-distance transportation. More than 60 percent of the coal used for power generation worldwide is consumed within 50 km of the mine site.

Environmental Impacts of Coal Consumption and Transportation. Using more coal to produce hydrogen will have a number of environmental consequences. Coal mining itself causes numerous environmental issues, ranging from widespread land disturbance, soil erosion, dust, biodiversity impacts, waste piles, and so forth, to subsidence and abandoned mine workings. Once coal has been extracted, it needs to be moved from the mine to the power plant or other place of use.

The main pollutants resulting from conventional combustion of coal are sulfur oxides (SO_x), nitrogen oxides (NO_x), particulates, CO_2, and mercury (Hg). SO_x is dealt with through lower-sulfur-content coal as well as flue gas desulfurization (FGD).

Newer processes for power generation, such as integrated gasification combined cycle power generation, which involves a conversion rather than a combustion process, is more effective at reducing criteria pollutants than existing pollution control technologies are.

Potentially the most significant future issue for coal combustion is CO_2 emissions, since on a net energy basis coal combustion produces 80 percent more CO_2 than the combustion of natural gas does, and 20 percent more than does residual fuel oil, which is the most widely used other fuel for power generation. Likewise, the CO_2 emissions associated with making hydrogen from coal will be larger than those for making hydrogen from natural gas. Using currently available technology, the CO_2 emissions are

about 19 kg CO_2 per kilogram of hydrogen produced, compared with approximately 10 kg CO_2 per kilogram of hydrogen manufactured from natural gas.

Atmospheric emissions from coal-fired generating plants are of concern to various bodies—national and international (greenhouse gases, considered under the UN Framework Convention on Climate Change, are mainly CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, and SF_6).

Current Coal Technologies. Conventional coal-fired power generation uses a combustion boiler that heats water to make steam, which is used to drive an expansion steam turbine and generator. Various designs of coal combustion boilers exist, the most modern and efficient of which use pulverized coal and produce supercritical (high-pressure/high-temperature) steam. Overall efficiencies are typically in the 36 to 40 percent range. Although a staple for power generation for decades, this conventional combustion technique is not suitable for making hydrogen. Hydrogen-making technologies employ a conversion process rather than a combustion process. These conversion processes, such as gasification, are suitable for making power and/or hydrogen.

Clean Coal Technologies. Clean coal technologies use alternative ways of converting coal so as to reduce plant emissions and increase plant thermal efficiency, leading to an overall cost of electricity that is lower than the cost for electricity from conventional plants. Systems under development include low-emission boiler systems (LEBSs), high-performance power systems (HIPPSs), integrated gasification combined cycle (IGCC), and pressurized fluidized-bed combustion (PFBC). The goal is to attain thermal efficiencies in the 55 to 60 percent range (higher heating value [HHV]). With the exception of the IGCC systems, all of the others rely on increasingly sophisticated emissions control systems; IGCC uses a different conversion system to reduce emissions at the outset. It is this gasification technology that is best suited to making hydrogen from coal.

Gasification Technology. Gasification systems typically involve partial oxidation of the coal with oxygen and steam in a high-temperature and elevated-pressure reactor. The short-duration reaction proceeds in a highly reducing atmosphere that creates a synthesis

gas, a mix of predominantly CO and H_2 with some steam and CO_2. This syngas can be further shifted to increase H_2 yield. The gas can be cleaned in conventional ways to recover elemental sulfur (or make sulfuric acid), and a highconcentration CO_2 stream can be easily isolated and sent for disposal. The use of high temperature and pressure and oxygen minimizes NO*x* production. The slag and ash that is drawn off from the bottom of the reactor encapsulate heavy metals in an inert, vitreous material, which currently is used for road fill. The high temperature also eliminates any production of organic materials, and more than 90 percent of the mercury is removed in syngas processing. Syngas produced from current gasification plants is used in a variety of applications, often with multiple applications from a single facility. These applications include syngas used as feedstock for chemicals and fertilizers, syngas converted to hydrogen used for hydro-processing in refineries, production, generation of electricity by burning the syngas in a gas turbine, and additional heat recovery steam generation using a combined cycle configuration.

Oxygen-Blown Versus Air-Blown Gasification. Gasification plants exist that use either air-blown or oxygen-blown designs. Air-blown designs save the capital cost and operating expense of air separation units, but the dilution of the combustion products with nitrogen makes the separation of CO_2, in particular, a much more expensive exercise. In addition, the extra inert nitrogen volume going through the plant increases vessel sizes significantly and increases the cost of downstream equipment. Oxygen-blown designs do not introduce the additional nitrogen, so once the sulfur compounds have been removed from the syngas, what is left is a high-purity stream of CO_2 that can be more easily and cheaply separated. Because of the need to consider CO_2 capture and sequestration for future hydrogen generation plants, only oxygen-blown designs are feasible for consideration.

Estimated Costs of Hydrogen Production and Carbon Dioxide Emissions. Most gasification plants produce syngas for chemical production, and often for steam. IGCC plants then burn the syngas to produce power. The flexibility to polygenerate multiple products to suit a given situation is one of the strengths of the gasification system. Thus, relatively few gasification plants are dedicated to producing hydrogen only (or indeed any other single product). The future large-scale hydrogen generation plant will likely also generate some amounts of power because of the advantages provided through polygeneration. It is necessary therefore to preface any remarks concerning the costs of producing only hydrogen or the costs of sequestering CO_2 with this caveat.

All of the technology needed to produce hydrogen from coal is commercially proven and in operation today, and designs already exist for hydrogen and power coproduction facilities. However, technology advances currently in development will continue to drive down the costs and increase the efficiency of these facilities. Hydrogen-from-coal plants combine a number of technologies including oxygen supply, gasification, CO shift, sulfur removal, and gas turbine technologies. All of these technology areas have advances under development that will significantly improve the plant's capital and operating costs and thermal efficiency. Examples of these pending technology advances include Ion Transport Membrane (ITM) technology for air separation (oxygen supply); advances in gasifier technology (feedstock preparation, conversion, availability); warm gas cleanup; advanced gas turbines for both syngas and hydrogen; CO_2 capture technology advances; new, lower-cost sulfur-removal technology; and slag-handling improvements.

It is estimated that today a gasification plant producing hydrogen only would be able to deliver hydrogen to the plant gate at a cost of about \$0.96/kg H_2 with no CO_2 sequestration. If CO_2 capture were also required, it would cost \$1.03/kg H2. This pricing reflects costs for producing hydrogen from very large, central station plants at which hydrogen will be distributed through pipelines. In these plants a single gasifier can produce more than 100 million scf/day H_2. It is envisioned that a typical installation would include two to three gasifiers.

The economics of making hydrogen from coal is somewhat different from that for making it from other fossil fuels, in that the capital costs needed per kilogram of produced hydrogen are larger for coal plants, but the raw material costs per kilogram of produced hydrogen are lower. Coal is inexpensive, but the coal gasification plant is expensive. If the coal price is changed by 25 percent, the hydrogen cost is changed by only $0.05/kg. If the cost of the plant is changed by 25 percent, the hydrogen cost is changed by $0.16/kg. This should lead to a very stable cost of hydrogen production that can be lowered through future improvements in technology.

In addition to the CO_2 produced from making the electricity consumed in producing hydrogen, CO_2 emissions result from the carbon in the coal. The emissions depend on the type and quality of coal. With a CO_2 capture system in place, it is estimated that this figure could be reduced by as much as 80 to 90 percent, the exact amount depending on capital efficiency and cost-benefit analysis. Although the economics of hydrogen production from coal does vary somewhat with the quality of coal being gasified, essentially any coal can be gasified to produce hydrogen. Coals with ash content greater than 30 percent are already being gasified. The main effects of coal-quality variance on hydrogen production are the amount of by-products produced (primarily slag and elemental sulfur) and the capital cost, which would be affected mostly by the amount of additional inert material in the coal that has to be handled. For a gasification plant producing maximum hydrogen from coal, the variance in potential feed coal quality is estimated to produce a variance of less than 15 percent in the amount of CO_2 generated per ton of hydrogen produced. The lower-quality coals generate lower amounts of CO_2 per ton of hydrogen. Other effects of coal quality are less significant.

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Chernyak l.M., Boychenko S.V.
National aviation university, Kyiv, Ukraine

RESEARCH PERSPECTIVE TYPES OF ENVIRONMENTLALLY SAFE ADSORBENTS

Peculiarity of interaction of different types adsorbents (table 1) with water vapor defines by the parameters of porous structure (table 1) – specific surface, sizes and distributing of pores according to radius. As a rule, the lower pressure size, the higher water vapor adsorption, the less effective radius of pores, which has smaller size and more dense packed by globules.

For determination of hydrophobic property degree of different types of silica gel and organosilicon adsorbent “KREOSORB” were built by adsorption isotherms according water vapor (Fig. 1, 2).

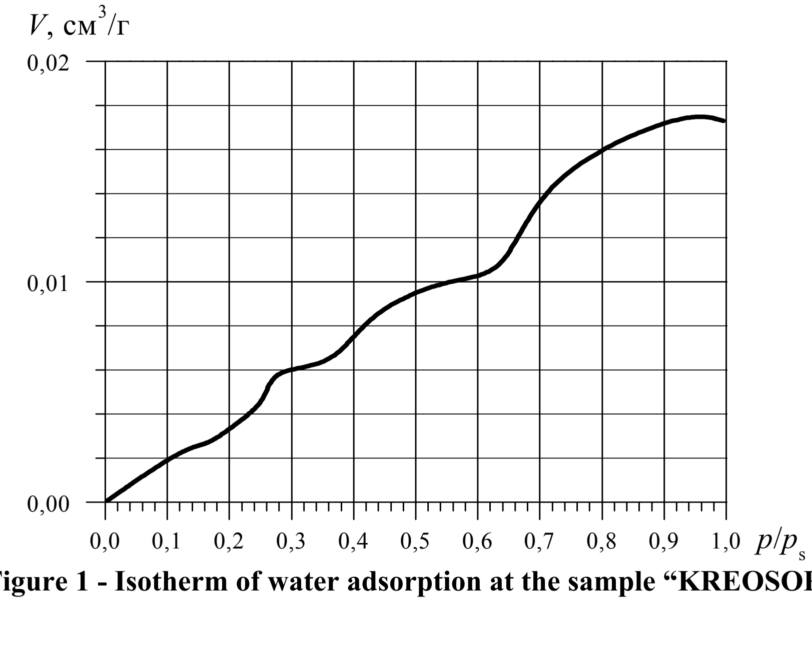

Figure 1 - Isotherm of water adsorption at the sample “KREOSORB”

The presence of methyl group's on the surface of organosilicon adsorbent determines its hydrophobic property. The standard of "KREOSORB" showed practically complete hydrophobicity (that adsorbed very negligible amount of water) (Fig. 1).

Saturation of silica gels by moisture is slow process (Fig. 2). At time of saturation by moisture at the room temperature, silica gels placing as follows: finely porous – mediporous - macroporous. Isotherms of water vapor adsorption on silica gel consist of protuberant and concave areas. Dynamic activity of silica gel layer after moisture depends on the size of grains. The degree of drainage depends on the terms of silica gel dehydration at the previous stage of regeneration. During heating saturated water of silica gel up to 200C is removal of physically absorbable water and proceeding in it adsorption properties. In case of subsequent increase of temperature the subsequent removal of water begins due to ON-GRUP of surface. Destruction of ON-GRUP on silica gel surface results worsening of its adsorption properties as dehydrator.

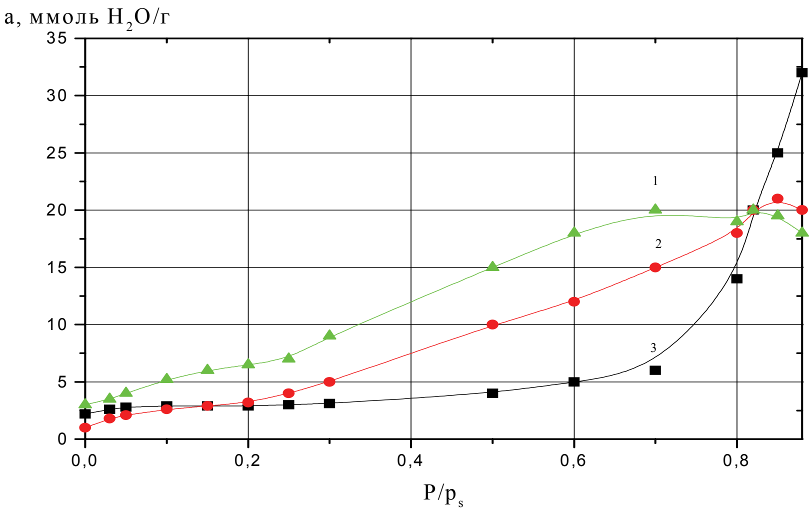

Figure 2 - Isotherms of different type's silica gel adsorption:
1 – microcellular;
2 – middling porous;
3 – large porous

It is possible that macropore silica gel has the highest hydrophilicity. In case of silica gels (as well as clay minerals) at absorption of water vapor from moist air part of pores, occluded with air and time is needed (more than 10 days), to attain an actual adsorption equilibrium.

As the result of researches analysis, it is possible to conclude, that the highest hydrophobic property has organosilicon adsorbent «KREOSORB». It gives possibility to promote the coefficient of useful adsorption during absorption of oil-products vapors.

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E. F. Novoselov, cand.chem. sci.(National Aviation University, Ukraine)
Volodymir Semenov, Assistant Professor, NTUU «Kharkiv Polytechnic Institute»

BIOFUEL FOR AVIATION

Future mid-term aircraft may use a bio-jet and synthetic fuel blend in ultra-efficient airplane designs. It appears that an approach of using a "drop in" jet fuel replacement, which may consist of a kerosene and synthetic fuel blend, will be possible for use in existing and future aircraft. Aviation jet biofuel, such as a implemented now batch of rapeseed methyl esters is an environmentally friendly, renewable and biodegradable fuel. No extensive modifications are needed to run aviation jet biofuel on conventional engines.

Microalgae have become of interest as they provide very promising starting material for aviation jet biofuel production.Microalgae are some of the simplest and oldest organisms. They are unicellular, exist through photosynthesis and their structure allows them efficiently convert solar to chemical energy stored in a form of fat acid triglycerides. The potential behind them is where they become significant as an energy source. The two major issues concerning growing microalgae for alternative to classic aviation jet biofuel production are as follows:

- Making the correct decision on a certain strain or strains to cultivate in order to finding one that will work best for aviation jet biofuel related purposes.
- Finding a method of cultivation which will allow for the algae to grow in significant amounts and therefore to be feasible for the commercial scale goals.

We have conducted a certain algae strain search in order to choose a correct strains, were lipid content was always of the utmost importance allowing extensive algae biomass harvest for aviation jet biofuel production. The following strains have oil content which falls into desirable range of usability. While only some few that were chosen were investigated to narrow the scope of the search, research into other listed below strains should be considered:

Botryococcus Braunii; Chaetoceros muelleri; Nitzschia communis; Scenedesmus dimorphus;Euglena Gracilis; Prymnesium Parvum; Phaeodactylum tricornutum; Pleurochrysis carterae; Tetraselmis chui; Tetraselmis suecica; Neochloris oleoabundans; Isochrysis galbana; Nannochloropsis salina; Dunaliella Tertiolecta.

A promising oil reach example strain - *Botryococcus Braunii* is a green algae. This strain can produce hydrocarbons which represent 86% of its dry weight (weight of the algae with all water removed). It is very unique in its ability to produce these hydrocarbon chain containing oil. Botryococcus is considered to be an ascendant of the organic compounds which make up most of the world's fossil fuel deposits.

Because of its popularity among aviation jet biofuel researchers, *Botryococcus* yielded the most information concerning its growth needs. When colonies of the strain are grown, they appear as a floating mass allowing for easy skimming harvesting off of the top of the growth medium. Optimal growth conditions to ensure maximum biomass and maximum hydrocarbon chain oil output can be achieved at the following parameters values:

- Ambient temperature - 23 ^{o}C
- A light intensity - 30-60 Wt/m^2
- A photoperiod - 12 hours light and 12 hours dark

Salinity - 8.8% (brackish waters)

The difficulty surrounding the algae to aviation jet biofuel production projects falls within finding an ability to cultivate algae in order to create enough fuel as the end product. Nowadays most algae cultivation is done in laboratories in order to see a lipid output in a profitable range, a mass cultivation method must be yet found.

We have compared primary conditions for specific microalgae strains growth:

A green algae, ***Botryococcus*** which is discussed in nearly every forum, it can produce oil up to 86% of its dry weight. Because of its popularity among aviation jet biofuel researchers, ***Botryococcus*** have provided the most information concerning its growth needs. As for drawbacks - ***Botryococcus*** is not able to sustain the agitation intensities of some of the growth techniques that were considered and if these techniques are the only feasible methods for production, ***Botryococcus*** may not be a sound choice. As of yet, no public source is available to acquire this strain in any amount.

Scenedesmus Dimorphus – being a heavy bacterium has a lipid content of 16-40%. The strain must be constantly agitated while grown because of the ease of sediment buildup which hinders its growth. The optimal growth temperature falls between 30-35 ^{o}C which may prove difficult considering a potential growth facility and the ambient temperature of the moderate climat area year round. ***Scenedesmus*** will use any and all light it is given and should be further researched for use in mass production. Unlike ***botryococcus, scenedesmus*** can be acquired from a variety of public sources.

Euglena Gracilisgure has a lipid content of 14-20% by dry weight. The optimal temperature requirement is 27-31 ^{o}C. ***Euglena*** was one of the few strains that had information on the nutrient medium content for optimal photosynthesis. The strain sustains a carbon dioxide concentration within the medium of 4% and an oxygen concentration of 20%. The lighting requirement for the strain is a photosynthetic photon flux of 100 micromoles/m^2s. ***Euglena*** can be acquired easily from a variety of public sources.

Prymnesium Parvum – known as a golden algae, has a lipid content on average of 22-38%. The difficulty with ***prymnesium*** is that it is considered toxic algae which could prove problematic when dealing with it in large quantities. If it were to be mass produced, various safety hazards would have to be taken into consideration. The strain optimally grows in salinity from 4% to three times the salinity of regular water which is a constraint that should be further analyzed. Most research groups inform that ***prymnesium parvum*** is a problematic strain and is usually mentioned in reference to how it should be destroyed.

Because of the general lack of information about strains and specific growth conditions for optimal growth, extensive lab work is needed for every strain that could be used for the industrial processes. The above list is an abridged one to show some information on cultivation and also the variety of issues with different strains. The necessary processes and methods to convert algae to aviation jet biofuel more fully can be found later. Aviation jet biofuel prodiction can uses green plant oils as a feedstock. In terms of oil produced per a land area, algae have a 5- to 31-fold advantage over the next best oil producing crops.

The two main systems of algae for aviation jet biofuel cultivation are categorized as open and closed systems. The **open systems** ponds operate in open-air. The lack of control over such systems proves to be an issue. Weather is impossible to control, contamination by unwanted strains cannot be avoided. As a result true open systems, will only provide a yield in the summer months. A greenhouse layer roof can be placed to allow a better control. This technology consists of a two layer roof so that when weather is extreme, the air pocket in between the layers is to be filled with soap bubbles. The foam protects from extreme sunlight, or shed snow accumulation in colder months. A third layer can be added which has water running over it creating additional, yield doubling growth surface. Better control can be achieved through the integration of raceway pond technologies which use paddlewheels to constantly move water, algae and nutrients to help growth. Overall, open systems are very inefficient concerning utilization of space and energy.

Closed systems allow for complete control of the growth medium, its movement, its inputs and the environment to which it is exposed. Most closed systems for algae cultivation are photobioreactors. Such systems have higher initial costs, contain complicated processes performed in batches or in a continuous flow while allowing for much higher output when compared to open systems. Closed systems can be located within facilities of more compact spaces and are covenient for nutrient CO_2 introduction.

Algae separation from its growth medium is called **harvesting.** The resulted algae concentrations must be greater than 15%. ***Microfiltration*** allowes to separate the algae from the medium as some single-celled algae are smaller than 5 mkm. **Centrifugation** separates the algae cells, leaving much denser (~20%) concentrate but requires large quantities of electrical power. At f**locculation** alum or ferric chloride is introduced to the solution, causing the algae to clump together. An alternative approach is to cut off the algae’s CO_2 supply. This results in autoflocculation. ***Sonochemistry*** is under development, it appears that high intensity ultrasound can clump the algae mass together.

Extracting Oil From Algae. Three methods of oil extraction are known. ***Oil presses***, or expellers can be used to extract oil from algae which must be first dried. This method is simple, but extracts at most 75% of the oils. At use ***of chemical solvents***, benzene or acetone are added to high-concentration algae paste destroying the algae cell walls, allowing the oils to escape. The solvent-oil mixture is distilled, leaving behind the oils. This method extracts 99% of the oil, but remains to be expensive and hazardous. Particularly promising ***ultrasonic cell disruption***. exposes the algae to high intensity ultrasonic waves, which create cell destroying cavitation. Finally algae derived oils are converted into aviation jet biofuel by reacting them with alcohol (usually methanol) in a process called transesterification which yields aviation jet biofuel and glycerol.

Conclusion: Methods of jet fuel similar biofuel production are considered.

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Iryna Vasiljeva, Assistant (National Aviation University, Ukraine)

ANALISIS OF THE PROBLEM OF AIR POLLUTION FROM AVIATION INDUSTRY

The Article describes the major industrial processes within the aviation industry, including the materials and the processes at making and repair of airplane.

Environmental policies based upon comprehensive analysis of air, water and land pollution are becoming an important supplement to traditional single-media approaches to environmental protection. The aerospace industry consists of manufacturers of aircraft, aircraft engines, aircraft parts, guided missiles and space vehicles, etc.

Many of the parts utilized by aerospace manufacturers are made by other industry sectors such as the plastics and rubber industry, the fabricated metal industry, the metal casting industry, the glass industry, the textile industry, and the electronic components industry.

Manufacturing processes for aircraft engines and parts may consist of the following basic operations: materials receiving, metal fabricating, machining and mechanical processing, coating application, chemical milling, heat treating, cleaning, metal processing and finishing, coating removal, composite processing, and testing.

In addition, there are a number of operations that may be used at aircraft engine and parts facilities but are not typical and are performed in conjunction with a variety of industries, such as foundry operations and manufacturing of electronic components.

There are many different materials involved in the production of engines and parts. The most common materials are alloys of aluminum, which are used primarily for aircraft structural components and exterior skin sections. Other materials are titanium, stainless steel, magnesium, and non-metallic such as plastics, fabrics, and composite materials. Typical forms of materials are honeycomb, wire mesh, plate, sheet stock, bar cast, and forged materials.

Metallic Alloy. Aluminum is used as a primary structural material in the aerospace industry because of its light weight, and because its alloys can equal the strength of steel. The ability to resist atmospheric corrosion also favors the use of aluminum.

High strength alloys typically contain copper, magnesium, silicon, and zinc as their alloying elements. Other alloying agents that may be used are: lithium for lightness; nickel for strength and ductility; chromium for tensile strength and elastic limit; molybdenum for strength and toughness; vanadium for tensile strength, ductility, and elastic limit; silicon as a deoxidizes; and powder metallurgy alloys for strength, toughness, and corrosion resistance.

The development of the gas turbine and the evolution of engines required materials with great resistance to temperature, stress, and oxidation. Nickel-based alloys have a high resistance to oxidation and are used for compressor blades and guide vanes, discs, turbine blades, shafts, casings, combustion chambers, and exhaust systems. Titanium alloys have excellent toughness, fatigue strength, corrosion resistance, temperature resistance, and a lower density than steel. Titanium alloys are frequently used to make hot-end turbine components and turbine rotor blades [1]. Below in the table 1 advantages and failing in properties of titan are resulted.

Table 1

Advantages and Lacks of titan

Advantages of titan	Lacks of titan
Small closeness	Active co-operation with gases at the promoted temperatures
High specific durability	Strong propensity to hydrogen fragility
High corrosive firmness	Low antifriktsionnie properties
Plasticity	Bad workability
High firmness in an atmosphere and in water	Low inflexibility of construction
High firmness in organic and inorganic acids	High cost

Non-Metallic Materials. Plastics, carbon and glass fibers, and synthetic resins and polymers are all used in aerospace manufacturing. There are two types of plastics used, thermoplastics and thermosetting materials. Thermoplastic materials are softened by heating and will harden on cooling and can be extruded (material is pressure forced through a shaped hole), injection molded (soft material is forced into a mold through a screw injector and pressure), or thermoformed (material is cast in a mold with heat and pressure). Thermosetting plastics are hardened by heating and form rigid three dimensional structures through chemical reactions.

Carbon and glass fiber strands are used to reinforce plastics for strength and stiffness while remaining lightweight. Synthetic resins and polymers are used as adhesives which produce smooth bonds and a stiff structure which propagates cracks more slowly than in a riveted structure.

Repair operations generally include all conversions, overhauls, maintenance programs, major damage repairs, and minor equipment repairs. Although specific repair methods vary from job to job, many of the operations are identical to new construction operations. Repair operations, however, are typically on a smaller scale and are performed at a faster pace. Jobs can last anywhere from one day to over a year. Repair jobs often have severe time constraints requiring work to be completed as quickly as possible in order to get the aircraft, missile, or space vehicle back in service. In many cases, piping, ventilation, electrical, and other machinery are prefabricated prior to the major product's arrival. Typical maintenance and repair operations include:

1. Cleaning and repainting the aircraft's surfaces, superstructure, and interior areas;
2. Major rebuilding and installation of equipment such as turbines, generators, etc;
3. Systems overhauls, maintenance, and installation;
4. System replacement and new installation of systems such as navigational systems, combat systems, communication systems, etc;
5. Propeller and rudder repairs, modification, and alignment [1].

Data in the table 5 are below resulted about Air Pollutant Releases by Repair Operations at the 410 Plant of civil aviation, (tons/year).

Table 2

Air Pollutant Releases by Repair Operations

Air Pollutant	Class of danger	Year		
		1997	2001	2006
Cadmium	1	0,0004	0,0004	0,0004
Chromium Compounds	1	0,009	0,004	0,004
Nickel	1	0,000008	0,000008	0,000008
Ozone	1	0,000008	0,00001	0,00001
Copper	2	0,001	0,001	0,001
Sodium the hydroxide	2	0,2	0,1	0,1
Aluminium oxide	2	0,009	0,006	0,0008
Phenol	2	0,0006	0,0004	0,0002
Formaldehyde	2	0,00095	0,0006	0,0004
Ouayt-spirit	4	1,8	0,29	0,14

The requirements of standards of quality of natural environment impose restraint on the output of matters, contaminating territory, air and water, especially having a 1 class of danger. An ecological policy foresees aimed on the permanent improvement of ecological indexes, warning of contaminations, observance of ecological laws and norms.

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UDK 621.7.02:504.064.4(045)

Yevgen Bovsunovskiy, assistant, Grigoruy Franchuk, Professor,
(National Aviation University, Ukraine)

CHANGE OF THE AIRCRAFT PARTS SURFACE CONDITION UNDE THE INFLUENCE OF AEROSOL GAS-DYNAMIC SUSPENSION CLEANING

The specificity of the surface microgeometry formation under the influence of aerosol gas-dynamic suspension flow was considered. The composition and character of metallic surface layer formation of aircraft parts was investigated. The possibility of surface material composition and properties adjustment changing aerosol gas-dynamic suspension flow parameters was determined. The hypothesis about the possibility of using aerosol gas-dynamic suspension flow to form corrosion-resistant coating on the detail metallic surfaces was set up.

Using aerosol gas-dynamic suspension (AGDS) method, which is described in work [1], is one of the directions in efficient and pollution-free cleaning processes. But the issues of impact action and intrusion of abrasive particles in the details surface are not enough covered. It was determined in works [2, 3], that processes which are based on the effect of solid particles impact on treated surface, proceed in different ways: the impact is done by an abrasive particle; the impact is done by an aerosol gas-dynamic flow which contains solid particles; suspended abrasive particles impact on a treated surface in the special emulsion which is sprayed with compressed air.

The formation of microrelief under the influence of aerosol gas-dynamic suspension flow can be presented as follows [2]: the initial stage consists of destruction of the most prominent microroughnesses, plastic deformation of their bases and elastic deformation of practically all of the treated surface; the next stage of treatment begins after deleting the most high asperities on the surface, located at the distance of no more than 0,8*d* (*d* is a middle size of abrasive particle) one from another, and consists of surface roughness mass averaging by plastic deformation of microasperities and microcavities of practically all of microrelief. Experiments showed that at collision of polydisperse particles and detail individual aerosol particles remove different volume of mass from the detail surface. Particles which have abrasive constituents with sharp sides cut into the metal and take off a scale; some particles, which have depth of cutting less than radius of cutting edge round-up, scrape the surface without shavings. Other aerosol particles, running into the treated surface, squeeze out the metal into sides, as it is shown in the work [2], the maximal depth of particle intrusion into a metal h_{max} is expressed by equation:

$$h_{\max} = a\left[\frac{5\pi\rho_r(1-\mu^2)V^2\sin^2\alpha}{4E}\right]^{\frac{2}{5}}, \quad (1)$$

where a, ρ_r are the radius and density of particle material; μ is Poisson index of the treated material; V is particles speed at the moment of collision with the surface; α is angle between the axis of flow and treated surface; E is the module of elasticity of the treated material.

It follows from the equation (1), that the more particle size and density and aerosol flow speed are the more intensive the process of mass taking off is.The resistance force at penetration through the liquid film is caused by the components of strain ductile tensor. The value of resistance force with high precision coincides with the level of resistance to penetration of thin wedge in the ideal liquid [4]. If we ignore the gradient of pressure in cavity microrelief, then resistance to penetration of abrasive particles F can be defined from equation:

$$F = \pi\rho V^2 H\left(\frac{\pi}{2\alpha} - 1\right)^2, \quad (2)$$

where ρ is density of suspension (determined by special method [2], in our case ρ is equal to water density); V is speed of flow; H is depth of penetration final value, here $0<\alpha<\pi/2$; α is angle between the generatrix of abrasive particle and plane of intrusion.

It is necessary to note, that in this task $H=R_{max}$, where $R_{\max}$ is the largest height of surface microrelief profile, which is impacted by the flow. The speed of abrasive particle is determined from the equation [4], taking into account the force resistant (2) to penetration of particles into cavity of microrelief and equation (3):

$$V_{\max} = \frac{V}{\left(1 - R_{\max}^3 \frac{\pi\rho(\pi-\alpha)^4}{m}\left[\frac{2}{3}\ln 2(\pi-\alpha) + \frac{1}{3}\right]\right)^{\frac{\ln 2(\pi-\alpha)}{\frac{2}{3}\ln 2(\pi-\alpha)+\frac{1}{3}}}}$$

where m is mass of abrasive particle.

While determining destruction depths under the influence of green silicon carbide with the grain of 40 – 60 μm with speeds of more than 140 m/s, deviation between the calculated and experimental data is within the limits of 20%. It is caused by the increase of interaction speed, which leads to decrease of destroyed surface elastic deformations and increase of cavitation damage of the abrasive particle water shell and its intensive fragile destruction. For the clay particles with speed of 300 – 400 m/s the calculated depth of intrusion is 0,5 – 1,5 μm.

The surface of samples before and after the AGDS method treatment was investigated with Auger-spectroscopy on the modernized electronic spectrometer 0940C-10-005 of G.V. Kurdumov Metal-physics Institute in the National academy of sciences of Ukraine [5]. The electronic Auger-spectroscopy (EAS) method is based on the processes of ionization of internal atomic levels with primary electronic beam, Auger-transition without emission and output of Auger-electron to the vacuum, where it is registered by an electronic spectrometer. Auger-electrons give small peaks on an energy distribution diagram.

It is possible to conduct not only quality but also quantitative analysis of the surface chemical composition by EAS. The methods of chemical analysis by EAS are divided into two groups: calculation and empiric. The first group is based on the use of levels which link the current of Auger-electrons with the concentration of the proper element and various physical factors; introduction of the Auger-peaks relative amplitude factor; use of different parts relative sections ionization. The methods, based on comparison of Auger-peaks amplitude of investigated element and external standard or internal reference element and on the construction of graduated curves, belong to the second group. The layer analysis is conducted by etching samples surface with the beam of argon ions of 1,5 mm in diameter with energy of 3000 eV and density of current 400 mkA/cm^2. EAS allows to identify parts by the energy of Auger-electrons if these parts have atomic number of $Z>2$ and to conduct layer analysis simultaneously for eight components with depth discreteness more than 0,5–1 nm. In EAS information is related to the surface area with thickness of 2–4 atomic layers. The absolute sensitivity of method is approximately 10–14 g, relative sensitivity for volume admixtures is of the order of 10^{-3} at. %.

The disk-shaped samples with the diameter of 10 mm and thickness 5 mm, whose surface was preliminary turned into the 14th class of roughness, were used for the Auger-spectroscopy method analysis. Two identical samples (from one stick) were made of the steel 30ХГСА and titanic alloy ВТ3. One of the samples from every pair was treated according to AGDS method with the parameters of installation: pressure on the entry of the nozzle is 0,6 MPa; concentration of abrasive particles is 1:3 by mass according to clay and water; distance to the treated surface is 0,07 m; axis slope angle of flow to the plane of surface is 90°; time of treatment is 60 s. After the treatment samples are washed with the clean distilled water and dried in the flow of warm-compressed air.

The untreated pair of samples was used as reference to define stabilization level of concentration of main parts included in composition of alloys. The spraying of surface layer of the treated samples was carried out before the main parts concentration came out to the stable (according to the reference) level. Research results are presented on Fig.1 – 2.

Analyzing dependences of the energy emission intensity change for different parts of the steel 30ХГСА by the depth on Fig.1 and Fig.2, it is possible to make conclusion, that for the first 30 minutes of spraying (depth to 0,1 μm) the layer of organic matters, settled on the sample surface from the air, is taken off. Then between 0,1 to 0,5 μm there is the layer of steel 30ХГСА, enriched with silicon to 20 at. %. Small admixtures of Ca up to 2,7 at. % are explained by remains of abrasive particles on the material surface, which could be removed by washing with high-speed flow of water. From the depth of 0,4 μm to approximately 1 μm the layer of steel is enriched with aluminum up to 40 at.% (possibly with the oxide of aluminum). The transition phase, decrease of silicon content and increase of aluminum content, is on the depth of 0,5 μm. Consequently, porous two-layer coating, which is schematically presented on Fig.3, appeared on the surface of steel 30ХГСА.

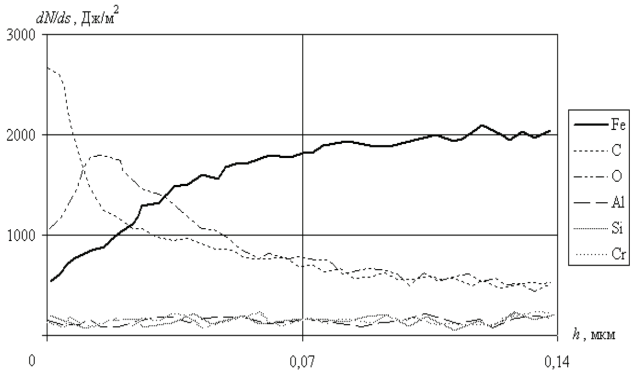

Fig.1. Changes of specific energy efficiency of 30ХГСА material parts by the layer thickness before the AGDS method treatment.

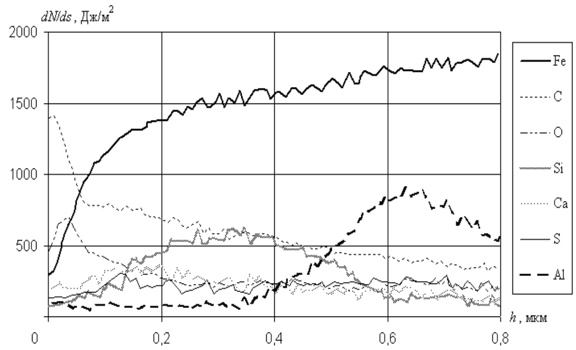

Fig.2. Changes of specific energy efficiency of 30ХГСА material parts by the layer thickness before the AGDS method treatment.

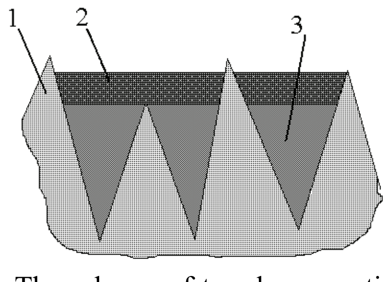

Fig.3. The scheme of two-layer coating after the AGDS method treatment: 1 is backing material; 2 is layer enriched with silicon; 3 is layer enriched with aluminum.

From Fig.2 based on the theory of mathematical statistics [6] it is possible to define the middle depths of silicon and aluminum particles bedding.

The function of the investigated random quantities is named the statistical estimation of unknown parameter of theoretical distribution. General mean is an arithmetic mean of the general aggregate parameter values. The parameter of certain element atoms amount distribution on the limited, identical for all of values surface area, is considered to be the depth of spherical particle centers bedding *h*:

$$\overline{h} = \frac{\sum_{i=1}^{N} h_i m_i}{\sum_{i=1}^{N} m_i}, \qquad (4)$$

where $\overline{h}$ is middle depth of bedding, μm; h_i is value of material atoms bedding depth, that is digitized by the graphic digitizer Windig25 based on the dependence on Fig.2; m_i is value of specific intensity of atoms energy; N is amount of digitized points on graph.

General dispersion is determined for the description of general aggregate bedding depth values dispersion around the mean value. The general dispersion D is an arithmetic mean of the general aggregate atoms bedding depth values square deviation from their mean value. D is determined from the equation:

$$D = \frac{\sum_{i=1}^{N} (h_i - \overline{h})^2 m_i}{\sum_{i=1}^{N} m_i}, \qquad (5)$$

Standard deviation $\sigma = \sqrt{D}$.

Let's limit the sampling of h = 0,35–0,8 μm for the aluminum general mean bedding depth determination, and to the sampling of h = 0–0,6 μm for the silicon general mean bedding depth determination. Calculation results of general aggregate parameters of the aluminum and silicon bedding depths in accordance with (4), (5) are presented in table 1.

Table 1.

Descriptions of the corrosion resistant coating layers distribution

Material	Mean bedding depth h, μm	Dispersio n D, μm	Standard deviation σ, μm
Aluminu m	0,6352	0,0221	0,1486
Silicon	0,3191	0,0255	0,1596

The layer of aluminum has more dense structure, than the layer of silicon, because it has greater hardness and gets deeper into the material of backing, leaving free cavities which are occupied with silicon particles.

It is known that changing the composition of oxide layers, it is possible to regulate the corrosive behavior of steel in different conditions [7]. The previous investigation of corrosion resistance of the metallic surfaces treated according to AGDS method are presented in work [8].

Thus, changing the parameters of AGDS flow it is possible to form or avoid formation of the corrosion resistant material layer on the metallic surfaces of parts.

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Makarenko V.M., aspirant, (National Aviation University, Ukraine)

ANALYSIS OF ISOTROPIC ACTUATOR APPLICATION FOR EXCITATIONS COMPENSATION

A model of orthotropic plate linear vibration and sound radiation due to concentrated force and bonded to the plate surface isotropic piezoelectric patch was elaborated. Applied point force is used as disturbing excitation and actuator is employed as compensating excitation. The presented results indicate significant noise reduction for the optimal set of piezoelectric patch parameters.

Plane structures with active patches are extensively used in mechanical, aeronautical and structural engineering. Piezoelectric materials are also used as actuators and/or sensors due to their direct and converse piezoelectric effects. Recent aircraft designs employ more lightweight materials and structures so that noise, produced by these structures become more important than it was before. In order to favorably modify the behavior of plate-like structures the influence of actuator patch has to be optimized for each mode of plate oscillation.

Theoretical assessment of transverse motion of simply supported plate oscillation

Let us consider the sound radiation of thin rectangular orthotropic plate of finite size $a \times b \times h$, which is simply supported (SS) along its entire periphery. Piezoelectric actuator can be presented as 4 moments acting at the actuator edges. The most widespread isotropic piezoelectric actuator is lead zirconate titanate (PZT, Pb(ZrTi)O_3). The plate oscillates under external concentrated force F_F and voltage U_k, applied to the electrodes of piezoelectric patch. In such case, forced response of the plate is defined by Helmholtz equation and equation of transverse motion $w(x, y)$.

$$\Delta p + k^2 p = 0;\ \text{z=0}\ \frac{\partial p}{\partial z} = \rho\omega^2 w$$

$$D_{11}\frac{\partial^4 w}{\partial x^4} + 2\left(D_{12} + 2D_{66}\right)\frac{\partial^4 w}{\partial x^2 \partial y^2} + D_{22}\frac{\partial^4 w}{\partial y^4} + \rho h\frac{\partial^2 w}{\partial t^2} =$$
$$= -\frac{E_p l^2}{h_p\left(1-\nu_p\right)}\sum_{k=1}^{r} U_k \exp\left(i\varphi_k\right)\left(d_{31}\frac{\partial^2 Q_k}{\partial x^2} + d_{32}\frac{\partial^2 Q_k}{\partial y^2}\right) + \sum_{F=1}^{N} F_F \exp\left(i\varphi_F\right)\delta\left(x - x_F\right)\delta\left(y - y_F\right) \quad (1)$$

where D_{ij} are bending stiffnesses:

$$D_{11} = Q_{11}\frac{h^3}{12} \text{ and } Q_{11} = \frac{E_x}{1-\nu_{xy}^2\frac{E_y}{E_x}},\ D_{12} = Q_{12}\frac{h^3}{12} \text{ and } Q_{12} = \frac{\nu_{xy}E_y}{1-\nu_{xy}^2\frac{E_y}{E_x}} = \nu_{xy}Q_{22},$$

$$D_{22} = Q_{22}\frac{h^3}{12} \text{ and } Q_{22} = \frac{E_y}{1-\nu_{xy}^2\frac{E_y}{E_x}} = \frac{E_y}{E_x}Q_{11},\ D_{66} = Q_{66}\frac{h^3}{12} \text{ and } Q_{66} = G_{xy},$$

where $E_x = E'_x\left(1 + i\eta_x\right)$, $E_y = E'_y\left(1 + i\eta_y\right)$, $G_{xy} = G'_{xy}\left(1 + i\eta_{xy}\right)$, ρ is plate density; $l^2 = (h - h_p)^2 - h^2$; E_p is Young's modulus of the plate; h_p, ν_p – thickness and Poisson coefficient of piezoelectric patch; d_{31}, d_{32} is piezoelectric charge (strain) constants; $\left(x_F, y_F\right)$ – coordinates of *F*-th force location; φ_k, φ_F are phases of actuator and force correspondently; $Q_k\left(x, y\right)$ is generalized location function for *k*-th piezoelectric actuator, which is described in terms of Heaviside function H(·) in the following way

$Q_k(x,y)=\left[\mathrm{H}(x-x_{k1})-\mathrm{H}(x-x_{k2})\right]\ \left[\mathrm{H}(y-y_{k1})-\mathrm{H}(y-y_{k2})\right]$,
where $x_{k1}, x_{k2}, y_{k1}, y_{k2}$ are the coordinates of piezoelectric patch.

In addition, the boundary conditions for w of SS plate are

$$w(0,y)=\frac{\partial^2 w(0,y)}{\partial x^2}=0;\ \ w(a,0)=\frac{\partial^2 w(a,y)}{\partial x^2}=0 \ (2)$$

$$w(x,0)=\frac{\partial^2 w(x,0)}{\partial y^2}=0;\ \ w(x,b)=\frac{\partial^2 w(x,b)}{\partial y^2}=0\,. \ (3)$$

The solution is found in terms of the Green function G.

$$w(x,y)=\frac{E_p l^2}{h_p(1-\nu_p)}\sum_{k=1}^{r}U_k\exp(i\varphi_k)\left\{d_{31}\int_{y_{k1}}^{y_{k2}}\left[\frac{\partial G(x,y,x_{k1},y_0)}{\partial x_{k1}}-\frac{\partial G(x,y,x_{k2},y_0)}{\partial x_{k2}}\right]dy_0+\right.$$

$$\left.+d_{32}\int_{x_{k1}}^{x_{k2}}\left[\frac{\partial G(x,y,x_0,y_{k1})}{\partial y_{k1}}-\frac{\partial G(x,y,x_0,y_{k2})}{\partial y_{k2}}\right]dx_0\right\}+\sum_{F=1}^{N}F_F G(x,y,x_F,y_F)\exp(i\varphi_F)$$

The solutions received with the Green functions can be used for different boundary conditions. The only change in Green functions itself is required.

The Green function associated to eq.(1) of transverse motion of plate would be:

$$D_{11}\frac{\partial^4 G}{\partial x^4}+2(D_{12}+2D_{66})\frac{\partial^4 G}{\partial x^2\partial y^2}+D_{22}\frac{\partial^4 G}{\partial y^4}-\rho h\omega^2 G=\partial(x-x_0)\delta(y-y_0)\,,\ (4)$$

For SS plate Green function have the following form

$$G(x,y,x_0,y_0)=\frac{4}{abh\rho}\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\frac{1}{\omega_{mn}^2-\omega^2}\sin\frac{m\pi x}{a}\sin\frac{n\pi y}{b}\sin\frac{m\pi x}{a}\sin\frac{n\pi y}{b}\,.$$

Eigenfrequency of SS orthotropic plate oscillation can be defined as follows

$$\omega_{mn}=\sqrt{\frac{1}{\rho h}\left[D_{11}\left(\frac{m\pi}{a}\right)^4+2(D_{12}+D_{66})\left(\frac{m\pi}{a}\right)^2\left(\frac{n\pi}{b}\right)^2+D_{22}\left(\frac{n\pi}{b}\right)^4\right]}$$

ALGA optimization. Fitness function formulation

All of the solutions presented in the paper can also be represented in the form of product

$$w(x,y)=\sum_{\{n\}}^{\infty}\left(\sum_{F=1}^{N}W_{nF}(F_F,x_F,y_F,\varphi_F)+\sum_{k=1}^{r}T_{nk}(U_k,x_{k1},x_{k2},y_{k1},y_{k2},\varphi_k)\right)R_n(\omega)\psi_n(x,y),$$

where $R_n=\left[\rho hab\left(\omega_n^2-\omega^2\right)\right]^{-1}$, and $F_n=\sum_{F=1}^{N}W_{nF}+\sum_{k=1}^{r}T_{nk}$ is the fitness function of n-th mode, $\psi_n(x,y)$ is product of beam functions (mode shape). Total fitness function is determined as $F_\Sigma=\|F_n\|_2$. The optimization performed with the help of ALGA allowed defining the optimal parameters of piezoelectric actuators for vibration and sound radiation reduction.

Conclusions

The dependence of sound power level, radiated by the plate, on piezoelectric force parameters, namely forces value, its location and phase, was researched in the report. The analytical method of sound radiation evaluation was elaborated for the orthotropic plates with different boundary conditions excited by isotropic and orthotropic piezoelectric actuators. The solutions received with the Green functions can be used for different boundary conditions. The only change in Green functions itself is required. The influence of actuator phase can be approximately defined by the position of actuator centre. The number of modes that could be controlled depends on the number of actuators that is used.

Vadim Zakharov, Yuriy Zakharov,
Pridneprovsk State Academy of Civil Engineering and Architecture, Ukraine, Dnepropetrovsk

BUILDING ACOUSTIC DESIGN IN CONDITIONS OF AIRCRAFT NOISE CLOSE TO THE SANITARY-HYGIENIC LIMITS

One of the most actual ecological tasks of modern town-planning is the protection of city building against negative action of aviation noise. The specialized acoustic scientific laboratory and the design group which is a part of Pridneprovsk State Academy of Civil Engineering and Architecture, carries out development of acoustic sections on different design and construction stages. The basic result is drawing up of the general scheme noise protection in structure of the complex transport scheme by development (updating) general plans of the built-up areas, with detailed studying of influence on the population of different kinds of noise pollution transport sources, an estimation of a sanitary-ecological condition of separate objects of research, development and introduction of practical recommendations on its improvement; carrying out of detailed inspection of the noise mode of different types of buildings (industrial, public, inhabited, etc.), definition of acoustic characteristics of the influencing on them noise pollution sources.

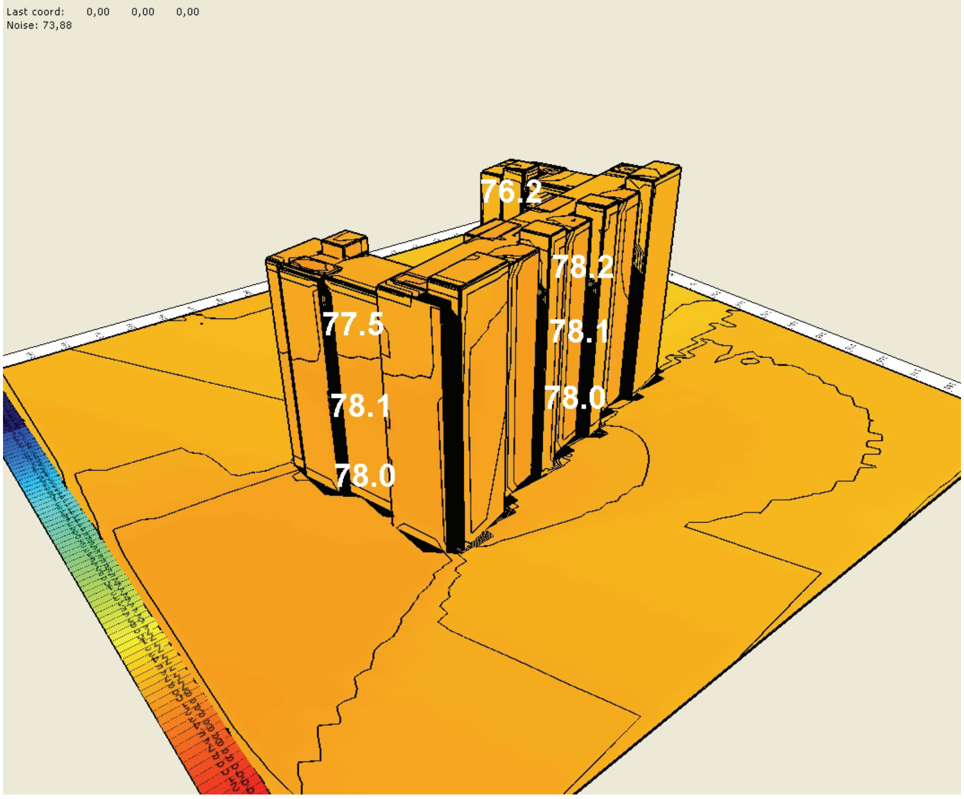
Exhaustion of ground resources within the limits of territory borders of many modern cities demands an application of new building complexes on agglomeration. Located in a residential suburb and actively functioning objects of external transport often render essential adverse external influence on newly erected objects. The greatest negative external influence on such objects of protection renders noise from the airports of civil aircraft. Designing and construction in such conditions demands the obligatory account of this external negative factor.

The application of specially developed in Pridneprovsk State Academy of Civil Engineering and Architecture techniques basing on the substantive statements of designing and construction, using positions of applied acoustics allow to do an estimation, the analysis and forecasting of acoustic mode condition of the city environment. Mentioned techniques allow to develop recommendations on city environment improvement with application of the advanced methods and means of struggle against noise in sources of its initiation, on a way of distribution and in objects of protection. It allows at the stage of exploratory researches to estimate the suitability for construction of surveyed territory sites, validity of application of corresponding techniques of a planning and building, to avoid unreasonably high expenses on the noise protection, to recommend space-planning and constructive decisions of buildings, inhabited apartments, their separate constructive elements, etc.

Consideration of acoustic questions and their decision on different design stages, allows to our customers not to make mistakes in the functional and space-planning decision of buildings, providing in inhabited and other rooms the admissible noise norm, comfortable conditions for people residing. It allows to avoid excessive material inputs at reconstruction existing and construction of new buildings and constructions.

Below is the fragment of an illustrative part of real town-planning object is presented, which noise mode is surveyed with application developed by us and approved on real town-planning objects the original software. It allows to carry out the reliable forecast of the noise mode of city territories and the buildings placed on them in view of the action of various acoustic pollution sources of on the people who are being in the rooms, to develop and introduce effective methods and means of protection against noise.

On Figure 1 the examples of a cartographical estimation of the noise mode for newly designed apartment house in the town of Skhodnya of the Moscow area are presented. On Figure 2 the estimation of the predicted exceedings of admissible maximum levels of a sound in the rooms of apartments of the designed 17-floor 6-section apartment house regulated by the Sanitary Code 2.2.4/2.1-96 at action of an aviation source at night of day accordingly before and after the realization of a noise protection variant (a window of «the Scandinavian design») is presented.



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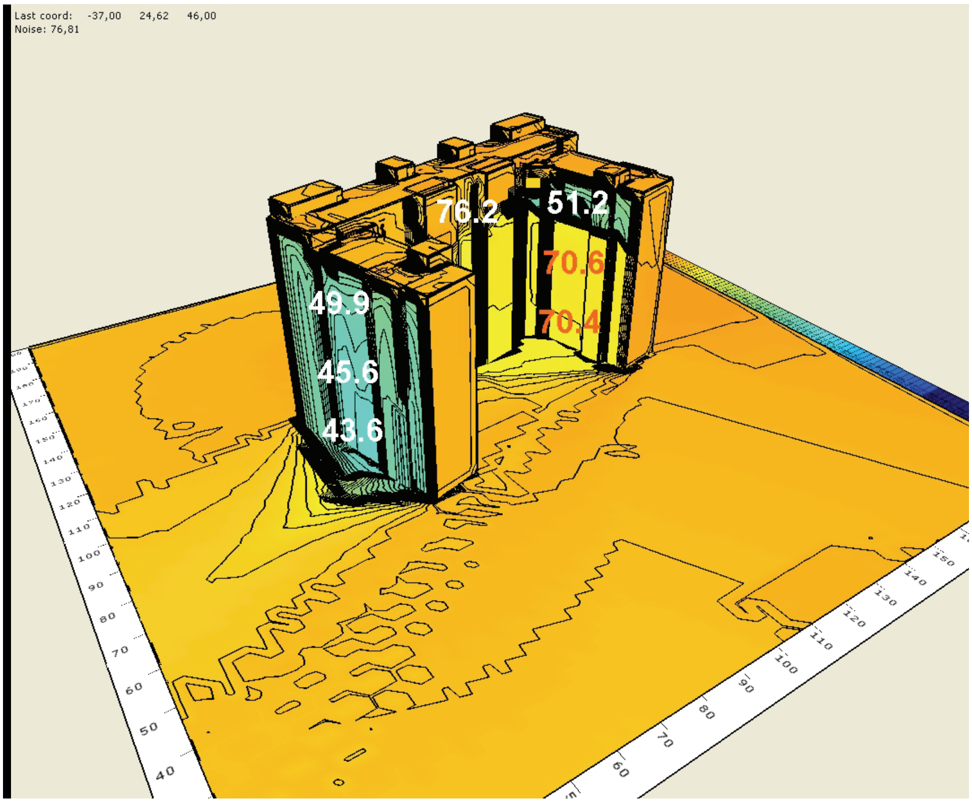

b

Figure 1 - Cartographical estimation of the noise mode of protected objects at action of *maximum* levels of *aviation* noise during *day time* and *night time* of day.

a. Overview from the direction of northern and east facades of the house;

b. Overview from the direction of the southern and western facades of the house.

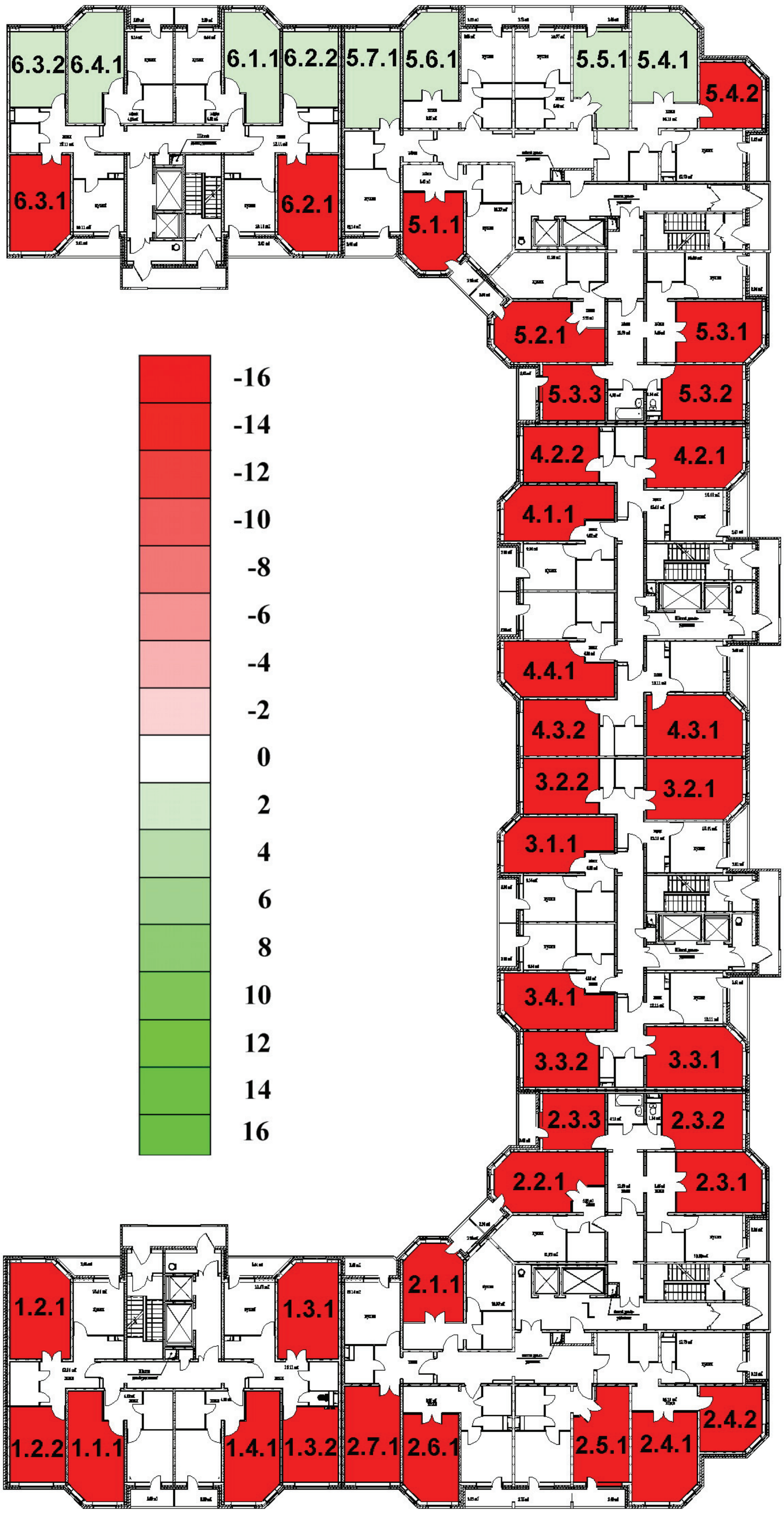

Figure 2 - Predicted exceedings of admissible maximum levels of a sound in the rooms of apartments of the designed 17-floor 6-section apartment house regulated by the Sanitary Code 2.2.4/2.1-96 at action of an aviation source at night of day before the realization of a noise protection actions.

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Y. Shevchenko, student (National Aviation University, Ukraine)

ESTIMATION METHODS FOR ACOUSTIC IMPROVEMENT OF ROOMS USING MEASUREMENTS OF REVERBERATION TIME

Estimation methods for reverberation time as a main approach for evaluation of premise acoustic characteristics has been considered. The veracity of results, obtained in reverberation room has been proved. Assessment of acoustic characteristics of auditoria has been carried out.

One of the most important factors we should take into consideration speaking about sound travel from sound source to the recipient is room configuration and sizes. The room geometric characteristics can totally change information we hear. This fact is very often neglected in room designing. Presently it is very important to develop various effective techniques for estimation of acoustic room parameters.

The task of my work was to apply the method of determination of room acoustic characteristics using estimated reverberation time and prove that this method is suitable for assessment of rooms of various types.

The most satisfactory reverberation time is determined by sound intelligibility for particular purpose, and there for it depends on room type (for example, classroom, concert hall, studio, office). If reverberation time in the room is long then at speech generation residual sound exceeds direct sound. At low reverberation time information is perceived clearly, but without necessary background. Optimal values of reverberation time for frequency 500Hz for the room, the main purpose of which is speech transmission, can be determined by the following empirical dependence:

$T_0 = 0.3\lg V - 0.05$ (1)

Reverberation room

The first example of reverberation time measuring is based on the measurements carried out in reverberation room of the National Aviation University.

The room dimensions are: volume – 173.7 m^3; total area of bounding surfaces – 180.6 m^2.

Reverberation time was measured when petard exploded. Calculations were held by using Spectran application program and Microsoft Excel. The proximity of result to actual physical values can be proved by confidence interval with 95% of confidence level. The results of average reverberation time with reliable intervals are shown in Fig. 2.

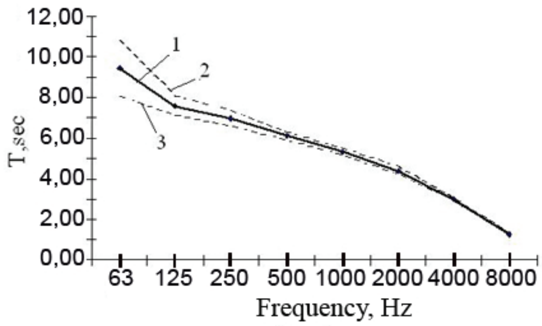

Figure 2 - Confidence level for 95% reliability for reverberation time, measured in reverberation room:
1 – reverberation time;
2,3 – confidence intervals

Thus the figure shows that the room gives adequate results of reverberation time measuring for frequencies from 125 Hz to 4000 Hz. For frequency 1000 Hz a reliable interval is 0.19 sec.

Some problems appear for frequencies lower than 125 Hz when diffusivity of the field is disrupted. This happens because of discrepancy between linear room sizes and generated low-frequency waves. The wavelengths are not always properly correlated with linear room sizes. Discrepancies at high frequencies are explained by waves damping within the room. It causes the same defect of the sound field diffusiveness at high frequencies.

Another example of experiment, carried out in reverberation room was measuring of fan sound power. Experiments were held by two methods: direct and comparative one. Measuring process technique for both methods and formula for sound power calculations were stated in state standard GOST 12.1.024-81 and GOST 27243-87 and are based on reverberation time.

Calculation result of fan sound power in octave frequency band is showed in Fig. 3.

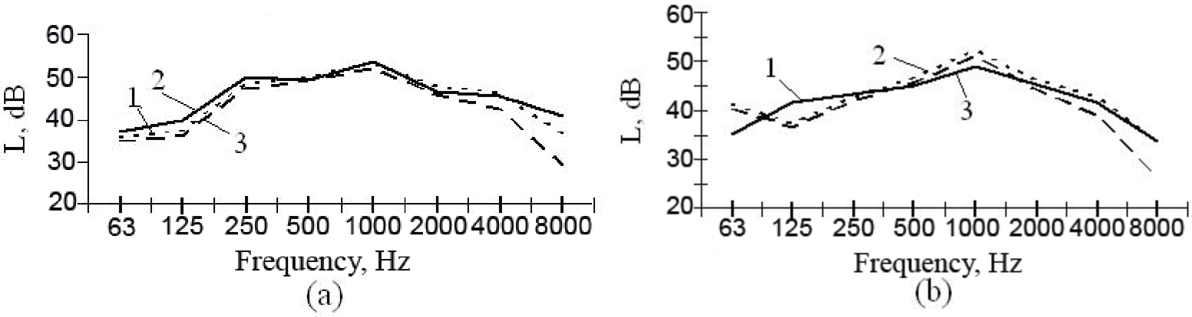

Figure 3 - Measurement of sound power level for fans: (a) for ВЕНТС 100ЛДБ, where 1 – Excel evaluation; 2 – Comparative method; 3 – Spectran evaluation; (b) for ВЕНТС 100ДБ, where 1 – Comparative method; 2 – Excel evaluation; 3 – Spectran evaluation.

The divergence of the continuous line can be explained by human factor as measurement of sound pressure is a very complicated procedure and may lead to some degree of discrepancy.

But in general such results are acceptable and can be considered accurate as difference of sound power does not exceed 4-5 dB for the highest divergence.

Such results show that we can have the same result, applying different methods of measuring and different approaching techniques can be applied in the reverberation room.

The results prove that when reverberation room is properly designed we can receive adequate experimental outcome for different approaches.

Classroom evaluation with the help of reverberation time approach method

Measuring reverberation time is the main parameter for all types of rooms. We propose estimation of reverberation time for room acoustic evaluation.

To show how it can work on practice estimation of usual classroom in building 9 of the National Aviation University were carried. This room is designed to deliver lectures and hold practical lessons in it. The main task is usual speech transmission. According subjective perception acoustic characteristics of this room are far from perfect. Therefore the estimation of reverberation time was carried out.

Measuring reverberation time was organized with the help of petard explosion. Measuring was carried out by Brul&Kier equipment (the measuring tract).

The Spectran application program was used for reverberation time calculation within the octave frequency band.

Typical room size: volume – 135.47 m^3; area of boundary surfaces – 162.63 m^2, including 13.28 m^2 of the window surface.

To estimate acoustic properties of the room reverberation time was evaluated according to reference point of 500 Hz, using established formula (1) for optimal reverberation times. According to the formula (1) the optimum reverberation time for room volume of which is 135.47 m^3 is 0.59 sec. The result for classroom was 1.29 sec.

Thus, some amount of echo is created in the classroom. As a result information can not be received effectively and clearly. Besides, such information dissipation may cause general noisiness that leads to nervous system irritation and may cause tiredness and inability for further efficient work.

Thus, the reverberation time itself as a main parameter has already proved the violation of acoustic characteristics of the lecture-room. We can conclude that room construction was made, for roominess, but not to get appropriate acoustic qualities of the room. Such situation requires some changes for improving improper room design. Some measures could be as follows: installation of dissipating components on walls, corners; covering surfaces with high absorption coefficient materials to reduce sound reflection; installation of some pieces of furniture that will contribute to sound waves dissipation and absorption; redecoration of classroom for improving acoustics qualities of the room.

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Oksana Vovk, Assistant Professor,
Yulija Nikitchenko, Aspirant, National Aviation University, Ukraine, Kyiv

UTILIZATION OF TIRES AS COMPLEX DECISION OF POWER-DEFICIT PROBLEM

A worsening of mountain and geologic conditions of hydrocarbon materials mining, tightened of ecological norms, unstable situation in the oil market force for looking of new alternative energy sources. It is not so difficult to make a forecast that already in a next decade a greater part of fuel and energy growth will be necessary to provide due to energy saving methods.

A definition "the energy saving methods" foresees both the implementation of technologies, which increase the effectiveness of traditional energy carriers using and a diversification of energy balance due to alternative energy sources using. This implies that the effective energy saving policy is a guarantee of economical growth and stable development of country at whole.

An idea of alternative fuel implementation, which first appeared just in time of oil crisis in USA at 1970, starts to spin up in the present days. In those years this problem has been solved thanks to oil price stabilization, as the oil quantity was enough for needs of all World. Nevertheless, today this situation is changing: according to the forecast of scientists, the world oil reserves remain for few decades only. Therefore, world energetics is exposing to substantial structural changes, connected with predicted decrease of oil volume mining by leading manufactures.

A definition "the alternative sources of fuel and energy" has more deep meaning in comparison with simple conception on development an inculcation of the "alternative" methods and technologies. To provide the effectiveness and advisability of any "alternative" project, it is necessary to integrate the project with protection of the environment, namely, main flow of investments direct for inculcation of projects, which combine the receiving of alternative energy carriers with utilization of accumulated wastes.

For instance, utilization of scrap automobiles tires is economically sound and ecologically friendly sector, which corresponds to modern requirements of stable development policy. Scrap tires are high-capacity and continuous accumulated source of hydrocarbon materials, which imperil a high danger for health and life of human and environment at whole.

According to the data, sounded at the U.N.O. Conference on environment and development (Rio de Janeiro, 1992), a volume of solid waste will increase in 4-5 times up to 2025 year. At the same time, the world volume of scrap tires is valued at 25 millions tons with year-on-year increase in seven millions tons. In Europe, the total volume of accumulated scrap tires is three milliards pieces (around two millions tons). In USA about 280 millions used tires accumulated annually, and they total volume is exceeded two milliards pieces.

Concerning the treatment, only 23 % of used tires come to use after wear and tear, namely an export to other countries, incineration with energy receive, mechanical fragmentation for road building and others. The rest 77 % of scrap tires do not found their post-life application.

Regarding to Ukraine, annual accumulation of scrap tires is 0,74 millions tons. Only at Kyiv region the used tires growth is 100 thousands of scrap PKW tires and 65 – 70 thousands of LKW scrap tires. About 2 % of amortized tires are incinerate; about 1 % - retreaded and come back on exploitation stage. The rest are get to the unapproved garbage, ravines and suburban forest belts. This fact causes to worsening of difficult ecological situation in Ukraine.

Although Ukraine does not ahead the ratings among countries with great index of scrap tires accumulation, but in the nearest future the intensive automobilization could lead to creation of vast garbage of large – capacity polymeric waste.

In addition to sizeable accumulation of scrap tires on land, they have a direct impact on human health and all living world around.

First of all tire piles are excellent breeding grounds for mosquitoes, insects and rodents. Because of the shape and impermeability of tires, they may hold water for long periods providing sites for mosquito larvae development in particular. Such neighborhood within housing estates will cause the rise of infection cases among inhabitants. Most of infections from rodents and insects can have dramatic consequences for children and adults.

Regarding to tire burning, there is virtually no possibility of spontaneous combustion of tires at the garbage. However, once fully ignited, a tire fire is difficult to extinguish. They can endure for weeks or months, depending upon the volume of tires. A tire fire creates dense, oily smoke, which can be carried great distances, impairs visibility, and soils painted surfaces. Toxic gas emissions include polyaromatic hydrocarbons, CO, SO2, NO2, and HCl. Heat from tire fires also causes some of the rubber to break down into an oily material. Prolonged burning increases the likelihood of surface and groundwater pollution by the oily material. Emissions from open tire fires can be more toxic than emissions from an incinerator, regardless of the type of fuel. Airborne emissions from open tire fires can have a serious impact on health and the environment. Open tire fire emissions include "criteria" pollutants, such as particulate, carbon monoxide (CO), sulfur oxides (SOx), nitrogen oxides (NOx), and volatile organic compounds (VOCs). They also include "non-criteria" hazardous air pollutants, such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs); and metals, such as arsenic, cadmium, nickel, zinc, mercury, chromium and vanadium. The emissions from an open tire fire can pose significant short-term and long-term health hazards to nearby persons. These health effects include irritation of the skin, eyes, and mucous membranes, respiratory effects, central nervous system depression, and cancer.

That is why a European Committee was adopted a special directive “About garbage” from 2^{nd} of April 1999, according to what a scrap tires burn is prohibited from 2003 year.

Left on the garbage or putted under the ground scrap tires do not exposed to biological decomposition. Their contact with rainwater or underground water lead to washing out of toxic organic substances: dihpenilamin, dibytulphtalat, phenantren and others.

In spite of negative influence of scrap tires, they are valuable raw materials.

Rubber is a basic component of any tire. Taking into account the coefficient of wear a rubber part in scrap tire is approximate 65 %. According to the physical and chemical characteristics, rubber is a unique material because of its properties: it is saves elasticity after temperature treatment, it does not react with plentiful aggressive materials, and it is flexible at the high coefficient of wear. In combination with steel, aramid, polyamide or rayon tire cord, rubber shows itself as highquality material.

All above-mentioned facts attest that scrap tires, which consist of rubber mainly, have a big potential of utilization. And depending on main goals of investor, who invest money into utilization projects, it is determines how possibly in existent economic conditions at the high use of potential of threadbare tire as valuable material again effectively to enter them in an economic turn. In other words, choose the most acceptable method of processing.

Nonrenewable natural raw oil forces to use the second resources with maximal efficiency, that in place of waste stacks it follows to develop and inculcate the new sphere of industry – commercial processing of amortized tires.

World practice shows that scrap tires treatment is able to provide the effective decision of the accumulation problem by the economic advantageous ways. The most widespread methods of utilization of tires are incineration with the purpose of energy receipt (most popular is incineration of tires in cement stoves), pyrolysis at the conditions of low or high temperatures with the receipt of easy distillate, and also receipt of rubber crumb and powder, that used for making of polymeric mixtures and build materials. Each of the mentioned method is actual depending on the ultimate goal of utilization, inasmuch as every method implies to get a different products quite.

A particular desirable way to dispose of used tires is recovery of hydrocarbons and carbonaceous materials from tires. The hydrocarbons can be used as fuel source replacing expensive petroleum products.

To extract secondary oil products from scarp tires pyrolysis systems are commonly used. Pyrolysis is known by a number of different terms including: gasification, devolitization, destructive distillation, thermal depolymerization, thermal cracking, carbonization and coking.

Under the influence of temperature at the absence of oxygen scrap tires are separate on solid, liquid and gas substances. At that a long polymeric links are change into hydrogen molecular parts.

Pyrolysis can be performed in batch or continuous processes, either at atmospheric pressure or under vacuum. Systems that are more sophisticated reprocess tires into liquid and gaseous fuels, aromatic compounds and solid carbon products. The carbon products are similar in character to the carbon black used in the manufacture of tires, printing inks, toner, paints, as well as other products.

Pyrolysis is a two stage thermal decomposition, which heats the rubber in the absence of oxygen to break it into its constituent parts: carbon, oil, etc. The stages are primary cracking and post – cracking. De –polymerization and primary cracking, which take place progressively, occur by heating the tires to 450º – 500º C. Aromatic components produced at 700º – 800º C. Both processes can occur in a one-step furnace at 550º – 600º C.

It is well know fact that temperature influence of sulfur content in liquid secondary products. Therefore, to obtain a low sulfur content hydrocarbon liquids it is necessary to keep a temperature within the range 450º – 500º C.

Key influences on the process are temperature, retention time at the reaction temperature, pressure, and type of gaseous atmosphere. There are several types of reactor, either oxidative or reductive, and batch or continuous, fluidized bed, rotary kiln, traveling grate, and retort.

Gases are separated from oils in the condenser: light oils leaves the top of the fractional condensation column, heavy oils are collected at the bottom. The amortization of the volatile products is produced at low temperatures by continuous and simultaneous post-cracking.

Pyro – oil consists almost entirely of aromatic hydrocarbons, with $\pm$ 26% by weight of either benzene or toluene, the remainder is heavier molecular weight aromatic. The heavy oil remaining after recovery of the benzene and toluene can be catalytically cracked for more benzene, toluene, and xylenes for gasoline blending.

Pyrolysis produces a minimum of three commercialisable products including saleable steel, oils and carbon products. The resulting carbon products have proven viable as a replacement for some types of carbon black for use in inks, toners for photocopiers and printers, paint and even in tires.

Considering an ecological constituent, the pyrolysis technologies are most environment friendly. First, scrap tires treatment allows reducing a loading on the environment due to shorten their (tires) quantity. Moreover most of existent technologies do not use water for technological needs, do not produce wastes as well as all obtained products are valuable secondary raw materials with wide range of post-life application, and do not exceed a limits on emissions due to leakproofness of apparatus.

Investigation of scrap tires accumulation problem, their management, refer to set of laws and normative, and also statistical data show that scrap tires recycling is an economic profitable and ecological effective solution of two actual problems: looking for alternative sources of energy and how to treat accumulated scrap tires. This direction of investigation is enough perspective, which is able to show to all humanity how to save our lives and our Earth.

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O. M. Lozhachevska, Doctor of Economics, Professor (National Aviation University, Ukraine)
V. V. Matveev, Candidate of Economics, Associate Professor (National Aviation University, Ukraine)
M.V. Novykova, Candidate of Economics, Associate Professor (National Aviation University, Ukraine)
N. M. Kravchuk, Assistant Professor (National Aviation University, Ukraine)

MODERN TRENDS OF GLOBALIZATION PROCESSES IN THE AVIATION INDUSTRY

The investigation of globalization processes have been made along with the determination of positive and negative globalization effects. There have been reflected modern trends of integration of enterprises in the aviation industry.

Today the globalization process grows very fast. The biggest companies penetrate into the market and extend their activity. Globalization is beneficial for large-scale companies and destructive for small noncompetitive firms. In order to become competitive and successful in the global market companies should have strong production and sales capabilities. However, not all companies which won a considerable share of the domestic market can enter the world market.

The most important factor of globalization progress is a scale process of trade liberalization and investment activity in the world. Achieving a higher level of world economy liberalization contributes to strengthening the competition and attempts to reach a new qualitative level of global competitiveness by means of creating global alliances.

Global alliances aim at development and implementation of new products and services, financial strengthening of corporate development, reduction of transaction costs, etc. These processes are most evident today in such global industries as aircraft and motor car construction, air transportations, banking and insurance.

Strategic partners can get a global status only in cooperation. In recent years cooperation in the form of the alliance has considerably developed and changed a lot. Single targets characteristic for traditional joint ventures were changed for global strategies which force companies into alliances. That's why cooperation based upon the alliance gives plenty of opportunities for taking a good share of the world market.

Nowadays globalization influences a lot upon the development of any state. The modern world economy is dominated by global leaders on the one hand and on the other hand by most countries which consider economic globalization as new qualitative development conditions which can not be influenced by but should be taken into account.

Globalization is the objective process on a planet scale which has both positive and negative impact (table 1) [1]. On the one hand, through the distribution of innovations in technologies and management, active exchange of goods, services, investments it contributes to effective functioning of domestic economies. In the result, human society enjoy continuous increase of economic growth, general output expansion which will cause the increase of quantity and quality of manufactured tangible values under their simultaneous reduction in price. This should help to solve many social problems, improve the level and quality of lifestyle on a planet scale. Globalists in such a way hope to stimulate the total human progress and achieve the harmonization of an international community. From their point of view globalization is a bearer of hopes and progress.

However on the other hand globalization strengthens unbalance, asynchrony and disproportion of the development. Antiglobalists do not acknowledge the general usefulness of globalization and emphasize first of all its negative impact. In general antiglobalists consider the modern pattern of globalization to be irregular and unfair for most population of the planet, it can cause new global catastrophes.

Globalization intensifies not only economic but also political and social disparity between countries.

Therefore, globalization being a controversial process should be regulated on domestic and international levels.

Table 1

Globalization impact

Positive impact	*Negative impact*
▪ Growth of productive efficiency, social labor productivity, competition; ▪ Cost reduction of goods and services due to rationalisation, distribution of new technologies, technological innovations; ▪ More reasonable operation of all production factors; ▪ Extension of specialization and international division of labor; ▪ International trade expansion (due to cost reduction) on a reciprocal basis; ▪ More reasonable use of international capital that contributes to the growth of international direct investments and therefore provides new opportunities for a newly based industrial modernization; ▪ Growth of international competition, formation of new incentives for production development, labour productivity, motivation of scientific developments, mobilization of capital into socially stable areas; ▪ Motivation to more reasonably use and more efficiently distribute the natural recourses; ▪ Providing conditions for free exchange of information and knowledge; ▪ Establishing the system of equal access to information, technology and efficiency; ▪ Extending personal freedom, etc.	▪ Globalization threatens individuality and sovereignty of nations and countries which are not currently ready for equal competition with the most developed countries of the world and in the nearest future it will result in the absolute domination of the WEST over industrial civilizations of the EAST and the poorest countries will loose their sovereignty; ▪ Globalization will result in the growth of governmental and social control over the personality and therefore will threaten the personal freedom. Democracy and globalization are incompatible; ▪ Globalization will bring a polarity effect into the world society, strengthen disparity between vanguard of the global community (the USA, Western Europe and Japan), so called "golden billion" which comprise 19% of the world population and control 71% of the global trade of goods and services and backward periphery which comprise most population of the world with considerably lower lifestyle. During last 10-20 years ten periphery countries managed to enter a single world market. All other countries are condemned to backlogging; ▪ Globalization will inevitably result in the domination of the USA and developed countries over the whole planet.

Like any other structurally complicated process globalization is developing under the influence of numerous economic and non-economic factors [2]. The economic factor includes the enormous accumulation and centralization of capital, growth of big companies and financial groups which activity is transcending national boundaries adjusting to a world market zone. The non-economic factor implies political, social, technical elements and international events.

Political factors – national boundaries are gradually dwindling, becoming more and more transparent, giving more opportunities for freedom of movement, intensifying liberal tendencies, deregulation of the market and goods. International events – signing various acts by international organizations. Social factors – weakening role of traditions, social ties and customs, improving of people mobility. Technical factors – Internet, transport communications, etc. Means of transport and communications provide new opportunities for prompt spreading of ideas, goods, and financial resources.

Thus, the modern globalization process is a multifactor systematic process, development of which can be interpreted as a complicated interaction of economical, political, legal, mentally cultural and generally civilized factors. Globalization provides advantages to the countries which pursue an efficient domestic policy of development and competitive recovery. But still it can seriously slow down the development and bring crisis about in case of irrational economical policy of the country. Therefore, globalization comprise either threat or opportunity; both war and peace. However, domination of the first or second is currently more and more dependant upon understanding by mankind of humane values and country capability to better use globalization benefits.

Transport is an important sector of every state. Volume of transport services is much dependant upon the economic status of each country, and transport itself often stimulates the economy activity level. Air transport plays a special role among other kinds of transports.

The socio-economic system like an airline solves problems of both continuous production process and social issues. Due to the influence of various unfavorable factors we can evidence failures at air transport enterprises which can result in flight delays. Flight delays have economic and social consequences. For air transport companies it is very important to guarantee continuous production process. Flight regularity is one of the most important factors which characterizes airlines activity of air transportation production. Flight delays result in demurrage of aircrafts, disturbance of other flight rhythm and ill-coordinated work between divisions of a particular air transport enterprise. Strengthening of production stability contributes to the reduction of economic losses due to failures; apart from that it has an important social nature as it facilitates the qualitative improvement of customer service due to elimination of inconveniences caused by flight delays, saves time of passengers. The airlines performance will satisfy passengers only provided that there is a strong guarantee of flight safety and flight as well as efficiency and culture of servicing.

Aviation alliance is a mutually beneficial cooperation of large airlines. Such cooperation is also advantageous for passengers: if the national carrier cannot transport the client to the remote place itself, it forward the passenger to its alliance partners. It helps to operate worldwide flights with the utmost comfort. Apart from that the mutual system of accumulative benefits in alliances gives the passenger the opportunity to accumulate benefits in one airline to use them later in the other.

Today in the international aviation we can single out three key aviation alliances. They are Star Alliance, One World, Sky Team. The information about aviation alliances is presented in Table 2.

Table 2

Te biggest global alliances

Name	Date of foundation	Number of members	Number of daily flights	Number of destination places	Number of destination countries
Star Alliance	May 1997	19	17000	897	160
Oneworld	February 1999	10	9297	700	142
Skyteam	June 2000	11	16409	841	162

Establishment of global aviation alliances influences the industry as well [3, 4]. Therefore, we can conclude that the airlines which do not intend to enter global alliances have a risk to leave the industry and air transport market.

There are also definite globalization tendencies at air industrial companies due to establishing global corporate structures in the process of capital consolidation. In the result of tremendous circulating assets mobilization and consolidated financing programs in these productive organizations there is possibility to determine and solve global issues.

Production capabilities being served by enormous circulating assets, intelectual and labor resources helps to determine and solve relative issues, become a leader in the competition [5]. The largest global companies in the aviation industry are: “Boeing”, “Lockheed Martin”, EADS, “British Aerospace”, “Rayth eon-Hughes” and others.

Therefore, the basic financial requirement which is formed by the world market for the “addmission” to manufacturers which project and product modern aircrafts is consolidated capital that is based upon production with the annual sales volume amounted to min. some billions of USD. So, according to the opinion of the authors, in order to get over crisis in the aviation sector of

Ukraine it is necessary to create favourable environment for the national economic agents activating the world experience of air enterprise integration into a unified system.

Thus, globalization processes are unprejudiced processes which take place in socio-economic systems of any level on "survival of the fittest" basis.

Today the process of Ukrainian economy transformation and integration into the system of international labor division are tightly connected to the growth of national competitiveness. Manifoldness of this problem under the competition growth, instability of social and political factors, restructuring of the world aviation system, internationalization of operations complicates the management decision making and forces air enterprises to search methods of capabilities consolidation and cooperation development in the struggle for survival or market leadership.

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M.G. Lutskiy, (National Aviation University, Ukraine)
U.G. Simonenko, (National Aviation University, Ukraine)
V.V. Davydenko, (National Aviation University, Ukraine)

PROSPECTS OF CORPORATE MANAGEMENT BY INNOVATIVE DEVELOPMENT

Influence of new technologies on principles of functioning of enterprises in the conditions of global innovative development is examined, optimization of regional potential, increase of status of innovative strategy and bringing up of it from functional to the corporate level.

Orientation of socio-economic development in a modern world and Ukraine causes increase of interest to researches in area of innovative management as the proper paradigm possessing potential for development of social structures in a quickly changing and increasing competition environment. The dominant role of innovations in the process of development of the system of public production and reproduction is characterized by concrete social dependences evidently demonstrating correlation of innovative management with the specific of socio-cultural context.

Radical transformations overcoming all system of public production put the leaders of organizations before the necessity of sound changes in practice of management. Process of optimization of administrative activity, carried out on the base of transition to solving of problems of modern management by introduction in administrative activity of the proper innovative traditions is, in fact, the process of innovative updating of administrative culture, taking place at all levels of hierarchy. Development and forming of the innovative administrative technologies based on actualization of humanistic principles of management confirms once again the role of socio-cultural factors in the process of regulation and development of economic mechanisms.

Therefore, the fruitful solving of problems of administrative activity is directly related to the complex analysis of general tendencies and regularities of development of innovative culture, revealing specific features of cooperation of innovation with the introduction environment, and also research of the structure and construction of models representing general and partial aspects of this phenomenon of innovative culture.

Problems of innovations and organizationally-administrative culture, was studied by the well-known scientists as: F. Taylor, G. Gaunt, F. Gilbreit, G. Emerson, G. Ford, M. Weber, M. Vudkok, and others.

Economic world experience irrefutably proves that effective and steady development of subjects of economic activity in different spheres of business is achieved due to the large-scale use of innovations providing strategic competitive advantages on the market. Solving of problems of economics of regions is possible only on the way of scientifically-innovative breach. Selection of priorities of innovative policy requires the deeply grounded strategic approach. It is impermissible to use limited facilities of the state on support of false innovations developing prevailing, but out-of-date technologies, laying up the same a technological backwardness and low competitiveness of products.

However, up to the present there is unclaimedness of innovative management, conditioned by high profitability of traditional forms of activity. Informative opacity of market, state privileges on the export, absence of stimuli for redrawing of investments in innovative projects is the second impedimental circumstance. But the main reason of delays in innovative development of regions is absence of the informative providing of vital functions and management by region and other territorial socio-economic communities, moreover, not small role here belongs to the innovative systems on the base of corporate educational structures, innovative processes being a catalyst at all levels.

Sluggishness of the economics management system, foremost, at corporate level, high degree of indefiniteness, absence of the proper informative base – all these factors sufficiently introduction of tradition of forming of the coordinated conceptions and programs of innovative development of the corporate economic systems. The extrapolative methods used for the long-range planning, supposing saving of development trends of the corporate systems and carrying fully objective character, does not work now, and it is necessary to employ expert methods for the decision-making. For preparation of decision to the experts it is necessary to possess system information, i.e. to examine corporation not isolated and taking into account only competitors, and in more wide plan, - as an element of the large open system [1].

Modern approach to the management of development of the large corporate system is impossible without the use of innovations on the base of information technologies, as success of any administrative actions depends on that, as far as measures on collection, processing and representing of information are universal and effective. The tasks of authorities are universal – any administration must work out actual problems, distribute critically important information, multiply profitability, promote the growth of welfare of personnel and support high level of efficiency. Exactly in these important directions the correctly chosen information technologies allow changing of the administrative work in the revolutionary way.

Daily all new and new goods and services appear at the market. Expansion of the spectrum of instruments, fund and currency markets, is calculated in tens and even by hundreds. There is permanent improvement of existing and appearance of new products of consumption. An assortment row broadens transiently.

Appearance of new technologies carries in itself enormous possibilities for the sphere of education, health protection, business, and facilities of communication. However along with the positive changes for the life-support of people consequence of scientific and technical progress carry negative character. Traditional methods of management and economics adjusting do not operate any more. And since it is unreasonable to slow the development of scientific and technical progress, and removing of its influence on the change of usual economic climate is impossible, so objectively inevitably there is the necessity of making of new methods of management.

Development of new technologies and markets resulted in that today in a whole world the economy growing of economic subjects is determined by that share of products and equipment, which contain progressive knowledges and modern decisions. In economic literature this process is being characterized as transition from an industrial economy to the economy based on knowledges [2], which will prevail in age XXI. Their basic difference is in the following. In the industrial economy perfection of products is achieved due to the employment of new knowledges to the natural resources, equipment, labor, and in the innovative type of economy this development is provided due to application of new knowledges to knowledges.

Science grows into one of the most important spheres, determining the prospects of position of separate countries in geopolitics. In any case, the innovations are a boom in the whole civilized world. Specialists forecast, that certain enterprise, certain region or certain country, which will be unable to increase their scientifically-technological potential, will be doomed to deep dependence, or even rather on absorption (direct or indirect) by other innovatively strong enterprises, regions, states.

In connection with the set transition to the economy of high technologies, i.e. sphere of science of both education and practice, leaders of enterprises and organizations, frequently set themselves a question about: what are the most modern principles and tendencies in methodology of innovative management? The innovations are accepted to consider not only the guarantee of steady economic development but also to bind it with the venture, which means risk business. In innovative activity it is impossible to operate without the risk. But essentially all economic activity is related to the vagueness of result, and to employ resources in yesterday far more risky, than in tomorrow. As leading foreign and domestic experience shows, introduction of innovations can appear highly risky only for those, does not possess sufficient competitiveness and modern methodology.

In opinion of the most specialists, it is expedient to examine the innovations from the position of process of mastering of food and process innovations directed on the increase of scientifically-technological level of the certain enterprise, and it is necessary to consider new technologies in the field of business (business-innovations) as complementary, because they are developing in a greater degree round strong industry, not vice versa. Thus, it is suggested to consider the problem of mastering of innovations without depending on some certain terms, in its ideal form, and only then to correlate theoretical aspects with a practical situation.

Economic science indicates eight key spaces or basic spheres of activity, within limits of which the enterprise determines its main objectives. This is position of the enterprise on the market, level of productivity, availability of productions resources, stability rate, system of management, professionalism of personnel, social responsibility and innovative activity. In the long-term decision-making all aggregate of the determined strategic goals stands before an enterprise, however, in the certain stages of economic development some of them are more meaningful, than other. The situation analysis of strategic objectives of the enterprise shows that up to the present objectives in the sphere of scientific researches and developments are the most sufficient ones.

We examine the environment of enterprise traditionally as consisting of three spheres: general (policy and economy, scientific and technical progress, society and ecology), direct (suppliers and consumers, competitors, shareholders and creditors) and internal surroundings (scientific research and experience constructive works, marketing, production, finances and personnel). Development of new technologies substantially affects each of the selected elements individually, beginning from the political decision-making and concluding by the promotion of personnel. On the whole, the pressure appears so considerable, that to ignore or control this process appears impossible.

In the quickly changing world of high technologies your tomorrow competitor can be not today's opponent, he may even absent presently. Fumio Kodama [2] names them “enemies-invisibles”. They appear on the market without some warning signals, from nowhere. Reality is such that new technologies suddenly appearing in a great numbers find by surprise sluggish ones. The influence of innovations appears stronger than the power of that or another enterprise, region, state. And until the new methods of management by economic subjects will not be produced in the changing terms, related to the transition in the new economic mode, the sphere of innovative activity will remain one of the priority ones and, simultaneously, problematic for perspective development of an enterprise. This conclusion confirms the necessity of research of the methods of innovative and strategic management by an enterprise and establishment of intercommunication between them.

Modern principles of innovations’ management on the enterprise are preferably to examine in their evolutional becoming, in the light of that, how the terms of business conducting have being changed, and what influence transformation of external environment rendered on the methods of decision-making.

According to the modern researchers [3], in the theory of innovations’ management determine four stages, four generations of development of scientific research and experience constructive works [2]. Complication of receptions and methods of realization of innovative activity grows as far as markets and technologies development.

At the moment it is rather difficult to say confidently, from what point in history of economic theory it is necessary to conduct counting out of innovative management in its modern understanding. Some specialists [2] attributes becoming of the theory of management to the innovations with the appearance of the first laboratories, first subdivisions of scientific research and experience constructive works in large companies.

Primarily guidance by scientific-research work was carried out by scientists. They were responsible for the selection and implementation of researches projects. Many of such developments had not only substantial scientific but also commercial results.

Scientific-research activity, the management of which was carried out by scientists-researchers is accepted to attribute to scientific research and experience constructive works of the first generation.

In course of time, corporate managers realized the necessity of management in the research activity. Now companies concentrate their attention on those projects, which, foremost, were targeted on their business. Today we attribute such management of scientific-research work to the second generation of scientific research and experience constructive works.

All system of factors of competitiveness of innovative firm can be subdivided into two basic groups.

The first group includes the parameters of the external environment affecting competitiveness of a company, but being out of the sphere of its direct influence (external factors). They are:
- level of competitiveness of firms-competitors;
- state economic policy in the countries-importers of goods and services;
- state economic policy in countries-exporters of goods and services.

The second group consists of factors of competitive advantages of the firm. Different aspects of market activity of innovative firm, as well as parameters reflecting the employment of the internal resources, are included into the group of these internal factors. This group includes:
- technical level and rates of updating of products;
- rates of technological updating;
- organization of production on the firm;
- availability and completeness of the employment of labors resources;
- availability and completeness of the employment of capital;
- level of qualification of the authorities and personnel of the company;
- market strategy of the firm;
- reputation of the firm;
- cooperation of firm with consumers;
- investment attractiveness;
- efficiency of production;
- consumption cost of the produced goods;
- useful effect of the produced goods.

With the development of scientific and technical progress the growth of industrial scientific research and experience constructive works occurs. Accordingly charges on research activity increase. Now the investments in the development of food and process innovations begin to make greater share of total corporate expenses. The prospects of the companies strongly depend on the successful work of researches departments. Then, as well as now, research activity was quite unforeseeable, and nobody could say, when will be created deserving market product.

In order to reduce market and temporal vagueness, companies began to form the balanced business- portfolio directed on rational distribution of profit and risk between the produced products and perspective food innovations. Scientific-research projects began to select on the basis of portfolio matrices, analysis of competitiveness and life cycle. The practice of technological management, based on the conception of the strategic planning, is accepted to attribute to the third generation of scientific research and experience constructive works.

In practice of the third generation basic attention is concentrated on the satisfaction of obvious necessities of consumers, i.e. those, that lie on a surface. Enterprises offer new products to the market on the basis of marketing researches. At such approach users can only guess about goods and services appearing soon on the market. Wholesalers, suppliers, shareholders, can only suppose where to invest their facilities. Thus the so-called hidden needs remain dissatisfied.

As an alternative specialists [2] offer joint participation in the development of new products, both producers and buyers, suppliers and other interested parties. Such joint activity must begin on the stage of the development of an innovation. And when the innovation will be ready for commercialization, its useful properties have been already tested by all interested parties. Such approach is directed, foremost, on the satisfaction of the hidden necessities of buyers.

Thus, the needs of clients and technical availabilities suffer simultaneous development within the framework of fourth generation of scientific research and experience constructive works. It is the process of the interdependent education in which the real necessities are considered and solving in the light of technologically feasible conceptions and availabilities.

New practice of realization of scientific-research activity brings in substantial changes in the conducting of scientific research and experience constructive works. In the process of research on the basis of fourth generation it is necessary to define, how it is possible to use scientific and technical knowledges for determination and satisfaction of the "hidden" needs of users. Hence it is possible to talk about expansion of mission of scientific research and experience constructive works in the process of the enterprise management. Meantime the authors of many manuals in innovative management continue to consider it as one of the functions of management, not noticing the fact, that innovative activity stops to be as such and all more and more strengthens its value in the corporate plan.

It is interesting circumstance that in the methodology of strategic management four stages of the development are selected as well. Their evolution mirror reflects principles of the development of four generations of scientific research and experience constructive works. Briefly we will describe them.

The first systems of planning in the world practice were based on conducting of annual financial estimates-budgets by expenses items on different goals. Their main task was in the costs' management. In this period of development of economic relations realization of the financial planning was considered as sufficient condition for the effective functioning of the economic subjects. In the development of methodology of strategic management name this stage is determined as "management on the basis of control under execution", and the possible reaction of organizations on the changes was determined after accomplishing of events [3].

With acceleration of rates of economic development and rivalry, companies could not anymore depend upon forming of a budget as on the system of preparation to the solving of future competition problems. To increase competitiveness in new terms, they passed to the long-term planning which quickly proved its utility and was accepted by many large and sufficient number of middle firms.

As far as growth of the crises phenomena occurs, toughening of competition forecasts on the basis of extrapolation left off to respond requirements of dynamically changing external environment. Financial and long-term planning was integrated into the strategic planning purpose of which consisted in the determination of future market position, with that a company could adequately react on its changes. A new method got the name "management on the basis of foresight of changes".

In 1970-1990 western firms pass from the strategic planning to the strategic management of their activity, which also name a market one, underlining here the external orientation of organization management. Such approach to the management allows economic subjects to pass from the reactive form of management (decision-making as reaction on current problems) to the management on the basis of analysis and forecasts. It allows not only reacting on the changes of external environment but also to create them, influence on them. Methodological principle of modern strategic management consists in the construction of a strategy not from the past to the present, but from the future through the past to the present and is determined as management "on the basis of flexible urgent decisions".

Thus, the origin of methodology of strategic management, and innovative management, is accepted to consider from point of evolution of the planning systems as reaction of economic subjects on complication of external terms of business conducting.

Brian Twiss [4] also compares innovative and strategic planning and selects some aspects of their intercommunication. In particular, in the decision-making concerning strategy of scientific research and experience constructive works notices the necessity of consideration of such strategic factors, as analysis of external environment, placing of resources and corporate strategy. Technology is the main motive power of changes in organizations, potentially able to give them new possibilities. Therefore technologists must take active part in the process of strategic decision-making, in fact only they can estimate the range of this potential [5].

Growth trends and influencing of science and technical progress testify to actuality of integration of strategic and innovative management. In fact any strategy is the changes, and any changes, directed on the perfection of some process, are innovations. Only participation of technologists is not enough in the strategic questions. In the world of new technologies strategy and innovations must go parallel at the same time. The question is about that in the basis of every strategic plan should stand the task of the development and bringing up to the food innovation and mastering of new process technologies.

Mutual penetration of strategic and innovative management can result in the possible future these two types of management, one of which today related to the general management (strategic), and other – to functional one (innovative), is fully integrated. Such suggestion is based on that the innovations determine the general line of the perspective development of an enterprise in a greater degree.

On the basis of the selected functions of strategic and innovative management in the process of enterprise management and taking into consideration the set tendency of transition to the innovative type of economic development into the world economy, it is possible to draw conclusion that in the economic theory and practice there are certain preconditions for integration of two types of management.

Fully probably, that it will be not management, but programming of strategic innovations: firstly, economics in general and management in particular stronger gravitate to the technique and technical equipping; secondly, it is possible the programs in the strategic management will be wide-spread by an enterprise soon, just as the programs on the operative control and adjusting today; thirdly, it is better to set a certain executions sequence to the future and then actively create the changes friendly to itself, i.e. influence on the situation, but not simply passive manage.

Many scientists assume that in age XXI position of countries in geopolitical competition, along with education and health of population, will determine the development of science and key productive systems of the newest technological mode, possibilities of informative environment, and also ability of economic mechanism to generate high innovative activity. So the question of transition to the innovative economy is geopolitical one. And it is necessary to adhere to the principle, that not a single country can be competitive in all spheres simultaneously.

Up to the present, the main reason of innovative passivity is seen not in absence of financial resources, but rather as an innovative management on enterprises. Absence of their own funds is rather related to the shortage of perspective projects, as well as to the leader-innovator able to organize their development and realization. With respect to the strategic activity in general and innovative in particular, an alternative to official restraining factors can suppose two reasons, as unwillingness and lack of ability to master new technologies.

Today for satisfaction of needs consumers and saving of competitiveness a food assortment must be fully changed for the period from 3 to 5 years. Those who continue to apply out-of-date technology will suffer guaranteed losses. It is already proved that in course of time they either is beggared or forcedly pass to introduction of innovations. Overwhelming majority of domestic enterprises in the last twenty years appeared not able to apply new technologies in industries. The more greatest, the goods' producers were able to do, was to change the form or color of a good, but such changes on the essence brake development of technical progress, because facilities, instead employment in new technologies, are employed in the packing equipment. The real breach in the economics can be attained only due to the basic and improving innovations which can become basis of forming of technique and technologies of new generation and to satisfy the same constantly changing requirements of consumers.

Going back to the factors restraining innovative activity, we will notice that a rare manager will give objective estimation to quality of the management carrying by him. It is possible to assume from the above-mentioned, that some managers simply have not yet learned this type of activity new for them. Even if innovative activity is carried out on enterprises, its management corresponds to the first, in the best case to the second generation of management of scientific research and experience constructive works. As foreign specialists speak out [2], with respect to the fourth generation the question about the transition on this level stands sharply before them. So it is possible to draw conclusion that from the point of strategic competitiveness of domestic commodity producers should increase rates to master the management of scientific research and experience constructive works at level of the third generation. And it means, in the basis of every strategic plan it is necessary to put mastering of new technologies and productions. It is thus needed to mean that new technology remains progressive much longer, than equipment.

The aforesaid serves as confirmation of the necessity of research of the increasing affection of new technologies on the principles of functioning of enterprises in new terms. The increase of status of innovative management and bringing of it from functional to the corporate level is objectively needed. In the conditions of strengthening of the role of new technologies as factor of the economic growing and development, innovative activity must become general strategic purpose, to be not a partial functional task.

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L.L. Lytvynenko, Post-graduate student (National Aviation University, Ukraine)
V.O. Novak, Candidate of Economic Sciences, Professor (National Aviation University, Ukraine)

FORMATION OF BASIC TRANSPORT PROVISION PRINCIPLES

The urgent problem of inappropriate transport provision in implementing Ukrainian foreign economic policy has been revealed, conceptual scheme of effective cooperation of transport systems of different countries has been improved. The complex of measures in provision of efficient transport services of Ukrainian companies has been worked out.

Ukraine has already set its own course to be included in the system of global economic relations and international labour division, taking account of special features of national economy and geographical structure of foreign trade. Ukraine completed the process of joining World Trade Organization. This step demanded from the government realization of special measures concerning the integration of the transport structures within regional unions, as well as coordination of defined integration processes with formation of the single transport space.

Transport plays a vital role in the development of foreign economic ties and realization of geopolitical potential of Ukraine as a transit country. Successful development of the transport system will be of great importance for the ability of Ukraine to attract supplementary foreign investments. It is important to enhance implementation of transportation development objectives not only for transport industry, but for the whole Ukrainian economy, for the effective functioning of productive and social sphere provided by stable and reliable work of transport.

Thus, the problem of improvement of transport-economic ties, in particular in the sphere of aviation, is a matter of current interest. Urgency and practical significance of the indicated problems caused the necessity in carrying out of the research studies in the given sphere.

The article aims at the formation of basic transport provision principles improvement of the conceptual scheme of effective cooperation of the transport systems of different countries in realization of international transportations, development of the complex of measures in provision of efficient transport services by participants of the transport market.

By analyzing literature sources [1-5] several verifications in researching of the set problem have been made. Acute problems in Ukrainian transport industry have been caused by different factors considered further in the article.

World transport is a complex system consisting of the world transport companies, intermediaries and forwarders, on the one hand, and traffic control authorities of different countries, on the other hand, operating as interrelated and interactive elements. On the whole, the dynamics, structure and volumes and directions of transportations by means of transport, tendencies in foreign trade activity of the country transport industry determine the level of development of transport industry of Ukraine.

Transport is the mean of provision of foreign economic relations and an exporter of transport services as well.

As indicated in [5], transport provision in implementing the foreign economic policy is organized in economic, legal, technical and technological aspects system of servicing by different modes of transport and transport-road complex of Ukraine foreign trade relations and realization of Ukrainian transport production on international markets.

Export of transport services is one of the main types of foreign economic activity of Ukraine, concerning the provision of services by the subjects of foreign economic activity of Ukraine to foreign subjects of economic activity.

Bilateral and multilateral international agreements and specific forwarding contracts determine conditions and order of realization of export of transport services abroad.

The regulation of transport activity concerning foreign economic ties and export of transport services is carried out at the government, sectoral, interindustrial and regional levels, as well as directly by the subjects of this activity.

For total satisfaction of foreign trade requirements in export-import transportations by domestic transport the volumes of export of transport services abroad are regulated by the state taking into account the conjuncture on international freight markets.

Transport development must be fulfilled according to the directions and forecasts of social and economic development of Ukraine in consideration of independent social and economic development of regions. It must respond to the specific requirements of economic efficiency of investments and provide sufficient rise of technical level of all transport modes and their technical renewal and modernization.

It should be mentioned that the complex of interrelated and interactive factors of external environment affects the development of transport-economic ties of Ukraine. In the authors' opinion, positive stereotypes of traffic development can considerably improve the situation in the Ukrainian transport industry, in particular:

- global and national economic growth;
- gross national product increase;
- easing of currency exchange restrictions;
- modernization of transport means;
- reduction in the price of capital;
- development of combined transport;
- reduction of prime cost of transportation and handling;
- improvement of transport technologies and introduction of new ones;
- introduction of new transport market segments;
- renewal of domestic terminals;
- liberalization of the national transport market;
- expansion and modernization of transport network;
- integration of Ukraine into the global economy etc.

However, there are also external environmental factors restraining the development of transport economic ties of Ukraine. Among them:

- industrial recession;
- devaluation of currency;
- operational costs exceeds inflation;
- growth of the prices for covering of costs;
- insufficient capital;
- noise and emission control;
- increase of depreciation of technical means and deterioration of their structure;
- insufficiently developed communications;
- restrictive government regulations.

Scientific and technological achievements also affect considerably the transport industry development. New up-to-date equipment and machinery, for instance satellite air navigation systems, global distribution systems, loading-unloading systems, new materials have appeared in the last years. Almost all operations are computerized nowadays [2]. Searching of the ways of transport costs reduction is getting new meaning (for instance, wide using of Internet in transportations).

As showed in [5], the government transport policy in the sphere of foreign trade activity is aimed at strengthening of Ukrainian positions at the international air freight markets, creation of special conditions for the development and efficiency rise of foreign economic ties, provision of an independent foreign trade through realization of the following measures:

- providing of the governmental support of technical and technological modernization of transport-road complex of Ukraine for the acceleration of reaching of the world standards of transport servicing quality;

– intensification of integration of the transport system of Ukraine with the world transport system;

– setting and developing of transport and economic ties with foreign partners on a parity basis;

– protection of the national interests and legal interests of Ukrainian transport businessmen;

– openness of the transport system of Ukraine for foreign partners and investors;

– stimulation of export oriented types of transport activity, development of the transport export potential of Ukraine;

– maximum approaching of national transport legislation of Ukraine to the rules of international law;

– creation of favorable conditions for the free enterprise in the sphere of transport and intermediary servicing of foreign economic ties, development of the competition and restriction of monopoly in this industry.

In accordance with the forecasts demand rise on transport services at a rate of 4-5 % annually is expected. Up to the present transport system of Ukraine is only partly ready to provide transportations in such volume.

At the moment the export potential of the Ukrainian transport-road complex is using incompletely. In this situation, the insufficient competitive capacity of the Ukrainian transport and reducing of it in the last years are the main negative factors [5].

As indicated in [1] the reasons of the low transport competitive capacity are as follows:

– outdated basic funds, moral and physical depreciation of them, discrepancy between their technical level and perspective requirements;

– low level of intersectoral coordination in the development of transport infrastructure resulting in disconnection of a single transport space, irrational resource employment and reduction of transport employment effectiveness;

– unsatisfactory level of the technological organization of the forwarding process;

– insufficient informational provision;

– slow improvement of transport technologies and their insufficient connection with productive, trade, storage and customs technologies;

– slight rate of employment of geopolitical position of Ukraine and abilities of it's transport communications in international cargo transit through Ukrainian territory;

– existence of numerous technological barriers of cargo transportation through the state and customs frontier of Ukraine;

– lag in realization of the state and sectoral programs in the sphere of different activity types, transport modes, transport machine building;

– low level of transport servicing;

– insufficient integration rates of the transport-road complex of Ukraine with the European and world transport systems;

– absence of legal regulations concerning the transport provision of foreign economic activity, instability of legal basis and absence of necessary guarantees of property for foreign cargo owners and carriers.

Under the conditions of fierce competition Ukrainian transport companies endeavour to operate with powerful foreign world carriers on the international transport market. However, to increase transport competitiveness the government should improve regulatory mechanism.

Transport industry is currently updated through globalization and internationalization processes in world economy. Therefore, Ukraine aims at European integration requiring solving of problems concerning provision of competitive capacity of national air transport and large-scale modernization of air transport industry.

In the authors' opinion, the provision of the competitive capacity of the transport-road complex of Ukraine on international markets of transport services is connected with solving of two interrelated problems of great importance: firstly, creation of economic and legal conditions promoting the most complete usage of the potential of Ukrainian foreign trade and transit cargo carriers, and, secondly, technical and technological modernization of the Ukrainian transport.

Simplification of terms of crossing of state and customs frontier of Ukraine, and also carrying out of well-considered tariff and price policy, taking into account national interests and its transport-road complex on the whole, will facilitate increase of competitiveness of Ukrainian transport.

It is extremely important to provide the protection of rights of all participants in the transport process and eliminate unscrupulous Ukrainian and foreign competitors seizing markets of transport services.

Maximum provision of Ukrainian competitive benefits in air traffic development might have a positive impact on the economic situation in this country in general, and its economic growth and raise competitiveness on international markets, in particular.

Generally, successful and effective cooperation of transport systems of different countries in the sphere of international cargo and passenger transportation is being provided by:

- observance of mutual advantageous economic requirements in the sphere of international transportation;
- unification or harmonization of the rules of international law, that regulate international transportation, export and import, transport forwarding as well as other transport services;
- consistency of applicable technologies, commercial requirements and consumer service standards;
- applying of coordinated technical, technological and ecological standards and claims concerning interactive elements of the transport systems [5].

From the authors' point of view, creation of a single and harmonized system of the informative providing of international transportations will be enabled by providing of transition on a single common standard of the informative providing of international transportations and harmonization of the system of the informative providing of international transportations by introduction of up-to-date IT-technologies in the process of international transportations.

Standardization of technical and technological procedures of transportation and maintenance of international transportations, as well as hard observance of international standards and requirements concerning harmful discharges into the environment will facilitate application of the concerted technical, technological, ecological standards and requirements of interactive elements of the transport systems.

In the authors' opinion, creation of coordinating and deliberative organs in countries participants of international transportations concerning standardization of legal norms regulating international transportations and harmonization of legal norms regulating international transportations by their observance by all participants of the process of international transportations on a parity basis should be implied by unification or harmonization of legal norms regulating international transportations.

As for us, observance of mutually beneficial economic requirements under realization of international transportations should allow elimination of monopolistic and oligopoly control in segments of market of international transportations and complete and comprehensive observance of different kinds of common agreements and contracts with partners in international transportations as well.

Compatibility of the applied technologies, commercial rules, consumer servicing standards is also considerably important in the provision of the transport systems' interaction effectiveness of different countries in performing of international transportations. In opinion of the authors, it should include creation of single technological and commercial rules of realization and maintenance of international transportations, and also creation of single consumer standards in realization and maintenance of international transportations.

Taking into account all the above-mentioned, the authors' improved version of the conceptual scheme of effective cooperation of the transport systems of different countries in realization of international transportations is shown on Fig. 1.

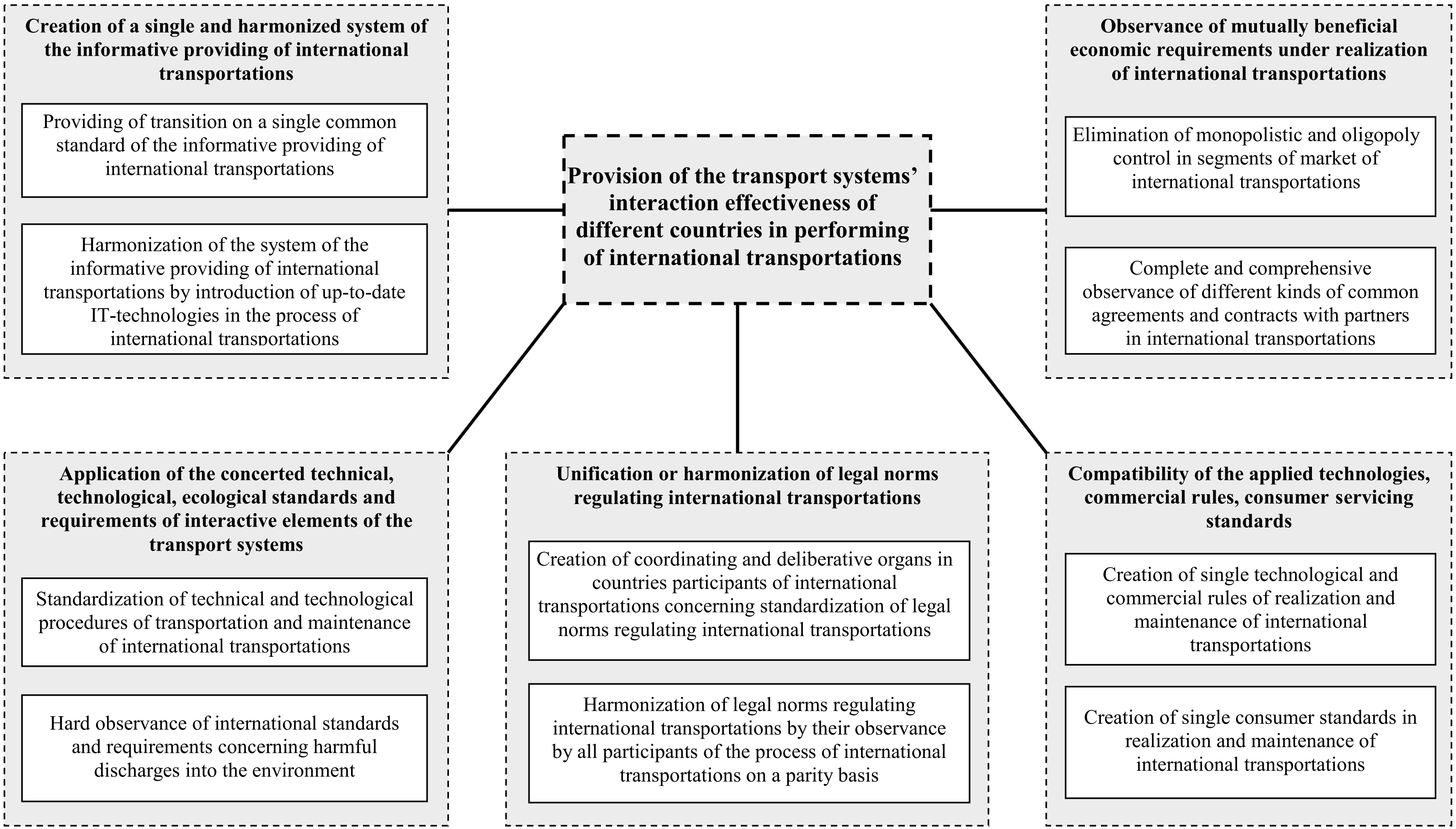

Fig. 1 Improved conceptual scheme of effective cooperation of the transport systems of different countries in realization of international transportations

Up to the present, representatives of different modes of transport involved in realization of transport development projects. For instance, the world air transport society is solving actively the problems of increasing of the absolute quantity of air accidents, congestion of air transport, intensification of the demand on air electrical communications and the sufficient growth of operating costs of air companies etc.

Taking into account all the above-mentioned the following measures should be taken into consideration to provide efficient transport services on through implementation of Ukrainian competitive benefits:

– working out of mechanisms providing financial support to the development of transport infrastructure in cooperation with public and private sectors;

– scientific and technical provision of innovation and investment projects improving the Ukrainian transport export;

– outline of technical and economical backgrounds and complex project documentation on the development of transport infrastructure;

– strengthening of additional organizational efforts to ensure highly coordinated actions at all levels of power;

– on drafting and implementing the above mentioned projects one should develop mechanisms to consolidate interested parties (local authorities, business communities);

– support of Ukrainian carriers on the international market of transport services, in particular, scientific provision of drafting international agreements to prevent application of discriminative terms in international transportations; ensuring of normative legal basis concerning activities of international transport companies;

– creation of the system of transport and logistics complexes (in order to reduce the time of delivery, and traffic costs and to optimize tariffs), as well as further development of information and logistics technologies;

– formation of the network of special traffic centers;

– renewal and modernization of transport facilities.

In the result of the conducted research authors have come to the conclusion that transport-road complex of Ukraine requires systematic and well considered modernization, transport provision in implementing the foreign economic policy of Ukraine requires further improvement. The complex of measures in provision of efficient transport services of Ukrainian companies and improved conceptual scheme of effective cooperation of the transport systems of different countries in realization of international transportations were proposed by the authors in the direction of development of Ukrainian transport system. Further researches in the given sphere will be extremely important and perspective, as improvement of transport-economic ties of Ukraine will affect positively the dynamics of macroeconomic indicators of the country and cause economic growth in all sectors of economics, in particular, in the sphere of aviation.

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T.A. Akimova, Post-graduate student (National Aviation University, Ukraine)

MAIN ISSUES OF AIRPORT MANAGEMENT AND DEVELOPMENT IN UKRAINE

The main objective of the article is to formulate the problems of Ukrainian airports and to suggest the ways of their solution. There is a problem of technical incomplience of Ukrainian airports with the requirements. There is also the necessity of perfection of the legislative component. Ukrainian government must support the new airport projects due to the favourable financing.

Economic globalization, market liberalization and increasing aviation deregulation together influence the world aviation businesses. And these trends accelerate the increase competition that all airports faces in developing new routes. Understanding and demonstrating the economic value of airports is increasingly important in terms of making the case for growth and in gaining support of local communities.

As business markets become national and international in scale, airports are increasingly being viewed as catalysts for local economic development. Their ability to generate jobs and attract new business is being used in many locations as a justification for public investments in new airport construction and expansion. Anticipation of new business activity also calls for appropriate planning.

In view of the geographical location of Ukraine, creation of terms for development of transportations of transits and transfers through its territory must be important direction of public policy.

Due to growth of international, political and economic relations independent Ukraine becomes more and more attractive to businessmen and tourists from all the countries of the world. Currently in Ukrane there is a trend of increase in air transportation volume.

In the nearest 15 years it is probable that the transport flows will undergo considerable growth. According to the opinion experts the volumes of air passenger transportation will grow in 4 times for the countries of the CIS, and Ukraine in particular (Fig.1).

Passenger flows through the airports of Ukraine have increased on 24,3 percent for 2007 and made up 9,2 million passengers. The passenger flows increased in the following airports: Kharkiv on 27,9 per cent, Donetsk on 19,2 per cent, Odesa on 27,1 per cent, Lviv on 52,4 per cent, Dnipropetrovsk on 23,9 per cent.

There are 34 airports in Ukraine. There are points of admission through the state border in 23 airports. 5 airports provide freight transport: Kyiv (Antonov), Yalta – heliport, Limanske, Dzhankoi, Ozerne.

9 airports are centrally administered. These airports are usually called “strategic”: Government enterprise „“Boryspil” international airport”, Utility enterprise „Donetsk international airport”, Utility enterprise „Odesa international airport”, Government enterprise „Lviv international airport”, Republican enterprise „Simferopol international airport”, Aviation utility enterprise „Kharkiv international airport”, International airport “Dnipropetrovsk”, Utility enterprise „Kyiv (Zhuliany) international airport”. Each strategic ariport covers area with radius about 250 km. But even in these airports technologies, technical state of facilities, systems and equipment do not always meet the standarts.

Airports that don`t belong to strategic service considerably less volume of air transportation. In 2007 the volume of air passenger transportation in Ukraine equaled 9186,2 thousand passengers. 97,08 per cent of passengers were managed in strategic airports. As for the international transportation, part of the strategic airports was 98,33 per cent. The above mentioned lets us conclude that the nonstrategic airports do not have possibility for independent development at their own cost.

Absence of terminal handlers in the airports which meet modern requirements can result in decline of passenger trafic dynamics.

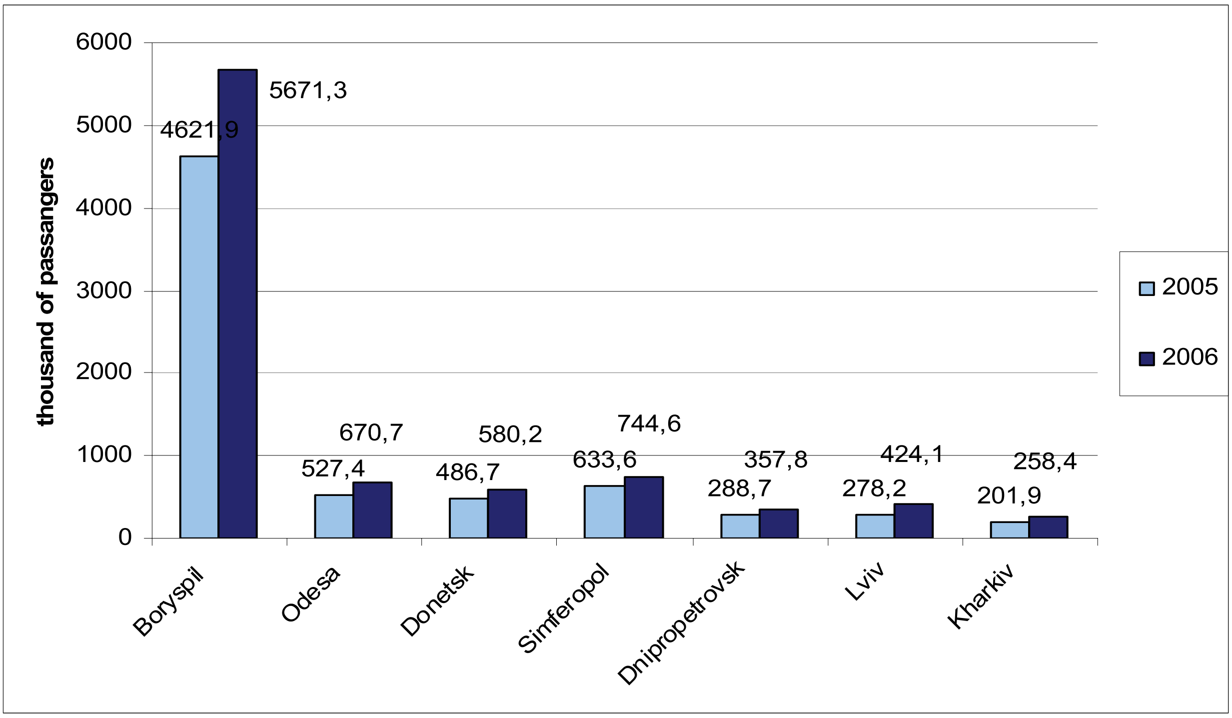

Fig. 1 Passenger flows through the leading airports of Ukraine

The main problem that should be solved is technical incomlience of Ukrainian airports with the ICAO and IATA requirements. Technical incomplience means aggregate of the following problems: insufficient terminal, runway and apron capacityt, considerable degree of capital assete and production equipment wearing out, capital buildings need immediate reconstruction.

The centralized operative control of different types of ownership is absent in Ukraine. That does impossible sufficient operativeness in accounting and implementation of orders, directed on airports development.

Also it follows to mark the necessity of perfection of the legislative component, that passing proper acts wich will stimulate the processes of transmission in a concession or lease some objects of airports. These changes preliminary must be carefully discussed and concerted with the Ministry of transport of Ukraine.

Ukrainian government must support the new airport projects due to the favorable financing. For developing airports investment costs are the most significant cost factor. A decision to rebuild an airport is to a large extent a political decision.

The completion of the largest infrustructure project in Ukrainian history is a prerequisite for the EURO2012, European Football Championship, and the important factor for the future economic development of the country.

Airports must be given the opportunity to develop their capacities. In many cases, existing political interests limit airports` ability to operate in a competitive manner. Airports must be extremely careful that they are not exposed to less favorable opportunities and conditions that the airline business as a result of government actions. As a result of ongoing structural changes, the coming decades will be characterized by airport networks and airport alliances. In order for this new business area to grow it requires the continued interest of private investors. In addition, airports need to be able to operate under the principles of free market.

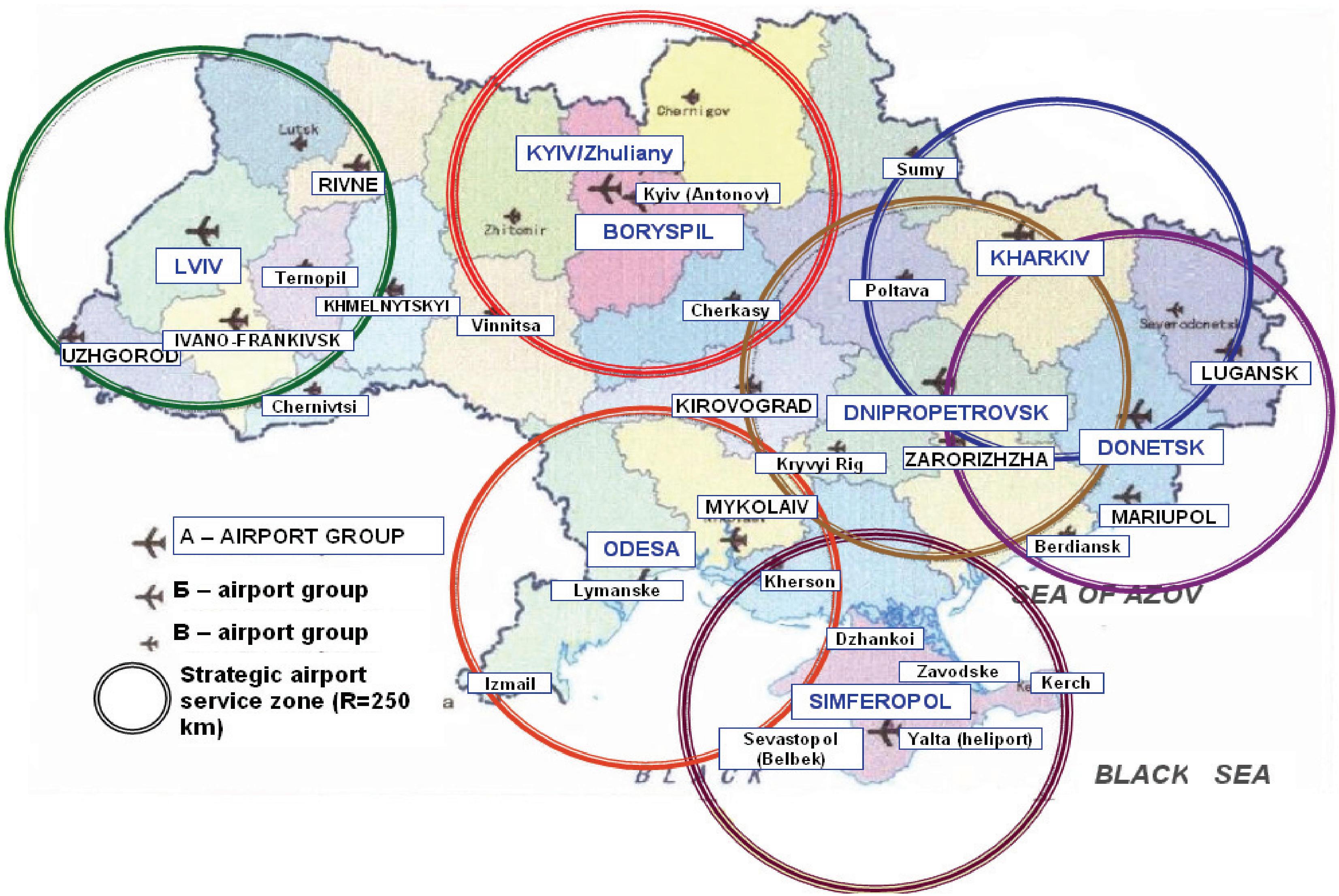

Fig. 2 Strategic airports of Ukraine

About 50-70 per cent of airport revenues come from airline usercharges while 30-50 per cent come from commercial airport activities such as leases, duty free, car parcing, airport ground handling services and supplies. For established airports, with continuous expansion plans, capital costs account for about 30-50 per cent of total costs. An efficient, well planned airport can save the airlines a lot of money. Therefore cutting capital costs is too narrow an approach. The goal should be to minimize the sum of airport user charges and airline operational costs. To optimize a masterplan in organizing the runway and terminal area layout to minimize taxiing distances is an accepted part of airport planning.

Joint participation by the airport authority and the airlines in the initial stages of the planning pricess is indispensable to the development of the successful programme. Early evaluations of airport projects will reduce the number of charges to the final programme and thereby minimize increased design costs. Such actions will also contribute to the probably of meeting scheduled completion dates.

The ultimate cost of any facility, both in terms of capital expenditure and annual user charges, will depend to a large extent, on its size. It is important that an accurate assessment of the required dimensions is made in early planning stages.

Airport managers must do far more now than just provide aircraft boarding gates, because today`s airport terminals do more than load and unload airplanes. They also serve as conference centers, freight depots, quasi-shopping malls, food courts and tourism bureaus. For airports planners and managers, financing terminal improvements often is less difficult than accurately anticipating growth to plan and build the necessary terminal space and related infrastructure. For an airport to be successful, it must be able to balance projected growth against major considerations such as runway capacity, available real estate and financial resources, and then create masterplan around that. A master plan ensures that the management of airside, landside and airport support facilities is done in a coherent way, respecting other providers. Modern terminals demand of collaboration on airport projects between consultants, suppliers, town planners, architects and designers.

The Build, Operate, Transfer (BOT) project is becoming a popular method of financing airports. With this method private companies or airport developers finance the construction of the airport in exchange for the operating rights for an extended period before transferring owership to the Airport Authority. Airports are monopoly businesses with very low risk and interest.

An important input to the planning process is the airport traffic forecast. An accurate forecast is essential since the sizing and the phasing of the airport project is dependant on the accuracy of the forecast. If the forecast understates demand, the facilities will be built too small and the airport will experience a capacity problem. If forecast overstates the demand, the facilities will be over-sized and the airlines will needlessly pay for under-utilised facilities.

It is essential that airport planning and development is done in a coordinated way in order to achieve safe and efficient, capacity balanced, cost-effective, functional airports.

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T.J. Gabrielova, Associated Professor (National Aviation University, Ukraine)
S.L. Lytvynenko, Post-graduate student (National Aviation University, Ukraine)

PECULIARITIES OF IMPROVEMENT UNIQUE OVERSIZED AIR LOADS CLASSIFICATION

The category „oversized load" in aviation was specified. Precise classification of unique oversized loads transported by air was developed in the direction of evenness and symmetry of aircrafts' loading distribution, introduction of supplementary classifications by necessity of application of loading and unloading facilities and by transportation terms and weight characteristics.

Extraordinary strengthening of competition on the world market of air transportations, and also dynamic development of the world market of super sized and super heavy air transportations have been conditioned by the number of factors, among which, in our view, factors related to appearance and wide application of super heavy and super sized loads delivering swiftly to the point of destination in the world economy are of great importance. Moreover it is not possible to take apart some types of super sized and super heavy cargoes taking into account possibility of partial or complete loss of their characteristics, and also taking into account the expenditure of superfluous time.

Creation of rather wide nomenclature of super heavy super sized loads by leading world companies requires application of maximum possibilities of transport means from their air carriers. Transportation of the given types of cargoes by air was impossible until quite recently because of lack of aircrafts with necessary unique transport descriptions.

The situation changed with the appearance of An-124-100 and An-225 types able to transport unique monocargoes weighing over 120 tones on the world commercial air routes. Appearance of these aircrafts made possible transportation of given types of cargoes, in particular, as well as super sized and super heavy cargoes non transported by air at all.

Taking into account the above-mentioned up to the present, in the authors' opinion, there is an acute necessity in the improvement of existing classifications of cargoes transported by air, especially this necessity is concerned with improvement of the existing classifications of unique super sized loads transported by air.

It is well-known fact that in the process of realization of transportation carrier delivers good getting characteristics of a load in the conditioned by a customer place. There are a lot of various classifications of loads for the convenience of realization of a process of transportation of loads. They allow determining the tariff class of load relatively quickly through dividing loads by definite descriptions, properties, features of transportation etc.

Basic and the most wide-used from the row of classification of loads is classification of division of loads by tariff nomenclature, and also transport classification of loads.

In accordance with classification of loads by tariff nomenclature specified in [7, PP.30-31], loads are divided by:

- origin – products of agriculture, food, chemical, light and heavy industry, ferrous and non-ferrous metallurgy;
- physical and chemical properties – perishable and stable to spoiling;
- transportation technique – dry and liquid;
- form presentation by a shipper to transportation – single container, bulk cargo, liquid etc.

Transport classification of loads, in particular, takes into account different characteristic aspects of transport organization, loading-unloading and transfer processes. However there are some basic subtypes of general transport classification of loads.

In particular in [7, PP.31-35] cargoes are classified by:

- method of transportation – piece, bulk, single container, dry, liquid and integrated the loads;

- physical and chemical properties – hygroscopic, freely heated, freely flash, inflammable, poisonous, explosive, radioactive materials, compressed gases, alkalis and acids, oxidizing materials etc.;

- regime of transportation – regime and non-regime;

- compatibility with other loads – compatible, incompatible, partly compatible, compatible or incompatible with that or other type of loads etc.

The classification of loads through distributing of them by physical and chemical properties [6] has been developed by the institute of complex-transport problems. In accordance with this classification loads are consolidated in groups by:

- physical condition – solid, liquid and gas;

- level of adaptation to implementation of loading-unloading works: piece, bulk, containerized, packaging, liquid and super sized;

- generalized physical, mechanical and chemical properties: dry, bulk, friable, adhesive, liquid not requiring protection from the environment, requiring protection from the environment, loads of large mass, loads of super large mass etc.;

- type of load – stone, building materials, ore, soils, cement, meat, pipes, timber, machine-tools etc.

Summing up the general types of existing classifications of loads, in opinion of authors, it is necessary to mark that the above-mentioned classifications are only basic and can be used in transportations of different kinds of loads, and, in particular, unique super sized loads by modes of transport, however their application in relation to the latter, in our opinion, is not so maximum optimum.

The problems of classification of loads in air transport, in authors' opinion, are considered sufficiently by neither leading researchers in transport industry, nor by the state administration authorities of different levels.

As the high-quality update of the normative-legal base of air transportations of cargoes in Ukraine took place only in 2003 with acceptance of Rules of air transportations of loads [1] developed by the Government service of Ukraine for supervision of providing of safety of aviation, with the appropriate replacement of obviously out-of-date and non-actual Soviet rules and manuals for organization of transportations developed as long ago as 1970-1980. However, in the given Rules of air transportations of loads effective classification of cargoes in aviation is practically absent.

There is only one determination «definite categories of loads» in existing Instruction for organization of transportations of loads by air transport [2] also developed by the Government service of Ukraine for supervision of providing of safety of aviation. They referred by developers as cargoes transportation of which, taking into account the character, must be performed under special terms.

Categories of loads indicated in classification include perishable, liquid, valuable, heavy, oversized, long sized, dangerous loads; living animals; automobiles and transport facilities; loads that stink strongly; military goods and double purpose goods; works of art, antiques and other kinds of museum exhibits; as well as non-accompanying luggage; human remains; moreover small packages and others.

To determine peculiarities, terms, technology of transportation and types of super sized cargoes in aviation, we will firstly analyze what one understands under these terms on other modes of transport.

On the automobile mode of transport loads are considered super sized if maximum sizes exceed 3.8 m in a height or 2.5 in a width, or 3 m in length, or which go outside the back of a platform more than 2 m. In particular, pipes, rolled profiles, timber, building materials, as well as machine-tools, different kinds of equipment, technical wheeled and caterpillar means, besides with military or general purpose and other materials belonging to the given types of cargoes on the automobile mode of transport [6, PP.5-9].

On marine and railway modes of transport determination of super sized load as such is absent, in principle. In accordance with the existing classifications of loads there are only bulk, oversized, super heavy, oversized super heavy and unique oversized super heavy freights on this transport mode. Cargoes are considered as oversized if their sizes exceed 3.4 meters in a height, or in a width, or in a diameter, or 14 meters in length. Super heavy loads are cargoes with mass over 35 tones and sizes less than that of oversized freights which are defined below. Oversized super heavy loads are those with mass over 35 tones and general sizes of oversized freights. Loads are considered unique oversized super heavy if their mass exceeds 100 tones and general dimensions of oversized freights [7, PP.419-436].

In accordance with the conducted authors' analysis of the existing classifications of cargoes in transport on the whole, in our opinion, super sized loads are cargoes requiring application of maximum possibilities of transport mean as by mass, as well as by geometrical and transportable characteristics owing to their sizes.

Up to the present technologies of unloading, loading, transportation of super sized loads on the automobile mode of transport, and also oversized and super heavy freights on the marine and railway modes of transport, developed and worked in practice by leading scientific schools, enterprises-practicians, as well as the number of leading authors, the acknowledged specialists in transport technologies and organization of air transportations are well-known. However, there is no efficient classification of unique super sized loads, transported by air, common in use by cargo air companies of charter type.

We shall try to give determination of super sized cargoes transported by air transport acceptable for all participants of the transport process and scientists specialized in transport technologies. As super sized loads on aviation transport, in our view, it is possible to consider those cargoes which are transported exceptionally by special ramp aircrafts with medium load capacity of Il-76 type, as well as by unique ramp aircrafts with large load capacity of An-124-100 and An-225 modifications.

The main peculiarity of ramp aircrafts is availability of special cargo hatch with ramp exceeding considerably sizes of standard cargo hatch of foreign aircraft types. Thus it should be noted that cargo plane Il-76 shall be considered as carriers of super sized loads, while aircrafts of An-124-100 and An-225 types can carry out transportation of exactly unique oversized super heavy freights with mass over 120 tones.

Exceptionally on the of An-124-100 and An-225 types of aircrafts it is possible to perform air transportation of super heavy, non-standard and super sized loads, such as: metallic constructions with large dimensions, all kinds of industrial equipment, aviation and aerospace technique, oversized ships, specialized heavy and super heavy wheeled and caterpillar technique, different kinds of other monocargoes.

Technologies of unloading, loading and transportations of unique super sized loads on the aerial mode of transport are developed mainly by factories-developers („Antonov Design Bereau") and producers of ramp aircraft („Aviant" and „Aviastar"), and also air companies basic operators of the given types of aircrafts – „Antonov Airlines" „Volga-Dniepr" and „Polet".

On the air transport, in our opinion, the classification of unique super sized loads offered in the dissertation work of A.N.Matovnicov [5] is probably the first effective one among the number of specialized scientific sources. In particular, the author have developed methodic of determination of basic criteria of classification of unique super sized loads, as well as the scheme of classification of unique super sized loads transported by air transport by wide-bodied ramp aircrafts, such as An-124-100, coming from the selection of bases of classification and determination of groups of unsteady and flat loads.

Taking into account indisputable and considerable contribution of the author to solving of extraordinarily topical, theoretically and practically significant problem of classification of loads on air transport, in our opinion, the given classification of loads, requires substantial improvement. For this purpose we have offered the improved classification of unique super sized loads transported by air transport (Fig. 1).

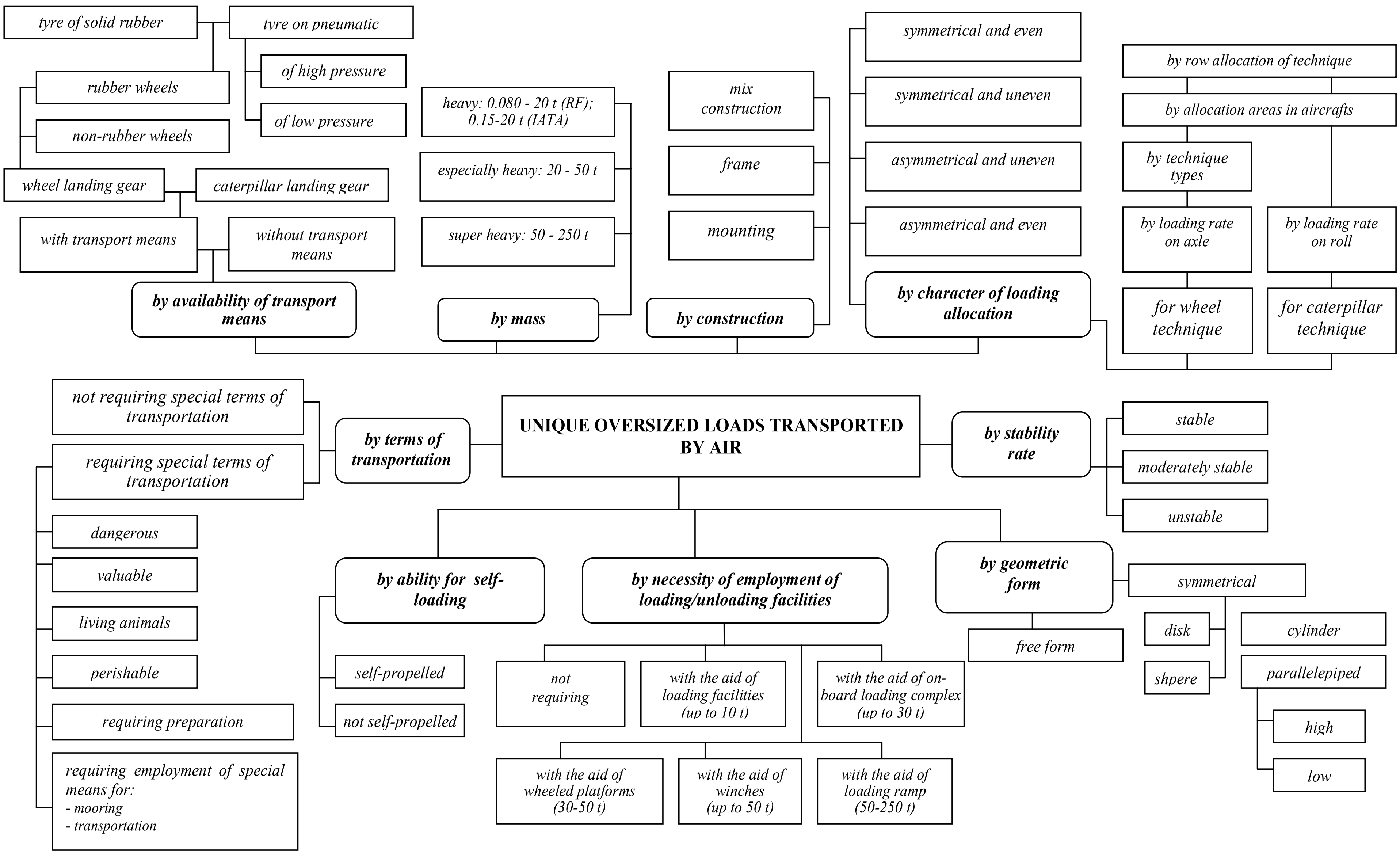

Fig. 1 Improved classification of unique super sized loads transported by air

Insertion of a number of the clarifications to offered in [5] classification of unique super sized loads transported by the air, described below, is conditioned by the necessity of improvement, both main terms and basic technology of loading-unloading and transportation of the given kind of loads on home-produced aircrafts of An-124-100 and An-225 types. Among main clarifications of classification of unique super sized cargoes transported by air, in opinion of the authors, it is necessary to mark the following.

Firstly, in our opinion, it is necessary to introduce additional and more high-quality allocating of loads not only by evenness and symmetry of distributing of loading in aircrafts, offered by the authors in [5], but also in accordance with instructions in loading and balancing of An-124-100 and An-225 cargo planes, and also taking into account the maximum loading capacity on an axis or roll accordingly for wheeled and caterpillar technique.

Excepting introduction of the allocation of cargoes in accordance with instructions in loading and balancing of the given modifications of aircrafts, the character of loading on the floor or ramp of plane has to take into account as allocation of technique by rows in aircrafts – double-row or central location, – as well as symmetrical or asymmetrical, by the types of technique – by the same type, double-type or different type location of technique accordingly and specialized areas of location of technique in aircrafts (A, B, C, D, E, F). Introduction of such type of clarifications in relation to the permissible loading on the floor of the freight cabin and ramp of the given aircraft types, in particular, it will give the opportunity to take into account the character of loading on them more precisely and simplify loading-unloading procedures, as well as mooring and balancing in cargo planes An-124-100 and An-225.

Secondly, the introduction of the supplementary classification for cargoes by the necessity of employment of loading and unloading facilities is offered by the authors. While performing the loading-unloading procedures with unique super sized loads on the air transport it is needed to use different specialized (sometimes absolutely unique and single developments, especially for the given modifications of aircrafts) facilities of platform and on-board plane mechanization. In particular, loading facilities used at the weight of the load up to 10 tones, on-board loading complex – at the weight of loads up to 30 tones, the wheeled platforms and winches – at loading from 30 tones to 50 tones and loading ramps – at loading up to 250 tones belong to the facilities of the above-mentioned type.

Depending on the necessity of the employment of that or other mean of mechanization, which can be used in the process of loading-unloading procedures, there are technical providing of this process offered by the airport or shippers (consignees) or if their availability is provided by the air company, that is also acceptable and it is enough wide-spread in transportation of unique super sized loads by air.

Taking into account the all aforesaid the selection of the following categories of loads not requiring employment of these facilities, and those, requiring their employment, with indication of all types of specialized facilities of platform and on-board plane mechanization is offered by the authors.

The insertion of clarification by the necessity of employment of loading and unloading facilities in the above-mentioned classification of loads will give the availability to basic air companies operating An-124-100 cargo planes („Antonov Airlines" „Volga-Dniepr" and „Polet") to carry out planning of the necessity of the employment of those or other types of loading-unloading facilities in the process of performing of transportation of unique super sized cargoes more qualified.

Thirdly, in our opinion, it is necessary to introduce in the classification of unique super sized cargoes transported by air more detailed distribution of loads by the terms of transportation: loads requiring special terms of transportation, in particular to select dangerous, valuable loads, living animals, perishables, loads requiring special preparation, loads requiring employment of the special facilities of mooring and transportation and others like that, and also and on those not requiring special terms of transportation.

Insertion of clarifications, concerning more detailed distribution of loads by the terms of transportation in the classification of unique super sized loads transported by air, is related to that the share of loads requiring special terms of transportation, as well as previous preparation (before flight), also requiring employment of special facilities for their transportation, grows swiftly in the general volume of unique super sized cargoes transported by the main operators of An-124-100 cargo planes.

In the component of distribution of super sized loads by the mass in the classification of unique super sized loads, transported by air, offered in [5], in our opinion, it is necessary to introduce a number of obligatory clarifications.

On the view of authors, the given clarifications are especially important for the Ukrainian operator of An-124-100 and An-225 cargo planes – air company „Antonov Airlines", while the level of importance of the given clarifications for the two other operators of An-124-100 cargo planes – the Russian air companies „Volga-Dniepr" and „Polet" is less meaningful owing to the peculiarities indicated below. So, in accordance with IATA documents, in particular [3,4], heave cargo is considered as load, one place of which exceeds 150 kg by weight, while in [5] the author suggests to consider heavy loads as cargoes weighing over 80 kg, that is in force only on the territory of Russian Federation in accordance with the federal rules of transportations of loads and can not be accepted by different multinational corporations and enterprises got used to perform transportations of their own loads by the generally accepted international rules of their transportation in the whole world.

Moreover, it was noticed by us that up to the present the appropriate international limit of the weight, after which the load is considered heavy, had been already introduced in the Ukrainian normative documents above described by the authors. Therefore, in our view, the offered weight ranges in the classification of unique super sized loads transported by air, namely – weights – from 0.150 tones to 20 tones, especially heavy – 20-50 tones, super heavy – 50-250 tones is the most correct and substantiated.

By way of the conducted conclusions the authors have been marked that all the above described clarifications concerning the classification of unique super sized loads transported by air will allow to adapt maximally mass-geometrical characteristics of loads to the characteristics of the unique cargo planes An-124-100 and An-225, and also systematize application of methodical and model apparatus in carrying of the given types of loads by the air transport.

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O. Tovkun, post-graduate student (KNTEU, Ukraine),
N. Tupitsin, candidate of science (National Aviation University, Ukraine)

INTERIM EVALUATION OF INVESTMENT PROJECT EFFECTIVENESS

The article is devoted to the problems of interim evaluation of investment project effectiveness and proposes the mathematical model of interim evaluation of effectiveness of enduring or completed investment project during determined last period of time.

Problem statement.

Typical characteristic of investment projects is the presence of time lag between consuming resources and getting revenue in projects. Therefore, quite often in project management practice appears such situation: the company executes project works and has certain expenses with factual absence of revenues for this project. And there are springing the problems: “How to define the effectiveness of executed works on project? How to estimate the efficiency of team work in project? If the fulfillment of projects is the main type of activity of a company, does the company function effectively?”

The problems of estimation of investment projects effectiveness was investigated in a quantity of works of such scientists as Berens V., Bearman G., Blekh U., Vasina G.O., Vilenski P.L., Voronov K., Gete U., Degtjarenko V.N., Kovaljov V.V., Livshyts V.N., Lukashevitch I.Y., Razu M.L., Smoljak S.O., Khavranek P., Schmidt S. etc. But the review of scientific works devoted to investment project effectiveness has shown an inability of common evaluation methods to estimate investment project effectiveness in determined accomplished period (as a part of project life cycle). Since their focus is an overall project effectiveness, they cannot provide a possibility to assess an effectiveness of partially completed project as well as an effectiveness of project in determined period within (and less than) the project life cycle.

Objective statement.

The main objective of the article is to show up the essence and to draw up the mathematical model of interim evaluation of investment project effectiveness.

Material explication.

As Interim Evaluation of Investment Project Effectiveness we propose to understand the methodology of evaluation of investment project effectiveness in determined accomplished period (as a part of project life cycle).

This methodology is the author’s vision to solving the problem of estimation investment projects effectiveness during interim stages of its execution and contains elements of traditional tool kit of measurement of investment projects effectiveness, earned value methodology, critical path methodology, graph theory etc [1-3].

Importance and necessity of interim evaluation of investment project effectiveness consist in ability to do following: to define what benefits the project has already brought to the company before project finish date or in determined last period; to estimate efficiency of work of project team in current period; to draw conclusion about quality of current project execution; to identify possible project risks and timely do correcting actions. For completed projects, where actual efficiency is known, an interim evaluation of investment project effectiveness enables to estimate project efficiency in separate determined periods in project life cycle. The methodology of evaluation of investment project effectiveness has particular worth for project-oriented companies where implementation of investments projects is a basic form of activity.

Let us determine the terms, which will be used during the determination of interim evaluation of investment projects effectiveness in this article.

– Investment project (further - project) - project, which foresees carrying out investments with the aim of getting the profit (net income) as the result of successful project execution.

– Investments – total sum of investments in different forms, which is necessary for project realization.

– Project income – total sum of revenues, planned to receive as a result of project execution. Depending on project payment schedule, project income may be received as the whole sum after project completion or as parts during project execution. If the project has intermediate result stages, during which the remarkable part of project income is received (for example, client accepts the results by parts and pays for executed project works), then such stages are reasonable to treat as separate sub-projects and to apply for their evaluation standard tool kit of estimation of investment project effectiveness.

– Net income of the project (before taxation) – total sum of project income minus total sum of project investments. If incomes and expenses of the project are executed in different time periods, for their comparison the discounting of corresponding cash flow have to be applied.

– Project works (or activities) - elementary structural components of project work breakdown structure. For every project work have to be defined: expected cost (and other required resources – if any), planned start and finish dates and connection with other project works. If there is a fixed time interval between some project works – in given calculation model such interval is treated as separate project work with given duration and zero cost.

– Project works path - linear chain of interconnected works in project network model from starting work of project to finishing one.

– Project network model – schematic representation of project works with stated interconnections between them.

– Project critical path – chain of interconnected critical works, which cumulative duration represents the total duration of project execution (the work is critical if change of its duration influences the total project duration). And non-critical works are characterized with the presence of remaining float (total path remaining float is the difference between its duration and critical path duration).

– Early date of project work finish – the date of earliest possible completion of project work (difference between early and late dates of work completion determines the possible float time for this work). For interim estimation of project effectiveness we will assume that early finish date of work is the most effective from the point of view of available resources (otherwise fixed time interval should be set between given and previous work with duration equals to difference between early and optimal date of project work finish).

The mathematical model of interim evaluation of investment project effectiveness can have the following representation:

$$ЧД_T = ЧД \times Кв_К \times Кс_К - Шп_К - Шв_К - ЧД_{К-Т},$$

where $ЧД_Т$ – is relative amount of net income of the project in period T (as part of total project's net income which can be correlated with period T based on the density and quality of project works execution in given period), monetary units (m.u.); ЧД – is planned total project's net income, m.u.; $Кв_К$ - is specific gravity of executed works in period K; $Кс_К$ - is level of complication of the executed works in period K; $Шп_К$ – is correction (fine) for time expiration of works in period K; $Шв_К$ – is correction (fine) for exceeding of actual cost above planned in period K; $ЧД_{К-Т}$ – is relative amount of net income of the project from the beginning of implementation of project (date t_0) to beginning of period of T (date t_1), m.u.

Explanation of elements of above-stated model:

- Specific gravity of the executed works in period K:

$$Кв_К = \frac{P_К^ф}{P},$$

where P_K^{ϕ} - is quantity of works, which actual date of completion belongs to period K; P – is total planned quantity of works within the project.

- Level of complication of executed works in period K.

As level of complication of project works we suggest to apply a ratio of labour-intensiveness of particular work to average labour-intensiveness of all project works (also can be applied resource-intensivity of works, their cost, work duration in time, importance of result of work etc):

$$Kc_K = \frac{\sum_{i=1}^{P}\left(T_i^{пл} \times \Phi_1(t_i^{\phi})\right)}{P_K^{\phi} \times T^{пл} / P},$$

where i - is sequence number of work in project; $T^{пл}_i$ - is planned labour-intensiveness of i-th work in project, man-hours; $T^{пл}$ - is total planned labour-intensiveness of project works, man-hours; $\Phi_1(t^{\phi}_i)$ - is function which determines actual completion of i-th work in period K.

The function of $\Phi_1(t^{\phi}_i)$ has the following representation:

$$\Phi_1(t_i^{\phi}) = \begin{cases} 1, & t_i^{\phi} \in [t_0, t_2] \\ 0, & another \end{cases},$$

where t^{ϕ}_i - is date of actual completion of i-th work; t_2 - is date of ending of period K.

In case of availability of information about actual labour-intensiveness for completed works, instead of indexes $T^{пл}_i$ та $T^{пл}$ followings indexes should be applied in model: T^{ϕ}_i - is actual labour-intensiveness of i-th work in project, man-hours; $T^{пл`}$ - corrected total labour-intensiveness of project works (in calculation of which for completed works the actual labour-intensiveness will be used, and for uncompleted - planned), man-hours. And the calculation of level of complication of the executed works in period K will take the following form:

$$Kc_K = \frac{\sum_{i=1}^{P}\left(T_i^{\phi} \times \Phi_1(t_i^{\phi})\right)}{P_K^{\phi} \times T^{пл`} / P}.$$

- Correction (fine) for time expiration of works in period K:

$$Шп_K = З_K \times шп,$$

where $З_K$ - is a change of duration of project, i.e. increase ($З_T > 0$) or decrease ($З_T < 0$) of duration of project caused by implementation of works in period K; шп - fine for every day of expiration, m.u.

Defining the index of $З_K$ it is necessary to take into account that the change of duration of project can take place in the case of non-fulfillment of planned works or implementation of unplanned works in the period K.

Therefore calculation of index $З_K$ can be split in the following way:

1. Presence of planned but uncompleted works in period K may bring to increase of project duration if their cumulative duration on certain j-th path of works bigger than time float after period K. In this case the change of duration of project will be determined via the biggest cumulative duration of planned but uncompleted works on all paths in period K reduced by time float of the path:

$$З_K^{planned\,\&uncompl} = \max_{j=j1,\dots,jM}\left[\sum_{i=1}^{P}\left(\Phi_2(t_{ji}^{пл},t_{ji}^{\phi})\times Г_i^{пл} - РЗ_j\right)\right]$$

where j - is sequence number of path of works in project; j_1 - is the path of works which has the least sequence number; j_M - is the path of works which has the biggest sequence number; $Г^{пл}_i$ - is planned duration of i-th work; $РЗ_j$ – time float of j-th path of works on an interval from the date t_2 to the date t_N (date of project completion); $\Phi_2(t^{пл}_{ji}, t^{\phi}_{ji})$ – function, which determines if i-th work which belong to j- th path of works is planned to implementation but uncompleted in period K.

The function of $\Phi_2(t^{пл}_{ji}, t^{\phi}_{ji})$ has the following representation:

$$\Phi_2(t_{ji}^{пл},t_{ji}^{\phi}) = \begin{cases} 1, & t_{ji}^{пл} \in [t_0,t_2] \cup t_{ji}^{\phi} \notin [t_0,t_2] \\ 0, & another \end{cases},$$

where $t^{пл}_{ji}$ - is the planned early date of finish of i-th work which belongs to j-th path of works; t^{ϕ}_{ji} - is date of actual completion of i-th work which belongs to j-th path of works.

As far as actual duration of work remains unknown till final work completion, it is reasonable to calculate time expiration fine in accordance with total planned duration for all works which were not completed by the end of period K. However, in case of availability of information about the exact dates of completion of enduring works, instead of index $Г^{пл}_i$ should be applied index $Г^{розр}_i$ – calculated duration of i-th work.

2. Presence of unplanned but completed works in period K may bring to decrease of project duration if these works belong to critical path of the project. Therefore the change of duration of project will be determined via the biggest decrease of duration of all paths of works caused by implementation of unplanned works in period K reduced by time float of the path:

$$З_K^{unplanned\,\&compl} = \max_{j=j1,\dots,jM}\left[\min_{i=i1,\dots,iP}\left(\Phi_3(t_{ji}^{пл},t_{ji}^{\phi})\times(Дt_2 - Дt_{ji}^{пл})\right) - РЗ_j\right],$$

where i_1 - is the work which has the least sequence number in project; i_P - is the work which has the biggest sequence number in project; $Дt_2$ - is an amount of days from the date t_0 (date of beginning of project) to the date t_2 (date of ending of period K); $Дt^{пл}_{ji}$ - is an amount of days from the date of t_0 to the planned early date of finish of i-th work which belongs to j-th path of works in the project; $\Phi_3(t^{пл}_{ji}, t^{\phi}_{ji})$ - is function, which determines if i-th work which belongs to j-th path of works, unplanned to implementation but completed in period K.

The function of $\Phi_3(t^{пл}_{ji}, t^{\phi}_{ji})$ has the following representation:

$$\Phi_3(t_{ji}^{пл},t_{ji}^{\phi}) = \begin{cases} 1, & t_{ji}^{пл} \notin [t_0,t_2] \cup t_{ji}^{\phi} \in [t_0,t_2] \\ 0, & another \end{cases}$$

3. On condition of correct construction of network model and observance of all logical intercommunications between works, it is impossible to place on the same path of works both planned & uncompleted works and unplanned & executed works in period K. Taking into account the above-mentioned the calculation of index of $З_K$ will take the following form:

$$З_K = \max_{j=j1,\dots,jM}\left[\sum_{i=1}^{P}\left(\Phi_2(t_{ji}^{пл},t_{ji}^{\phi})\times Г_i^{пл}\right) + \min_{i=i1,\dots,iP}\left(\Phi_3(t_{ji}^{пл},t_{ji}^{\phi})\times(Дt_2 - Дt_{ji}^{пл})\right) - РЗ_j\right].$$

➢ Fine for exceeding of actual cost above planned in period K:

$$Шв_K = BP_K \times (1 + шв),$$

where BP_K - is a variance between actual cost and planned for period K, m.u.; шв - fine per one monetary unit of exceeding of budget of project, m.u.

For calculation of index BPK it is reasonable to distinguish plan/actual variances for completed works in period K and for works, which began, but were not completed in period K:

• For completed works in period K cost exceeding or the economy can be expressed in the following way:

$$Взр_K = \sum_{i=1}^{P} \left(\Phi_1(t_i^{\phi}) \times (B_i^{\phi} - B_i^{пл}) \right),$$

where $\Phi_1(t^{\phi}_i)$ - is function which determines if i-th work was completed in period K (see above); B^{ϕ}_i - is actual cost of i-th work; $B^{пл}_i$ - is planned cost of i-th work.

• As far as we can not be sure whether actual cost of uncompleted work is final, let us assume that for uncompleted works only actual overspend is justified, not saving. Accordingly, the calculation of actual overspends for uncompleted works can be expressed in the following way:

$$Внзр_K = \sum_{i=1}^{P} \left(\Phi_5(t_i^{\phi}) \times \Phi_6(B_i^{пл}, B_i^{\phi}) \times (B_i^{\phi} - B_i^{пл}) \right),$$

where $\Phi_5(t^{\phi}_i)$ - is function which determines if i-th work is uncompleted in period K; $\Phi_6(B^{пл}_i, B^{\phi}_i)$ - is a function which determines if there is an exceeding of actual cost of i-th work versus planned.

The functions Φ_5 (t^{ϕ}_i) and Φ_6 $(B^{пл}_i, B^{\phi}_i)$ have the following representation:

$$\Phi_5(t_i^{пл}, t_i^{\phi}) = \begin{cases} 1, & t_i^{\phi} \notin [t_0, t_2] \\ 0, & another \end{cases} \qquad \Phi_6(B_i^{пл}, B_i^{\phi}) = \begin{cases} 1, & B_i^{\phi} > B_i^{пл} \\ 0, & another \end{cases}$$

Taking into account the above-mentioned the calculation of index of BP_K will take the following form:

$$BP_K = \sum_{i=1}^{P} \left[\left(\Phi_1(t_i^{\phi}) + \Phi_5(t_i^{\phi}) \times \Phi_6(B_i^{пл}, B_i^{\phi}) \right) \times (B_i^{\phi} - B_i^{пл}) \right].$$

➢ A relative amount of net income of the project for the period which precedes period T.

Presence of given element in the model of calculation of interim evaluation of investment project effectiveness enables to carry out the proper calculation not only for the period from the date of beginning of implementation of project (t_0) to the current date (t_2), but also separately for each of necessary last report periods. Required prerequisite is a conducting of interim evaluation of project effectiveness at the beginning of the current periods (at completion of previous current periods), i.e. calculation of index $ЧД_{K\text{-}T}$. If the date of beginning of period T is date t_0, the index $ЧД_{K\text{-}T}$ will be equal zero. Accordingly after project completion the effectiveness of implementation of project in the last current period will be equal general actual effectiveness of project minus effectiveness of project for the period from the date t_0 to the date of beginning of the last current period.

Expanding all above-stated elements the model of interim evaluation of investment project effectiveness will take the following form:

$$ЧД_T = ЧД \times \frac{\sum_{i=1}^{P}\left(T_i^{пл} \times \Phi_1(t_i^{\phi})\right)}{T^{пл}} - \max_{j=j1,...,jM}\left[\sum_{i=1}^{P}\left(\Phi_2(t_{ji}^{пл}, t_{ji}^{\phi}) \times Г_i^{пл}\right) + \min_{i=i1,...,iP}\left(\Phi_3(t_{ji}^{пл}, t_{ji}^{\phi}) \times (Дt_2 - Дt_{ji}^{пл})\right) - РЗ_j\right] \times$$

$$\times шп - -\sum_{i=1}^{P}\left[\left(\Phi_1(t_i^{\phi}) + \Phi_5(t_i^{\phi}) \times \Phi_6(B_i^{пл}, B_i^{\phi})\right) \times (B_i^{\phi} - B_i^{пл})\right] \times (1 + шв) - ЧД_{К-Т}.$$

Using the model of interim evaluation of investment project effectiveness the followings pre-conditions must be taken into account (apart from stated above in text):
- the model requires detailed work breakdown structure of project (with granting sequence numbers for all project works and path of works) and a network model with schedule of work implementation;
- all financial, material and labors resources which are used in the process of realization of project have to be appraised in terms of money to affiliate the sum of project investments and sum of project revenues should be estimated to calculate net project income;
- all investments on project have to be connected with proper works, thus the total cost of implementation of all works must be equal the total sum of investments of the project;
- all planned works should be accomplished as a prerequisite of successful project completion.

Conclusion.

This article is devoted to the methodology of interim evaluation of investment project effectiveness. The methodology is based on calculation of net income gained by project in particular period and intended to estimate project profitability before project completion date, to appraise the performance of project team in determined period, to assess quality of project execution, to foresee eventual project losses and prevent them timely. Also the methodology has special importance for project-oriented companies as it provides a possibility to make unprejudiced evaluation of companies' profitability in reporting period.

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G.V. Zhavoronkova, Doctor of economic Sciences, (National Aviation University, Ukraine)
N.V.Otlivaskaya, post-graduate student, (National Aviation University, Ukraine)

PERSONNEL MANAGEMENT PROBLEMS IN CIVIL AVIATION OF UKRAINE INFORMATION ABOUT AUTHORS

A review of world economic situation influence on civil aviation of Ukraine is given. High importance of formulating competitive and professional aviation personnel if proven. Structure of personnel of aviation industry of Ukraine is analysed and recommendations concerning its improving are made. Importance of well-thought personnel policy for the airline is proven.

Acceleration of techniques and technologies renewal intensifies competition between companies both in global and domestic market. Civil aviation as the most technically complex transport industry is subjected to this tendencies to the utmost. Transport as field of material production is characterized by such particular features as fast pace of development, wide structural changes in personnel under influence of scientific and technological progress (STP) and economic factors, instability of production process and big differences between enterprises.

Analytical data concerning staff component of airlines-members of IATA allows making conclusions that the highest specific weight in personnel structure belongs to air crew - 28% (pilots, second pilots, air stewards and others). Such distribution can be explained by stable rates of aircraft quantity growth, increasing of their capacity and as consequence number of crew members. Second place take specialists of surface subdivisions that are not connected with technical and commercial servicing of carriages. It's explained by constant growth of air services quantity and nomenclature during last 15 years. Third place in professional structure of airlines take staff involved in surface services of airport complex and specialists supporting technological processes of carriages. This tendency is connected with technological development and complication of transportation, improving of aircrafts' technological level requiring more personnel of different professional groups.

Despite growth of transportation activity quantity of office personnel decreased thanks to labor efficiency, technological innovations and applying subcontracting options with involving independent corporations. Efficiency of repair and maintenance with applying new procedures of computer diagnostics of disrepair, exchange of finished aggregates and involving professional repair bases has greatly influenced repair process in particular.

In Ukrainian aviation field trend for decreasing volume of carriages kept up to 1999. During 1990-1999 quantity of aviation personnel decreased in 1,3 times. Though this negative trends Ukrainian carriers survived and even increased their potential. Most productive direction of air transport activity is research and introduction of transport systems combining material support, trade, logistics and informational systems. Transport, informational and financial flows adapt to main developed complex.

Problem of competitiveness of Ukrainian companies on external markets becomes more acute. Wide introduction of new information technologies in aviation field requires training of specialists of appropriate qualification in development, exploiting, maintenance and protection of IT and media. Domestic airlines master contemporary types of foreign aircrafts. As aviation routs are filling with foreign aircrafts that have range of technical and technological differences in construction and maintenance training of definite number of specialists on company maintenance should be performed to provide technically literate exploitation of this aircrafts.

Thereupon higher demands to the quality of air transport services are made; structure and parameters of demand are changing. One of the most significant elements of airline competitiveness is its staff. Today using statistics aviation personnel of typical Ukrainian airlines can be clearly structured by age and educational parameters. By age criteria 45,2% is represented by group 25-35 years, 38,2% is in group 36-50 years and personnel in the age 51 year and more is formed by remaining 16,6%.

Educational structure of aviation personnel is the most important. Basing on age parameter 90,9% of specialists 20-35 years old have higher education, in group 36-50 years this figure drops to 75,6% while in group 51 year and more number of specialist that have higher education is the lowest - 66,6%. This is the evidence of improving of qualification level of young generation of professionals. Tendency in the oldest age group can be explained with big practical experience of specialists without higher education and absence of possibility for them to improve it.

Managerial background of personnel on higher positions doesn't correspond to modern requirements. Greater part of managers is not familiar with achievements of contemporary managerial science in terms of economic freedom and market relations. As consequence economic initiative and entrepreneurship spirit are developed weakly especially comparing to foreign airlines. In airlines where influence of scientific and technological progress and economical factors is weak trend towards "ageing" of specialists can be observed. Insufficient investments lead to ageing of transport technics, decreasing of technical reliability and exploiting safety. Long-term existence of this tendency may lead to catastrophic consequences for air transport complex.

Generalizing experience of large companies and assessments of domestic and foreign experts shows that in near 10-15 years managerial problems will lie mainly in the sphere of personnel, development and putting into life personnel policy**.** Destabilizing influence of market relations model reveals in reduction of steadiness of specialists' structure, appearing constant need in training, growth of requirements to professional and qualification level, strengthening of dependence between specialists and volume of work performed and in changes of age structure. That's why ssuccessful forming of personnel can be realized only on the grounds of well thought personnel policy. Manpower policy is one of the most important part of general economic strategy. Ukrainian carriers commensurate operational staff plans and decisions to the previously formulated personnel strategy that should be agreed with Ukrainian civil aviation development conception. It clarifies development of civil aviation for the long-term period, defines main directions for 15-20 years and offers ways of solving current and perspective problems.

For resolving task of defining number of specialists needed such complex indexes as general and additional need in specialists, qualification structure and professional structure are used. These tasks should be included to the general strategy and operational plan of the airline. Final stage in creating efficient professional-qualification structure is forming of personnel-oriented policy.

Efficient personnel management should be based on profound knowledge of personnel policy essence and its place in economic system of the airline. Picture 1 demonstrates influence of personnel policy on process of aviation enterprise forming and functioning.

Safety is included to the goals of organization but it plays supporting role for secure achievement of production goals. Safety is considered to be a method of saving all kind of resources including cutting costs and includes minimization of active and hidden shortcomings and improvement of technology. Meeting production plans includes providing quality of aviation product, implementing planned volume of carriages, entering new markets, making new routes, attracting customers and increasing general competitiveness of the airline. All other directions of personnel strategy and policy have own peculiarities and dynamics and influence formulating and realizing of main directions considerably. Service directions combine system of regulating staff component and payroll system.

System of regulating staff component has as its main goal improving of moral motivation, assessment of real and potential capabilities of workers, promotion perspectives, moral incentives, image, career, respect of collective and management. But this incentives will not help to create competitive staff if there is a misbalance between professional background and real conditions of airline's operation.

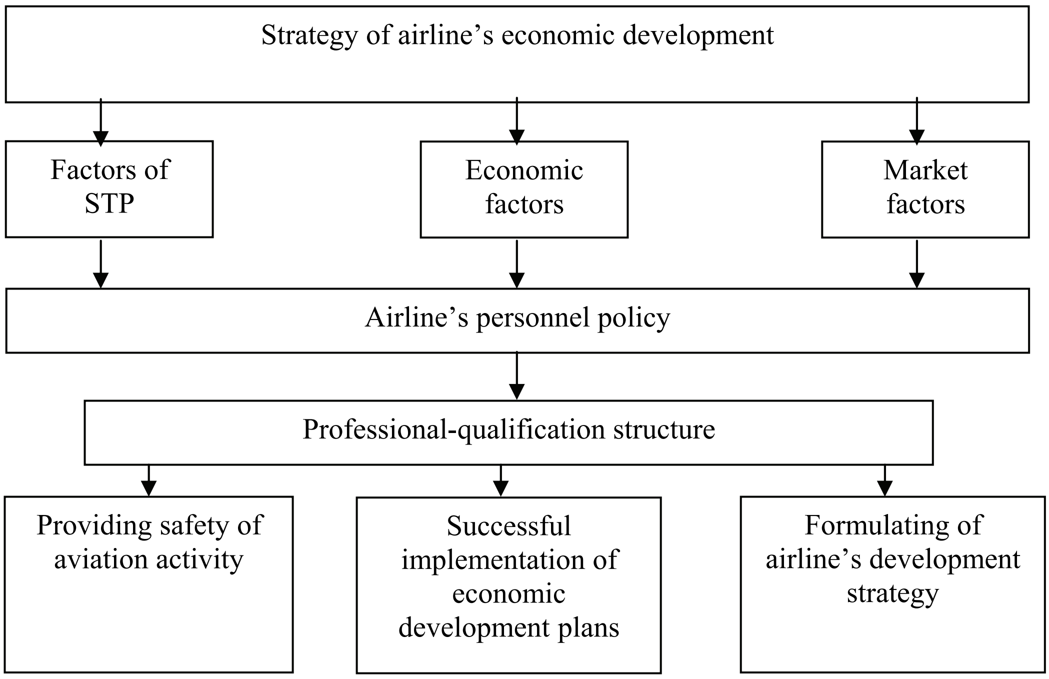

Fig. 1 Interaction of personnel policy and economic system of aviation enterprise

Main function of payroll system is material motivation to more intensive and productive work. Adequate level of salary corresponding to intellectual and physical efforts plays important role in formulating effective staff component.

Existing system of specialists training and re-training doesn’t correspond to contemporary requirements besides main problem of specialists’ quantity and qualification is not solved yet. Analysis of current state of staff component of Ukrainian aviation enterprises allows making conclusions that there is a high necessity in specialists in transport marketing. In conditions of rough competition and foreign companies entering Ukrainian air services market this drawback leads to negative consequences. Process of forming efficient transport legislation also falls behind real needs in Ukraine. And at the same time there is lack of specialists having good knowledge of national and foreign transport law. Existing specialists have as their task creating system of transport legislation of Ukraine and organization of its implementation, making decisions concerning patents for transport carriages, support and control of transport enterprises and providing consulting services.

So far airline’s personnel strategy should be directed first of all to formulating highly qualified staff component corresponding to real conditions of activity. Rates of its development should be faster than development of production system. In opposite case considerable financial losses may occur because of untimely mastering of new technics and STP will lead only to quantitative not qualitative changes in personnel structure.

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M.B.Yanchuk, Candidate of Economics, Associate Professor (National Aviation University, Ukraine)

DIRECTIONS OF STRATEGIC DEVELOPMENT OF UKRAINIAN CIVIL AVIATION INFORMATION ABOUT AUTHORS

World forecasts of air transportation development and connected with them possible negative trends in Ukrainian economy are observed in the article. Contemporary problems of civil aviation of Ukraine and ways of their solving in the framework of approved state programs, collaboration with European Union and international organizations are given by the author.

Within the course of integration to world economic partnership problems of national security of Ukraine gain character of current importance. Communications as well as aviation field are constituent elements of national security system. Having experienced years of total decline Ukrainian aviation demonstrate yearly growth in cargo and passenger transportation that can be grounds for future stable prospects. However Ukraine can't stay aside of problems originating from world fuel-energy crisis, confrontation between world-wide power blocks and complex geopolitical situation. International Air Transport Association (IATA), representing 240 airlines, that cover 94% of world passenger and cargo air transportation market, have published renewed forecasts for air industry for the year 2008. Losses of carriers can range from 2,3 billion dollars in case if oil prices will be at the level of 106,5 dollars per barrel, to 6,1 billion dollars if oil price will float around 135 dollars.

IATA forecasts that passenger traffic will increase no more than 3,9% this year that will be one and a half times lower than in 2007 when passenger traffic growth was 5,9%. In any event this world problems influence Ukrainian economics eventually, and aviation industry is not the exception. Macroeconomic risks connected with slowing down of internal and external conjuncture, economic growth and level of investment activity may cause nonrealization goals of development for the reason of insufficient budget financing that at best will provide exploitation and maintenance of objects in state property. Limitations will be evident for subsidy and subvention possibilities. That's why is necessary for Ukraine to outline issues of national importance requiring strategic view and strong position in defending them.

First of all attention should be paid to problem of harmonization Ukrainian aviation law with European one because Ukrainian carriers can't overcome all normative and juridical limitations in entering European market by themselves. One step toward agreeing this question is singing twinning treaty directed to total harmonization of Ukrainian law with legislation in force in all countries, members of EU and providing its implementation in aviation field. This project provides introduction civil aviation security requirements in Ukraine not only in the sphere of carriages but also in aircraft building and maintenance, and is directed to integration of Ukrainian market of air transportation to European and creating of united airspace. For successful running of this project Ukraine can open access to international market of carriages for national carriers by obtaining membership in European Administration of Safety Aviation. Accompanying processes in legislation harmonization activity are constant transfer of statistical information concerning development of united market in EU, providing renewed list of aviation laws with assistance of Eurocomission and operational coordination of new Ukrainian Air Code contents and other new aviation normatives for e.g. concerning introduction of electronic ticket technology.

Undeniable competitive advantage of Ukraine is its favorable geographical position from the point of transit communication Europe-Asia. But lack of sufficient capacities and technical conditions that big European airports-hubs possess, fill with contradictions Ukrainian practice of air transportation: to fly to China, India and Japan Ukrainian passengers have to fly to European airports of Amsterdam, Frankfurt and London and then fly then again above the territory of Ukraine to Asia. If in 1990 international passengers' departures were only 2% then in 2004 – 72%. To solve this problem government formulated main directions of land service improvement including:

- optimization of airports network (international as well as domestic), their quantity, quality and location should take into consideration geopolitical interests of state and economic expediency;

- growth in efficient activity with creating necessary conditions for renewal of fixed assets and introducing modern technologies;

- increase of Ukrainian airports competitiveness in international market of transport-transit carriages.

Today Ukrainian network of airports number 37 airports that perform air carriages. This figure includes military and plant airfields that mostly perform cargo carriages. From this quantity 29 airports function as independent enterprises, 1 – as structural unit of bigger airport, 2 – in structure of airlines and 5 are in subdivisions of big airports. Bigger part of airports are in communal property. In first years of existence of independent Ukraine as well as in whole CIS general volume of passenger departures diminished in 12-15 times because of significant growth of gas prices and decrease of population purchasing power. Besides availability on the territory of Ukraine developed network of automobile and railroads played its role in substitution for means of mobility for population.

With the purpose of stabilization of airports activity, increasing of flights safety, aviation safety, improving quality of passenger and aircraft services, developing of air transportation on domestic and international routes Program of development of Ukrainian airports was created. World practice shows that airports cannot completely cover their expenses only with comings from aviation activity. Up to half of income sums some foreign airports get from non-aviation activity – rent of property, providing rights for business development in airport to commercial structures, founding of paid stands for cars etc.

Converting Borispol airport to huge transit point, the so called European hub, is activity of high priority that's being carried nowadays and that will allow to increase passenger flow up to 12 mln. people yearly in first three years. Europe has six big hubs that include London Heathrow, Paris airport of Charles de Gaulle and airport of Amsterdam. All projects of airport infrastructure development, creation of transit network performing functions of dispensing centers for air carriages and improvement of service quality pursue goal of satisfying growing needs in domestic and international transit carriages and also in improving flights safety level and flights regularity. Hubs system that is usually introduced by country after abolition state regulation of airlines and improving processes in aviation industry is effective and efficient mechanism. Hubs offer a lot of advantages to airlines as well as for passengers especially in airports that conduct servicing megacity regions. Passengers get wide scope of flights and directions to choose from that are available in one place, and carriers have possibility to increase services intensity, to exploit larger aircrafts and to cut costs thanks to carrying activity simultaneously on several markets from one point. Thus airports as important functional part of air transport infrastructure perform great role in state policy of aviation activity. Stable and effective functioning of airport is necessary condition for providing complexity, national security, and defensive capacity, increasing level of living and rational integration of Ukraine to world economics.

Nowadays air communication with Ukraine is based on the principle of agreeing new flights: sides analyze what routes already exist, how many flights are performed on them and with what regularity, what were the grounds for making proposal for new flight. Usually introduction of one new flight is accompanied by another mutually profitable step that's given to other side as compensation for concessions made. Participation of Ukraine in program Open Sky will bring new possibilities, as well as new threats to its aviation security because it will be possible no more to limit flights of foreign airlines on Ukrainian territory. Thus rises an important question of creating new huge national air carrier that can resist aggressive European competitors – regular airlines and discounters. Main pretenders that will unite their capacities to become airline number one in Ukrainian air services market are Aerosvit and Ukrainian International Airlines. State already has 24% in Aerosvit shares and 62% of shares of Ukrainian International Airlines. In case of emerging of national carrier Ukraine will obtain possibility to put own competitor for European airlines and successfully use reverse side of Open Sky treaty – perform flights to all countries of European

Union. One more competitive advantage of future Ukrainian carrier is competitive price of transportation and modern airport Borispol.

Development of regional carriages – is another one key direction of state aviation body activity. One should remember that development of infrastructure defines industrial development and growth not vice verse. In situation of absence of principal decisions and mainly actions towards development of infrastructure economic growth will decrease, regional differentiation will grow, management of regions will get worse, possibilities of economically useful collaboration between state and business will drop. Territory of Ukraine is much smaller than territory of ex-USSR, that's why with loosing membership in it structure of air transportation has changed greatly: many routes stopped its existence or became unprofitable. To develop regional infrastructure program of building seven powerful regional airports was formulated. At the same time to involve into collaboration national aircraft construction enterprises Ukrainian government offered Ukrainian airlines to use only national aircrafts for domestic carriages – An-148 and An-140. In particular airline Aerosvit took obligations to buy ten airplanes An-148. This well thought strategic steps give opportunity to load manufacture and develop airport network simultaneously.

Membership in WTO opens new possibilities for Ukraine in relations with Europe and all countries of the world in aviation field. First step in this direction is signing treaty about aviation communications between Ukraine and Italy this year. This means that Ukraine will get more credit of trust from developed countries and will be considered a reliable partner in air transportation.

Forecasts of world economic growth and international trade made by assessments of Boeing company are positive. Annual rate of economic growth in near 20 years is considered to be at the level of 3,1%. Yearly growth of passenger carriages in this period will be 4,9%, and for cargo carriages -6,1%. During period up to 2025 airlines will need approximately 27210 new passenger and cargo aircrafts. But if situation in aviation industry becomes unstable it can be even more destructive than negative consequences that happened over terrorism, slowing down of economic growth and war in Iraq. To survive in this crisis large-scale changes are essential in the nearest future – governments should refuse using system of bilateral treaties that regulate world aviation and instead go to global consolidation. Ukraine has to do everything to take as much benefit for itself as possible from this situation and to enter world market of air transportation paying special attention to Near East. It promises significant widening of market in this region and provides stimulus for making new air routes.

Issues of improving level of flights safety and getting full membership in JAA remain direction of high priority in activity of state aviation bodies and government of Ukraine.

State policy should be directed to providing balance of social interests and business – it is necessary for Ukraine to keep strategic state management over infrastructure during tactical management being carried by business. Final goal of strategic development of aviation industry should be taking example of developed countries – searching for large-scale foreign investor.

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Iuliia Kozitska, Post-graduate (National Aviation University, Ukraine)

BUSINESS AVIATION IN TODAY'S ECONOMY

This article examines the role of business aircraft in a company's performance and determines the benefits which can be derived from using business aircraft. This article also detail a range of financial and non-financial benefits that accrue to operators and investigates whether business aircraft contribute to better operating of company or its financial performance.

Today's global economy rewards knowledge integration, customer relationships, organizational agility, information, and speed. To achieve these, a company needs mobility — of executives, customers, suppliers, and specialist teams. Understanding the benefits that can be derived from using business aircraft is key to grasping how the aircraft impact the performance of an organization.

While some companies have developed strategies to mitigate the adverse impacts of today's commercial air transport environment, others are even more proactive in concluding that mobility is key to success. The decision to use business aviation is generally intuitive — a common-sense feeling by the Chief Executive Office that the choice of greater mobility would be good for business because of strategic competitive urgency, accelerated transaction value, improved productivity, practical realities, or some other reason.

One underlying motive for business aircraft use is recognition of the value of face-to-face communication. Although business travel undulates with the economy at some companies, many longstanding business aircraft operators have concluded that the amount and quality of information that can be gathered or delivered face-to-face exceeds that of any other communication method. While phone, fax, video conferencing or email obviously are ideal under many circumstances, some critical information sources — such as body language, the strength of a handshake, sequential or lengthy meetings or events, seeing first-hand the whole environment — make "being there" imperative. From experience, senior managers — for whom personal productivity is under extreme and endless pressure — are acutely aware of these advantages, and their personal presence is often essential. To secure this communication advantage, a growing number of companies rely on the travel efficiencies that are unique to business aviation. But this is only the tip of the iceberg when it comes to benefits and value creation. Several business aircraft resourcing options are available. Among them are charter, "traditional" full aircraft ownership, joint ownership, co-ownership, and fractional ownership — an ownership scheme roughly akin to a time share where owners purchase a portion of an aircraft crewed and maintained by a management company common to all owners. Each of these options has advantages and disadvantages.[2]

In today's economy, increased productivity and the effective use of time, as well as a company's intangible assets — such as relationships, knowledge, people, brands, and systems — are taking center stage and driving shareholder value. Successful companies are utilizing and developing both old and new economy assets. In fact, it is the combination and interaction of all of a company's assets — more than any other factor — that will determine its economic success.

In this environment, the value of a business aircraft does not depend solely on their net benefits, but also on whether they enable a company to improve the efficiency or effectiveness of its intangible assets. Such assets include its people, their talent or specialist knowledge and even relationships. How people use time influences business success. Aircraft are leveraged by increasing employee productivity, accelerating speed to market, improving customer responsiveness, building employee satisfaction and retention, driving supply chain collaborations, knowledge sharing or other improvements. Companies winning in today's economy are mobile, able to move goods, people, information, and capital around the globe quickly and efficiently. Business aircraft (like computers and telephones) become "value enablers," tools that enhance an organization's ability to transfer knowledge quickly and easily.

This discussion would be incomplete without acknowledgement of the central and dominant role that scheduled commercial airline service plays in the business community. The vast majority of air travelers fly aboard the airlines. The safety, direct-cost effectiveness, and sheer volume of service provided by the airlines — particularly between airline hubs, for individual travelers, for infrequent flyers or those whose employers do not place a significant value on their time — is preferred in many situations. For nearly all companies, it will be a hybrid of commercial air service and use of business aircraft that best answers their travel needs.

Purpose of use business aircraft includes six categories:

1. Transportation of employees and executives
2. Transportation of customers
3. Transportation of suppliers
4. Transportation of cargo, parts and mail
5. Transportation for charity
6. Direct applications (using business aircraft as an aerial platform to accomplish a given task or simply as an incremental profit center)

Understanding the purpose of application for business aircraft is relatively straightforward. Cataloging and quantifying the benefits that can accrue from that application is more challenging, particularly given that individual corporate cultures, strategies and circumstances are unique, and that business aircraft are used for many reasons other than simple transportation.

There are six core benefits of business aircraft use:

1. Increase Employee Productivity
2. Expand Markets
3. Secure Competitive Advantage
4. Induce Operational Efficiency
5. Offset Company Expenses
6. Improve Risk Management

Understanding the net benefits of operating a business aircraft is key to isolating its asset efficiency. But, net benefits are only one possible justification. Many indirect or induced benefits are difficult to quantify. While they may not be easily converted into a monetary unit figure, they can have a profound effect on processes and out comes in an organization that may in turn contribute to bottom line performance. They should not be under or over-assessed. Also, the realization of certain benefits associated with business aircraft can be directly causal or merely probable, depending upon the circumstances. However, it is possible to identify how using business aircraft can stimulate revenue growth, profit margin growth, asset efficiency, employee satisfaction and customer satisfaction.

Revenue Growth includes critical performance components such as time-to-market and new products or services that help the company grow its revenues faster than its competitors, or capture more market share at its competition's expense. Benefits that can influence revenue or market share growth include, but are not limited to the following:

- Ability to respond rapidly to revenue/market share growth opportunities
- Accelerate transaction rates
- Enhance employee productivity
- Enable market expansion
- Facilitate critical meetings
- Increase customer base
- Improve customer relationships
- Protect intellectual property

Profit Margin Growth focuses on the relationship between costs and revenues. Cost controls play an important role in the realization of profit growth. Benefits that can influence profit margin growth include, but are not limited to the following:

- Employee time savings
- Accelerated transaction rates
- Decreased trip expenses
- Offset commercial airfares and shipping and mail expenses

- Decrease employee replacement costs
- Offset costs through charter revenue
- Reduced turnover
- Reduce staffing levels
- Increase customer base
- Improve customer relationships
- Improve risk management
- Protect intellectual property

Asset Efficiency is a measurement of how well a company is able to utilize its assets and capital investment for the creation of profits and reduction of costs. Benefits that can influence asset efficiency include, but are not limited to the following:

- Save employee time
- Leverage key employees
- Respond rapidly
- Increase customer base
- Improve access to markets
- Offset costs through charter revenue
- Improve employee motivation
- Enhance employee productivity
- Improve business process efficiencies
- Keep up with or get ahead of competitors

Employee Satisfaction is evidenced by low turnover rates, and generally satisfied and productive employees. Benefits that can influence customer satisfaction include, but are not limited to the following:

- Respond rapidly
- Decreased trip expenses
- Leverage key employees
- Enhance employee productivity
- Accelerate teamwork and cross pollination
- Improve business process efficiencies
- Facilitate critical meetings
- Improve customer relationships
- Improve risk management

Customer Satisfaction manifests when companies are able to increase the volume of business they do with existing customers based upon mutual satisfaction, relationship building and trust. Benefits that can engender employee satisfaction include, but are not limited to the following:

- Save employee time
- Enhance corporate image
- Engender employee pride
- Signal management support
- Improve employee moral and motivation
- Decrease travel induced stress
- Reduce aversion to travel
- Improved travel schedule reliability and predictability
- Access to highly efficient airports
- Expand commercial air service opportunities
- Enhance employee productivity
- Secure personal safety.

The benefits that were discussed (Figure 1) will help companies achieve improvements in each of these areas. The magnitude of the effect on these benefits will depend largely on a company's culture which often determined how effectively it used and benefited from business aircraft. For example:

1. Strategic transaction orientation: Being able to facilitate critical transactions was most regularly associated with direct shareholder value creation. One company was able to seize an overseas market because its fleet enabled management to be sufficiently agile and flexible. Accelerated transaction value has become a critical component to several industry sectors, especially those in consolidation.

2. Customer service orientation: Time-sensitive requirements, such as emergency customer services, supported sales retention and sales growth and could be most efficiently met by some companies using business aircraft (no ready substitute).

3. Process and quality improvement orientation: Being better able to manage and execute far-flung operations was found to be the most extensively cited trait. Business aircraft enabled executives to visit multiple locations, sometimes more than once a year, by customizing schedules not possible on commercial airlines. Executives were able to review operations, efficiency, quality, and customer service. We observed that benefits that accrued from use of business aircraft contributed directly to shareholder value creation at multiple levels, including profitability, asset efficiency, market share growth, and customer satisfaction.

4. Meritocracy orientation: When a company uses aircraft to treat all employees as an important asset, they achieve uncommon results. Because the workday could be lengthened without sacrificing employee family time, shuttling employees between company facilities offered significant productivity gains. Enhanced employee safety and security, as well as the security of intellectual property, were a characteristic of this orientation.

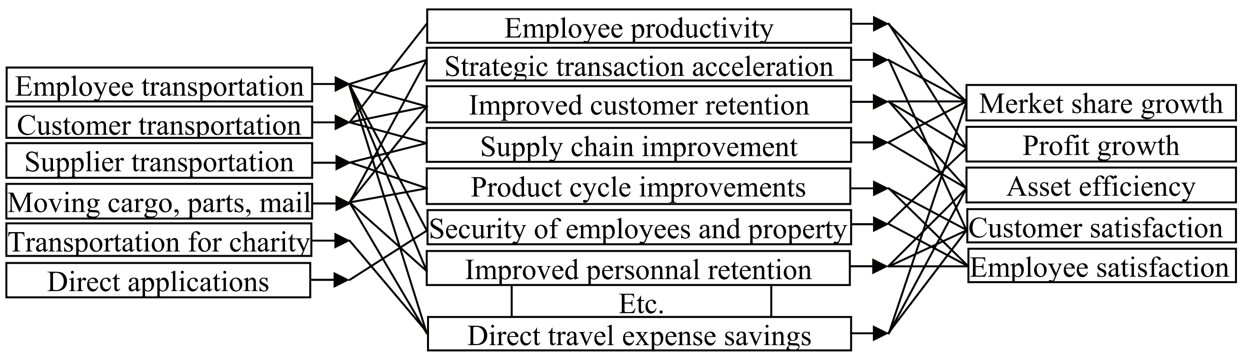

Figure 1 - Benefits which can be derived from using business aircraft

Business aviation help improve performance in the areas of greatest importance in today's fast paced economy (e.g., identifying and executing strategic opportunities for new relationships and/or alliances; reaching critical meetings and closing transactions; expanding into new markets; and increasing contact with customers). The challenge for any company is to identify all of the potential uses and benefits of these assets and to operate them in ways that will produce the greatest gain. Only then can management enjoy the effects of business aircraft use on long-term value creation. Business aircraft can be remarkable aids to business under certain circumstances, including during economic downturns.

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Gennadiy Yun, Doctor of Science (National Aviation University, Ukraine)

ECONOMICS IN AIRCRAFT DESIGN

The systems approach to the optimization of the main aircraft design parameters at the stage of primary modeling is considered. The bimodal procedure of external designing that includes the operational and parametrical aircraft modeling is proposed.

Formulation of the problem. The practical issues concerning the aircraft design and operation imply solving two problems. The primary task regarding the formalization of the process of functioning of the virtual airline fleet, which includes the designed aircraft and its mathematical model design, definition of optimal functioning modes with the purpose of maximum efficiency of the whole process at a fixed cost. We shall name the given problem the task of external aircraft design as it proposes a variety of questions that are determined by the influence of external factors and are connected with processing of the incoming external information. The solution of the second task concerns technical realization of the optimal aircraft on the basis of machine design methods and includes optimal characteristics and parameters realization of the aircraft on the whole and of its plants, units and details, in particular. This problem we shall name the task of internal aircraft design as it proposes a variety of questions that are determined by interactions of the aircraft subsystems and by the requirements put forward to its plants, units and details which are obtained by solving the primary problem.

The designed aircraft, being the element of the virtual airline fleet, which is regarded as the conditional air fleet of all airlines together, due to its technical and economic characteristics, one way or another, influences the economic efficiency of the given fleet. The technical and economic characteristics of the aircraft, in their turn, are the functions of the aircraft parameters defined during the process of internal aircraft design. Therefore, the problem of distinguishing the relation between design parameters at the stage of internal design and technical and economic characteristics at the stage of external design and their evaluation from the point of view of efficient functioning of the virtual airline fleet.

The choice of aircraft design parameters on the basis of investigation of their immediate influence on the economic efficiency of the virtual airline fleet, in fact, is almost impossible due to the cumbersomeness of the mathematical model and to the insufficient acuteness of the efficiency criterion to the variations of the optimized parameters. Thus, for the purpose of analysis and evaluation of economic efficiency in civil aviation application of the newly created aircraft, we need to describe it, alike other aircraft operated by the airline, by means of the medium aggregated indices. The medium aggregated indices are formed in the sphere of air fleet operation on the basis of technical and economic characteristics that are defined by design, construction and technological choices during the process of internal design.

It is common to determine five levels of problem solving in aircraft design [1]. Table 1 shows that level II corresponds with development of technical task and technical and economic substantiation of aircraft application in civil aviation and is, alongside, its entrance to the internal design.

Table 1

Stages and levels of aircraft design

Stages of design	Hierarchical level	Problem	Organizations in charge
External design	I	Forecast of passenger traffic in virtual airline fleet.	Virtual airline fleet
	II	Determination of elements of airline fleet and programme of new aircraft production; definition of technical and economic characteristics of the new aircraft; development of the technical task; technical and economic evaluation of relevance new aircraft application in civil aviation	Virtual airline fleet, Aircraft designer
Internal design	III	Determination of basic design parameters of the aircraft which correspond with the technical task.	Aircraft designer, Virtual airline fleet.
	IV	Design and construction works aiming at clarification of the basic design parameters of the aircraft, its construction and power scheme, general arrangement scheme. Definition subsystems structure and parameters.	Aircraft designer.
	V	Units and details construction and development of technical documentation for aircraft production and operation	Aircraft designer

During mathematical model development of the process of external aircraft design we shall follow the given concept: the choice of technical and economic characteristics of the designed aircraft should be performed together with the tasks of prospective planning of virtual airline fleet development.

General design model. Suggesting that the designed aircraft depends on the n varying parameters of $x_1, x_2, \ldots, x_n$, which we shall consider as the point $x = (x_1, \cdots, x_n)$ in the n-dimensional space of parameters. The equations and the inequalities

$$f_i(x) \le 0, \quad i = 1, \ldots, m \tag{1}$$

$$x \ge 0, \tag{2}$$

that describe the functioning of the aircraft, and the criterion of evaluation as well,

$$f_0(x) \tag{3}$$

depend on x. The restrictions (1) and (2) give a G sub-multitude of allowable solutions in the n-dimensional space of parameters.

The task of optimal aircraft design consists in identifying the point $x = x^*$ as the one that

$$f_0(x^*) = \min_{x \in G} f_0(x) \tag{4}$$

or in confirming that there is no x for the function $f_0(x)$ in the multitude G.

The scientific and methodological concept of systems approach to external aircraft design comprises that the model (4) is divided into two interconnected models: operational model and parametrical model. During parametrical aircraft design the following model is used which shows the interconnection of some dominating characteristics of the aircraft that are quantitatively presented as a set of parameters $x_1, x_2, \ldots, x_n$ (or X and Y). During operational modeling the subject of modeling is the aircraft itself. Because the designed aircraft is regarded in relation with other aircraft involved in the transport operation, it is natural to call the model of such type the operational model. At the parametrical level a certain finite quantity of D multitudes of aircraft design parameters according to the isolated criterion $a(x)$ compatible with the criterion of the operational task, is generated. Then using the operational model the optimal variant $x^* \in D$ is chosen from the D multitude.

Principles of operational modeling. Operational model of the aircraft corresponds with the completed multitude of aircraft interconnected by mutual relations. The relations under consideration assist to regard the analyzed model as a unity. From the point of view of mathematics, the relation is classified as the inequality, whereas from the point of view of physics, the given relations are resource restrictions, functioning and technology of transport operation performance.

In case of, apart from a system of restrictions, the criterion of optimal variant evaluation for the designed aircraft is chosen, the operational model of the aircraft can be presented as the problem of mathematical programming :

$$\min f(x_1, \ldots, x_n) \tag{5}$$

under restrictions

$$f_i(x_1, \ldots, x_n) \tag{6}$$

$$x = (x_1, \ldots, x_n) \in D, \tag{7}$$

where D is some area of n-dimensional euclidean space, that is very often regarded as the non-negative cross-entry of the E^n space.

Principles of parametrical modeling. Parametrical modeling shall be considered further as the method of investigation of aircraft mathematical models which researches the main characteristics of these aircraft making use of the most sufficient, "key" parameters and relations between the given parameters.

The basic principles of parametrical modeling can be built up using the method of deduction based on the general theory of systems. We shall circle around the abstract, least restricted description of the aircraft. Then by means of fixing some parameters we introduce additional structures and consider the consequences coming out of the given suggestion. Under the given structure of the aircraft the parametrical modelling consists in defining the values of all unidentified parameters with the help of the values of some fixed parameters of the given aircraft. This is performed conditioned by complying with the a priori regularities and restrictions or with the consistencies and limitations resulting from the process of investigation which connect the parameters. Numerous groups of parameters may be regarded as the identified (fixed) parameters at different stages of design for various technical purposes. Therefore, the general model of the designed aircraft should reflect this fact and should be developed without the primary division of parameters into the identified and unidentified, which is characteristic of models in the form of mathematical modeling problems.

On the other hand, after actuality of the problem, i.e. after identifying the optimal criterion, the fixed parameters and those parameters the values of which are to be defined, this model must ensure obtaining the isolated models in the form of mathematical modeling problem or of the optimal management problem that correspond to the given isolated problem. The requirement of the necessary flexibility in problem formulation is one the major peculiarities of parametric modeling.

At developing the parametrical model the first step corresponds with the limitation procedure. This procedure consists in determining the major, most sufficient design parameters. The whole of the values of these parameters provides the "necessary" information for decision making at the next stage of design. The process of limitation is very important. It is less formalized as the totality or "sufficiency" for description of the aircraft is highly subjective, definition of "sufficiency" of this or that parameter depends both on the stage of design and on the experience of the designers and customers, as well as on the a priori information and the existing system of scientific and technical concepts for the given industry, etc. Thus, the number of parameters creates the basis of the language which is used to describe the mathematical model of the aircraft.

If the limitation of the aircraft is defined, i.e. the parameters $x_1, x_2, \ldots, x_n$ are determined, the next stage takes place. The stage consists in recording the system of major relations of $R_1, R_2, \cdots, R_N$, which link these parameters.

While choosing the relations and parameters of the aircraft we shall follow these requirements:

- The parametrical model should be informationally compatible with the operational model, i.e. the outcome of the parametrical model must ensure the income of the operational model for those elements of the expenditures, productivity, flight regularity matrixes which depend on the parameters of the designed aircraft;
- The parametrical model should include all most sufficient requirements that correspond with the conditions of aircraft design, production and operation, and those relations and parameters which enable obtaining the closed form model;
- With the account of the above-mentioned requirements the parametrical model should include the minimum number of parameters and their connections.

Conclusions. Firstly, the systems approach to external aircraft design clarifies the organizational structure of the design and modeling procedure. Secondly, the systems approach assists the aircraft designer to systematize most known methods and algorithms of synthesis and analysis of such complicated technical systems as the modern aircraft. Thirdly, the systems approach increases the quality of the project and reduces the time for its development. Finally, by means of the proposed approach a number of new problems that emerge at the joint of aircraft design and prospective planning of airline business are effectively solved

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A.S. Vinyukov-Proschenko PhD in Economics (National Aviation University, Ukraine)
F.A. Sharifov Doctor of Science in Mathematics (National Aviation University, Ukraine)

ECONOMIC PROBLEMS SOLVING THROUGH AVIATION

The article is devoted to aviation economics problems solving by means of economic mathematical modelling. It describes three economic problems which have important influence on macro and microeconomics levels. The third problem has interesting applications in aviation in order to provide transportations given express freights by several aircrafts.

Air transport plays key role in economic development and in support of economic growth. It facilitates a country's integration into global economics, providing direct benefits for users and wider economic benefits through its positive impact productivity and economic performance.

However, while air traffic demand has increased as economics have grown, air transportation itself can play a key role as the cause and facilitator of economic growth. Using aviation in different fields of economy provides an effect for finding a better and faster decision of many economics problems. Some of such problems we discuss in this paper.

First problem has a close connection with a national government plans on construction highways to link a given number of inhabited localities in some region. In this problem it is required to build highways to link n settlements in some region according to some government plan. There exist several stages to put into practice the plan.

At the first stage it is necessary to design a fixed scheme of the highways and given settlements, so that all ways are denoted by lines and settlements are shown as points on a sheet.

At the second phase, it is required to determine land locations for all ways. For determination these land locations it is usually used to take at least one photograph of parts of region according to land locations at a height of the bird – eye view. This operation can be done economically feasible by finding a minimal fly route passing through all highways. Therefore the following problem arises at this stage.

Let $G=(V,E)$ be an undirected graph with vertices set $V=V(G)$ and edges set $E=E(G)$, where the sets.

Every given settlement and each cross-road point of ways from the design scheme are denoted as vertices in the set V and a part of lines between two points in the scheme is denoted as an edge of set E. If we make weight of edges proportional to real distance between their end vertices, then this problem is an example of well known the postman problem [1].

Here note that if degree any vertex in the graph G is even number, then minimal fly route is an Euler tour which traverse every edge once. In other cases, a minimal fly route has to traverse some edges twice.

Now consider second problem that has some applications in activity of oil gas company. An oil company has a field consisting of given number drilling platforms off the coast of some region, for example the Caspian and Black Sea regions.

Each platform has a set of controls that makes it possible to regulate the amount of crude oil flowing from wells associated with the platform back to onshore holding tanks. Periodically, it is necessary to visit certain of the platforms, in order to regulate the rates of flows. This traveling is done by means of a helicopter which leaves an onshore helicopter base, flies out to the required platforms and then returns to base.

Demand for the company's helicopter services is strongly influenced by oil and gas exploration, development, and production activities. These activities are greatly affected by federal leasing policies, regulations, oil and gas prices. The Company's helicopters provide a safe, reliable, efficient and fast method of transportation under a broad range of operational and environmental conditions, especially offshore and in remote areas. All of the Company's sixteen principal types of helicopters are available under a variety of contractual arrangements.

The Company maintains master operating agreements with each of its major oil industry customers, which set forth general rights and duties of the Company and the customer. Although the Company is a party to a number of oil and gas industry contracts with a term of one year or more, services are generally provided pursuant to monthly extensions of these operating agreements, and prices are fixed for each contract extension. Contracts for aero medical and foreign business are generally entered into for longer terms.

Charges under operating agreements are generally based on fixed monthly fees and additional hourly charges for actual flight time. Because the Company is compensated in part by flight hour, prolonged adverse weather conditions that result in reduced flight hours can adversely affect results of operations.

The Company's principal customers are major oil companies. The Company also serves independent exploration and production concerns, oil and gas service companies, hospitals and medical programs, and government agencies. The Company's largest customer, Shell Oil Company, accounted for more than 10% of the Company's operating revenues in fiscal 1996. The Company's five largest customers accounted for 34% of operating revenues in fiscal 1996.

Division managers of customer oil companies, who are responsible for a majority of contract services in connection with offshore oil activities, generally contract for helicopter services. Many oil companies also employ directors of aviation to evaluate the capabilities and safety performance of companies providing helicopter services and make recommendations to division managers. Company management and operations specialists are in regular contact with division managers and directors of aviation in connection with both existing service contracts and potential new business.

Helicopters are expensive to operate. The oil company wants to have a method for routing these helicopters in such way that the required platforms are visited, and total flying time is minimized.

If we make the assumption that the flying time is proportional to the distance traveled, then this problem is an example Euclidean traveling salesman problem, which is particular case of the well known traveling salesman problem. To formulate this problem as the traveling salesman problem on the graph $G=(V,E)$, it needs to denote every drilling platforms as vertices of the set V. With respect to this problem the set E contains the edges $e=(v,u)$ for any pair vertices v and u of the set V. It is required to find a simple cycle (or tour) passing through all vertices V and with the minimal length.

Up to now, there is not an effective method to solve this problem. However there many methods that attempt to solve this problem. Most simple ones is Nearest Neighbor Algorithm [1] that works very well, in sense that for many practice instances this method defines a tour with the length not far from the length of optimal tour. This algorithm can be used to solve number of practice valued problem, especially if the number of the drilling platforms is large (1000-10000). For finding a solution to the traveling salesman problem with a high degree of accuracy there exists other algorithms [1], which can be used to solve the real problems.

Note that the mathematical model of second problem or the traveling salesman problem is presented in [1]. The model contains all constrains of the well known the Linear Assignment Problem (LAP) and plus some specific conditions. Hence many methods for solving the traveling salesman problem find an optimal solution to the LAP at each its iteration, and then check the holding the specific conditions on this solution. The LAP has the following interpretation as the scheduling (sequencing) problem: given the set of n operations (jobs) and the set of n technical (machines). Each technician i can carry out any operation j with the time p_{ij}, for example, in days, and can be assigned to exactly one operation as well as each operation can be served by exactly one technician. The LAP is to find such an assignment of all technicians to all operations such that the total processing time is minimized. The LAP is both useful itself as well as a relaxation for difficult combinatorial optimization problems like the quadratic assignment (see [2]) and traveling salesman problems (see [1]). Many different algorithms with time complexity $O(n^3)$

for solving the LAP are studied in the literature. Now, we consider some modifications of the LAP that arise in Aviation.

Third problem. Many air companies have to control the safety of aircraft flight. In general case, the control process can include more stages: preprocessing, processing, checking the quality, repairing etc.

The successful application of integrated systems into the safety critical domain requires careful management and a realistic approach to planning the introduction of such systems. One such approach is through work on technology demonstration programs. British Aerospace and the UK Ministry of Defense have embarked on such a project, considering the integration of several flight critical applications across a common architecture from various view points including a safety perspective. This presented two main challenges Pilots Performance Advisory System**,** is a vertical flight path optimization tool. PPAS is a booklet analog to the optimization part of an onboard Flight Management Computer System (FMS). It delivers optimized climb, cruise, and descent performance data to the pilot. The data is computed based on Cost Index in the same way as an FMS type system. The data and presentation are tailored for each aircraft type and operator. The information is easy to use and understand. This allows pilots to manage their flights effectively. Let us consider a simple generalization of the LAP when the corresponding control process includes just two stages: processing and checking the technical quality of an aircraft. PPAS delivers significant COST savings to airlines by optimizing fuel burn for the operating Cost Index and achieving the required flight time for the flight. Hence time sensitive flights can be operated to meet arrival time requirements and non-time sensitive flights can operate less aggressively and more fuel conservatively. Regardless, the minimum possible fuel burn for the flight time is achieved by a system that responds to wind, weight, flight level, temperature, and Cost Index. Generally, 2% to 5% fuel burn savings are achieved relative to standard fixed Mach or LRC cruise profiles.

Let the costs of the processing and checking the quality by two different cost matrices $P = \| p_{ij} \|$ and $Q = \| q_{ij} \|$ are represented, respectively. Assume that from the management (for example, psychological) reasons if the technician i carry out the operation j then the technician i is not allowed to check the quality of the same operation j. This situation is well known, for example, in some State educational systems for the final examinations in high schools when the teacher employed at the school i is not allowed to mark a final examination of his subject at the same school i.

Let us represent the assignment of technicians to operations for processing stage by variables x_{ij}, so that if $x_{ij} = 1$ then it equivalents to the requirement that the technician i has carried out the operation j. The same set of technicians carried out operations for checking the quality stage. Let the requirement that the technician i has carried out the quality operation j is denoted by $y_{ij} = 1$ where all y_{ij} are also variables. Thus, the requirement that the technician i which has carried out the operation j is not allowed to check the quality of the same operation j, can be written by inequalities

$$x_{ij} + y_{ij} \le 1$$

for all $i, j = 1,...,n$. Then the sum

$$\sum_{i=1}^{n} \sum_{j=1}^{n} p_{ij} x_{ij} + \sum_{i=1}^{n} \sum_{j=1}^{n} q_{ij} y_{ij}$$

is total cost of assignments.

Let $GD = (U, V, E)$ be complete bipartite graph with vertex sets U, V such that $|U| = |V| = n$ and edge set E with two weights $p_e \ge 0$, $q_e \ge 0$ of any edge. Taking into mind the assignment nature of the third problem its mathematical model can be written as following;

$$\min \sum_{i=1}^{n} \sum_{j=1}^{n} p_{ij} x_{ij} + \sum_{i=1}^{n} \sum_{j=1}^{n} q_{ij} y_{ij}$$

$$\sum_{i=1}^{n} x_{ij} = 1, \quad \sum_{i=1}^{n} y_{ij} = 1, \quad j = 1,...,n,$$

$$\sum_{j=1}^{n} x_{ij} = 1, \quad \sum_{j=1}^{n} y_{ij} = 1, \quad i = 1,...,n,$$

$$x_{ij} + y_{ij} \le 1, \quad i, j = 1,...,n,$$

$$x_{ij} \ge 0, \quad y_{ij} \ge 0, \quad i, j = 1,...,n,$$

$$x_{ij} = 0 \vee 1, \quad y_{ij} = 0 \vee 1, \quad i, j = 1,...,n.$$

The problem is obtained by dropping the all constrains $x_{ij} = 0 \vee 1$, $y_{ij} = 0 \vee 1$, ($i, j = 1,...,n$) from the mathematical model is called the linear relaxed problem. There are examples for the matrices $P = \| p_{ij} \|$ and $Q = \| q_{ij} \|$ such that the linear relaxed problem has an optimal solution with $x_{ij} = 0 \vee \frac{1}{2} \vee 1$, and $y_{ij} = 0 \vee \frac{1}{2} \vee 1$, for all $i, j = 1,...,n$. It means that, in different LAP, this problem can not be solved by the methods of linear programming.

In some cases, for instance, if the entries of the matrices $P = \| p_{ij} \|$ and $Q = \| q_{ij} \|$ satisfy the following conditions:

$$p_{ij} = c_{ij} + u_i^1 + v_j^1,$$

$$q_{ij} = c_{ij} + u_i^2 + v_j^2.$$

Then the third problem is easy reduced to the well know minimum cost flow problem and in this case there exists an optimal solution to the linear relaxed problem for which $x_{ij} = 0 \vee 1$, $y_{ij} = 0 \vee 1$, for all $i, j = 1,...,n$. Here c_{ij} and u_i^1, u_i^2 and v_j^1, v_j^2 some real numbers. In other words, in this case the optimal solution to this problem is easy found. The feasibility the above conditions can be checked by finding an optimal solution to LAP with the coefficients $p_{ij} - q_{ij}$ of the objective function.

The third problem has many other interesting applications in aviation and it arises also in finding minimum routes of air transport means in order to provide transportation given express freights by several aircrafts.

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M.S. Kulyk, Professor, Doctor of Engineering
A.V. Polukhin, Professor, Candidate of Engineering
O.V. Solomentsev, Professor, Doctor of Engineering
A.M. Ovsyankin, Associate Professor, Candidate of Engineering
O.M. Polulyakh, postgraduate
(National Aviation University, Ukraine)

PROBLEMS WITH IMPLEMENTATION OF A QUALITY MANAGEMENT SYSTEM IN THE FIELD OF AVIATION PERSONNEL TRAINING

The article looks at major problems related to aviation personnel training at higher educational institutions. The authors propose ways of improving the situation through the quality management system based on the principles of the international standards ISO 9000 and oriented towards maximum satisfaction of employers' and students' requirements and expectations.

Aviation has always been at the cutting edge of science and technology. It employs the newest achievements of science and technology reflecting the current stage in the development of a country, society and industry. Its functioning is determined by such factors as critical loads on equipment and personnel, considerable fluctuations in flight parameters and air situation, impact of air environment characteristics. Consequently, equipment failures and personnel errors in aviation cause considerable negative effects, both material and human losses. In view of this, international and national aviation authorities pay much attention not only to ensuring trouble-free functioning of aircraft equipment and technological discipline, but also to professional training and general intellectual development of aviation personnel (human operators).

Ukraine's system of aviation personnel training covers all aviation branches and processes, including design, development, production, testing, operation and repair of aircraft and aircraft equipment, air traffic control, certification of companies, equipment, facilities, complexes and personnel. The system of aviation personnel training incorporates educational institutions awarding degrees on all levels of higher education (undergraduate, basic and full), and those educational institutions and centres that provide retraining, upgrading and certification of aviation personnel. On the whole, the national system of aviation personnel training fulfils its mission, but the present-day tendencies in aviation development and education call for adoption and realization of corresponding adequate actions on the part of aviation authorities, educational institutions, aviation enterprises, companies and agencies.

Let us look at some issues which open new horizons for improvement of aviation personnel training and have already been implemented in the National Aviation University. The analysis of international practice shows that requirements to aviation personnel training to a great extent have to be determined by the civil aviation system of training specialists. It is this system that should state the mission and policy in the field of aviation personnel training and outline the concept of and strategic action plan for the realization of the stated mission [1].

The Ministry of Education and Science of Ukraine has outlined five priorities in the field of higher education and science for the immediate future: achievement of the European level of quality and accessibility of education, its orientation towards spiritual values, democratization, researchers' and academics' social well-being and modern knowledge-based development of the society.

These priorities are to a considerable extent harmonious with the goals and tasks of the so-called Bologna process which determines the effort of the European states aimed at creation of compatible and more effective national higher education systems throughout Europe. The goal of this process is not unification but harmonization of national higher education systems, a transfer to a new education philosophy which provides for new organizational principles of education, up-to-date educational technologies, a new type of teacher-student interaction, transparency of the academic process, etc. Implementation of the credit-modular system of academic process organization was a practical step in the transition in this direction. Its first stage consists in the adoption of the modular principle of organizing the teaching material and the multi-grade rating system of assessing students’ knowledge, skills and competences. This work has been successfully carried out at the National Aviation University since 2004 [2, 3].

The experience gained by the university in implementing the credit-modular system shows that the already existing and innovative educational processes still need theoretical interpretation and practical testing for harmonious integration of innovative and already existing effective components for the purpose of creating successful systems of education functioning on the basis of productive interaction of components and able to ensure enhanced theoretical and practical training of specialists. To be competitive, a potential employee has to meet the following minimal requirements: a high professional level, mastery of up-to-date methods and technologies of designing, modeling and obtaining innovative solutions, ability to work in the global information space, fluency in one or more foreign languages, awareness of the basic requirements for employer-employee relations and conflict management techniques, initiative, sociability, high working efficiency, ability and readiness for work on their own, with high quality and performance results.

In view of the experience of the leading countries where education systems are based on systemic search for, selection of and proper regard for young people’s inclinations, abilities and talents, it is essential to apply individual approach to every person both during their application to a university and in the process of study. This calls for individual planning of the process of study and real, not fictitious, incorporation of optional (selected by students) disciplines into curricula alongside compulsory disciplines, which creates essentially new challenges for the academic staff, quite different from those of “facing the audience” teaching format. Students’ self-study acquires here a special significance.

In such conditions, the role of academics’ and students’ research is growing dramatically. Research becomes an integral element of the academic process, as the aim of science is to produce new knowledge. In view of its own experience and that of the leading West European and US universities, the National Aviation University practises the following types and forms of research: traditional research carried out by university departments and R & D divisions, setting up research teams of undergraduate and postgraduate students and young academics to solve specific research problems under the supervision of prominent scientists, students’ competitions in academic disciplines, scientific conferences, etc. Dynamic research activity enables the university to maintain the required level of the academic staff competence and to use the obtained research results to develop and publish up-to-date textbooks, manuals and other academic products and to use them in the academic process.

For the purpose of material and moral encouragement of students in their study, enhancement of their research and creative potential, patriotism and active social position, the University Senate (Academic Council) awards personalized scholarships to the best full-time students who show recognized achievements and tangible gains in research and development. These scholarships bear the names of prominent scientists: an outstanding spacecraft designer academician V. Chelomey, who graduated from the university, a prominent aircraft designer academician O.Antonov, an eminent researcher in the field of cybernetic systems, Correspondent Member of the National Academy of Sciences of Ukraine O. Kukhtenko, a well-known constructor, Correspondent Member of the National Academy of Sciences of Ukraine V. Shymanovskyy and other prominent academics who worked at the university at various times and made a considerable contribution to its development.

At the same time, while analyzing the university performance, its administration has come to the conclusion that one of the promising ways of further improvement of the quality of aviation personnel training lies in the implementation of the quality management system (QMS) in the academic process. It is well-known that quality management systems of businesses, companies and agencies of various branches are based on ISO 9000 standards and the most comprehensive experience in the field of their implementation has been gained by industrial enterprises [4].

Implementation of ISO 9000 standards in the sphere of education has certain peculiarities connected with the necessity of prior settlement of certain essential issues by an educational institution [5]. One of them is defining a product of the quality management system. The problem is that the required level of the product quality is to be achieved through realization of a set of pre-defined activities and be measurable. One option is that the product can be a graduate who has been awarded a diploma of the educational institution. Another possible option is that the product is the educational or other service provided by the educational institution.

In terms of the first interpretation of the quality management system product, problems may be caused by the difficulty to adequately assess its effectiveness, as a graduate's qualification level depends not only on provisions of the academic process quality system, but also on students' individual talents and peculiarities, their willingness to study. Under the second option, we get objective and measurable indicators of the educational service quality on all stages of the academic process. This argument played the decisive role in choosing an educational service as the major product of the quality management system at the National Aviation University. In view of the importance of R & D work at the university, a research service is viewed as a variant of the product. The functions of the quality management system are in this case developed in keeping with ISO 9001:2000 standard as it is applied by companies and organizations which provide industrial services.

The major principle to be realized within a quality management system is clear orientation towards requirements and wishes of the customers, i.e. service consumers. The academic process is organized in such a way as to provide students with the maximum amount of knowledge, skills and competences whose content and level are determined by the requirements of potential employers (customers).This task is realized by establishing a clear-cut and consistent chain of actions, starting with analysis of demand for specialists in a particular field and determination of the actual theoretical and practical potential which a future specialist already has and may obtain in the process of study. This analysis serves the basis for developing corresponding variable components of the course description and the program of specialists' training, which in their turn serve the basis for developing university curricula.

Besides satisfying the major requirements of the consumers of educational services, the system provides for mechanisms aimed at meeting their additional requirements, for instance, duration and type of the course of study, possibility to take internship at the customer's company, etc. An important additional requirement of airlines is that graduates should be fluent in English to meet the standards of ICAO, Eurocontrol and other international aviation organizations, and know the requirements imposed by aviation normative documents, e.g. JAR 66, JAR 147. etc.

Satisfaction of the above-mentioned requirements is achieved by the university by means of so-called "English-speaking" and "Spanish-speaking" projects, in whose framework all disciplines for students in 13 engineering specialities (majors) are taught in either English or Spanish. This makes it possible to train aviation specialists meeting up-to-date qualification standards on the international aviation job market and to guarantee their employment with both Ukrainian and leading foreign companies.

The extent of satisfying customers' requirements has to be continually monitored by means of establishing a close contact between the subjects of educational activities (university departments and faculties) on the one hand, and employers, alumni and other persons concerned on the other hand.

Another essential issue in the process of implementing a quality management system is the application of the process approach, which has a direct impact on achievement of the high quality of educational and research services. Introduction of the process approach makes it possible to set up a single integrated chain of action, beginning with defining customers' requirements for specialists and finishing with an objective assessment and confirmation of their satisfaction [6]. This involves interaction both between immediate participants of the academic process (Office of Studies, Humanitarian Development Office, Research Office, departments, faculties and students) and auxiliary divisions of the university. Besides, the introduction of the process approach gives the possibility to assign responsibility for each particular activity and its results.

Systemic approach realized in definite hierarchical processes aimed at managing such a complex system as a university makes it possible to give timely responses in case of potential nonconformities and to prevent them. It also enables the university management to monitor the overall system effectiveness.

An essential mechanism of effective implementation of the quality management system is active involvement of all staff and students in quality culture, their corresponding training and encouragement. Above all it concerns the university administration that declared their QMS-related goals and gave a guarantee that the university will accomplish the tasks aimed at ensuring high quality of its educational and research services. The position of the university administration is stated in two fundamental documents: the University Quality Policy and University Quality Goals. All university staff, students and potential customers have been acquainted with their content.

Another key point of the quality management system is its potential for continual development and improvement. As has been said above, aviation is a high-tech, fast-developing industry. This fact explains constantly changing requirements for aviation personnel. They are becoming more exacting, comprehensive and substantial. Consequently, the system of training has to react to the new requirements and introduce corresponding corrections into curricula and syllabi. Moreover, the structure of the quality management system has to undergo continual improvement. Processes have to be optimized and simplified, the quality management system as a whole has to get effective information and computer backup.

Having analyzed the international practice of implementing up-to-date management systems at companies and organizations, and the management system existing in the university, the National Aviation University launched a project aimed at design, implementation, improvement and ISO 9001:2000 certification of a quality management system, whose products are educational and research services.

This project is one of the university's top priorities. It is meant to facilitate the accomplishment of the university's strategic goals and tasks determined by the university mission - to strengthen the national educational and professional potential by means of high-quality training of specialists with various degrees for companies and organizations of all forms of ownership in civil aviation and other branches of economy, who will be competitive on the world market and ready for fruitful professional work in the context of ever-changing global community.

The quality management system which is being implemented at the university is built on the basis of the fundamental quality management principles, the major ones being orientation towards the customer, process approach, continual improvement, fact-based decision-making, etc.

Definition of the quality management system functions involved complex theoretical and applied research aimed at ensuring the system effectivity. The university regards implementation of the quality management system as a further important step in the development of the existing system of providing educational and research services, whose objective is to enhance the quality of the academic process and research and to guarantee maximum satisfaction of customer requirements related to the services provided by the university.

As has been said above, one of the most effective methods of satisfying the needs of specialists' employers is the use in a quality system of the process approach, which primarily consists in presenting all actions in the system in the form of processes with specified inputs, outputs, resources for their realization and corresponding normative documents. The outputs from one process serve the inputs to the next, which makes it possible to monitor all activities and their results, including integrated ones. Having analyzed the existing system of the university management and requirements laid down in ISO 9001:2000, the university singled out three major groups of processes: management processes, education and research processes and supporting processes.

Management processes involve monitoring, analysis, decision-making related to corrective and preventive action, supporting the effectiveness of the major education and research processes.

The processes of internal audits and data analysis for further improvement serve the purpose of identifying nonconformities and developing activities aimed at continual improvement of the quality management system.

Education and research processes are of primary importance for the provision of educational and research services. They constitute a complex of processes, interconnected through inputs and outputs and include pre-university training, admission to the university, design of new areas of specialists' training, organizational and methodological activities supporting the academic process, the academic process itself and the process of graduates' job placement. All these processes are carried out in contact with customers who define requirements for the process of specialists' training, to ensure customer satisfaction.

Supporting processes are aimed at supporting education and research processes by means of realizing the following processes: control of documents, control of human resources, control of infrastructure, control of work environment, control of information resources, control of publishing.

In keeping with ISO 9001 requirements, a package of QMS documents has been developed, including Quality Instruction, obligatory documented procedures, lists of documentation and forms. All documentation related to activities of all university divisions has been adjusted in view of the quality management system requirements. Other normative and routine documentation related to university divisions has been reviewed. Instructive and information materials have been developed to support the design and implementation of the QMS processes.

The organizational structure of the quality management system has been outlined and persons responsible for its major processes appointed. To coordinate the work of the university structural divisions related to management processes, the following steps have been taken: Vice Rector for academic work has been appointed University Administration Representative for Quality; the Division for Specialists' Training Quality Management, University Quality Council and Quality Boards of the institutes have been set up; persons responsible for quality at the faculties, departments and other structural units have been appointed. Scientific and methodological support of the design, implementation and improvement of the quality management system in the university is provided by a special workgroup including expert academics and university leading specialists.

The international certification Bureau VERITAS CERTIFICATION held a set of workshops in theoretical and practical basics of quality management for representatives of university structural divisions, who obtained certificates of ISO 9001:2000 QMS internal auditors, and for the university administration. Candidate auditors have been appointed and included into auditor groups. The plans for quality management system development provide for increase in the number of internal auditors after these candidates have completed a course of training and certification.

Implementation of the quality management system included carrying out a comprehensive internal audit in the university structural divisions involved in the provision of the educational and research services. The internal audit revealed a number of typical nonconformities to ISO 9001:2000 requirements.

Problems arising in the process of implementing the quality management system are connected with customer communication, monitoring and quantitative assessment of the effectiveness of the education and research processes, assessment and testing of students' knowledge, skills and competences, assessment of the effectiveness of the quality management system on the whole and its components, automation and computerization of paperwork flow, etc.

Problems related to customer communication can be solved by creating and implementing a system of contractual relations between an educational institution and customers, with customers' possible investing in specialists' training. Customers' preferences can be satisfied by developing specialists' training programs customized for individual companies. A university can set up "corporate" department subdivisions or other units, fully or partially funded by customers.

Problems related to monitoring and quantitative assessment of the effectiveness of the education and research processes involve defining an optimal set of indicators characterizing the quality of the processes, measurement regularity and techniques, application of information processing algorithms. These problems will be addressed by means of complex research aimed at determining nonconformities occurrence models, risk assessment models, process models, and by development of a complex of systemic models for separate aspects of the quality management system operation.

Problems related to assessment and testing of students' knowledge, skills and competences are connected with implementation of objective computer-based assessment systems. For this purpose the university is going to carry out research and pilot testing of corresponding tests and software.

Problems related to assessment of the effectiveness of the quality management system on the whole and of its components are topical due to the fact that the cost of designing and implementing the system is high whereas assessment issues are not covered by quality management standards.

Problems related to automation and computerization of paperwork flow are particularly urgent for those educational institutions which have a large body of personnel and students, the National Aviation University among them. The paperwork flow system has to be reliable, responsive to changes and corrections and optimal in terms of its complexity and user-friendliness for all university divisions and personnel.

All the above-mentioned problem issues are in fact tasks to be solved in the process of the quality management system continual development. They are included in university action plans for improvement of quality.

The dynamics of the university development on the basis of the concept of its transformation to a higher educational institution complying with the international standards opens favourable prospects for the university to achieve this goal, to reach international standards and to be integrated into the global educational and scientific space. Implementation of the quality management system on the basis of ISO 9001:2000 standard at the university will accelerate this process and bring the quality of the university education closer to requirements of international standards, which will promote attractiveness and competitiveness of the university within European educational and scientific space and facilitate mobility of Ukrainian students.

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Capt. R.A. Pérez, M.A. [Aviation SIMCOM-ATC, México]
G. Bejarle, M.A. [Universidad Autónoma de Baja California, México]
J.E. Méndez, M.S. [Aviation SIMCOM-ATC, México]

TESTING ON AVIATION COMMUNICATIVE PROFICIENCY: AN INTEGRAL EVALUATION IN A SECOND-LANGUAGE CONTEXT

Models of language proficiency should be based on an empirical assessment of authentic aviation communicative tasks rather than on textbook models of communication in single-language natural settings. This paper shows how research provided the empirical data from which language aviation proficiency should be evaluated. The conducted research identified the specific context in which a series of complex aeronautical activities and cognitive efforts were manifested. The resulting test design consists of a direct and integral language assessment instrument that uses a simulated setting in which Spanish-speaking pilots have to deal with communicative challenges specific to exchanging messages in a virtual scenario.

Since 1998, the International Civil Aviation Organization (ICAO) has pushed forward its policy on language proficiency requirements within states members after determining that language has been a contributing factor in aviation accidents and incidents worldwide. Therefore, ICAO has established standards, recommendations, guidelines, proficiency levels, and a full agenda to reach its objective.

ICAO´s language proficiency requirements establish a rating scale in which minimum skill levels of radiotelephony and plain language usage have to be met. As each state has determined its best method for testing their flight crews and air traffic controllers, ICAO has given extensive recommendations on the formation of tests based on holistic descriptors that help examiners determine the level of language proficiency.

"The objective of the ICAO language proficiency requirement is to ensure that flight crews and air traffic controllers have sufficient language proficiency in whatever language they use for radiotelephony communications to manage all of the potential communicative needs related to pilot and controller communications, ranging from routine phraseologies, to routine communications not encompassed by phraseologies, to non-routine situations (aircraft lost or low on fuel), to outright emergencies[1]"

Therefore, an instrument to assess language proficiency had to operate under ICAO standards by means of an integral approach (direct exam), rather than fragmented questioning items (indirect test of discrete features of language use). Ideally, the practice also had to ensure a "cognitive realism" in the sense that the simulation setting engages pilots in a decision-making, or problem-solving process that parallels the mental activities required in real-live situations.

Mexico, with the participation of pilots, air traffic controllers, linguists, and anthropologists supported by *El Colegio de Pilotos Aviadores de México* and sponsored by *ASA-CONACYT*[1], created an assessment instrument that uses simulated scenarios: Spanish-speaking pilots interacting with a live air traffic controller in English within the constraints of a flight profile, weather, traffic and navigational situations. Pilots are thus exposed to a variety of complex aeronautical activities and cognitive efforts. As the virtual setting becomes increasingly hazardous (e. g. fuel exhaustion),

[1] We thank *El Colegio de Pilotos de México* for the professional interest in pursuing this research and the resulting evaluation test design. We also thank CONACYT (which stands for *Consejo Nacional para la Ciencia y Tecnología*), which in agreement with ASA (*Aeropuertos y Servicios Auxiliares*), sponsored our research.

pilots are required to negotiate a resolution with the controller, which may include a Mayday declaration. The resulting communication process becomes increasingly difficult as second-language production demands progress from procedural (routine) to improvised (non-routine) communications. This language assessment instrument is called Aviation-SIMCOM-ATC.

1. A research setting to solve a test design problem

For a test to be valid and reliable, it must consist of two essential components: 1) a series of situations which lead the pilot-examinee to interact with a controller in such a way that examiners can observe the skills required for aviation radiotelephony communications, and 2) an unbiased observation procedure that guides the examiner to choose the actual proficiency level of the examinee's communicative skills.

Since this report might be useful to other countries to develop assessment models, it is relevant to consider that to deal with the following research problems is to provide a better understanding of how to reach a helpful and unbiased assessment. (We would like to thank Fernando Castaños, PH.D. (*Universidad Nacional Autónoma de México*) for the design methodology which unfolded the series of questions, and the ethnographic description, which provided us with useful insight on actual pilot communication skills).

***Problem Design 1*:**

What are the characteristics that a simulated flight setting must fulfil for an examinee to use his/her communicative skills in English language, according to the situations referred to in the holistic descriptors of the PRICESG[2] manual?

The setting had to include near-to-real speaking situations that simulate, to the highest degree, real flight communications. The controller's commands had to follow the internal logic familiar to the pilot. Other key situations –considered before and during the setting– must bring about dialogues both in routine and non-routine conditions. Therefore, the exchange of messages was, first of all, intended for the pilot to corroborate undemanding instructions with the purpose of comparing and confirming the controller's information. As the simulation moved forward, the pilot had to deal with more demanding instructions under unfavourable conditions, in which he/she was not supposed to collate the information in a first attempt. Such a challenging situation compelled the pilot to negotiate a different course of action with the controller, so that safety decisions can be finally made.

Problem Design 2:

How can the examiner be guided to do judicious observations on the pilot's communicative skills?

Due to the complexity of the interaction taking place in flight situations, it became necessary to make the examiner realise the key factors that bring about a successful communication, and the possible causes that produce communicative failures (as long as they are important). As a result, an evaluation guide was designed, a work entailing an analysis of certain key descriptors included in the ICAO manual. At the same time, this work had other implications: namely, to know what the elements of language are, and how they are used in communicative processes.

Research Problem 1.

How do the elements of language and the communicative processes relate to each other?

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[2] Stands for Proficiency Requirements in Common English Study Group. PRICESG was created to assist the ICAO´s Secretariat "in carrying out a comprehensive review of the existing provisions concerning all aspects of air-ground and ground-ground voice communications" (Manual on the Implementation of ICAO Language Proficiency Requirements p. *vii*).

In order to answer this question, it became necessary to distinguish three communicative phases or processes: a) Identification of the process that establishes a relationship between what is said within the communicative context and the situation; b) Message structure, that is, when the pilot appropriately recognizes and indicates the elements and the characteristics of a message; c) cooperative construction of the discourse, that is, when both pilot and controller participate in the articulation aeronautical discourse according to the elements of the communicative situation and the flight plan.

If such processes are not discerned, it is not possible to identify the pilot's proficiency level, for it cannot be determined what communicative skills he/she employs in two different levels. Hence, a second research problem arises:

Research Problem 2.
What are the categories required to study the relationship between the elements of language and the communicative processes?

The clue to answer this question was an ethnographic description of aeronautical communications. There was a particular need to understand the role of communication in the development of aeronautical tasks. This was the basis to explain why the discourse of radiotelephony communications acquires special characteristics that articulate the communicative processes. That is to say, a third research problem had to be defined:

Research Problem 3.
How does a pilot use the information received to perform the flight tasks?

To answer this question we needed: a conceptual framework to analyse empirical data, a record of the usage of language in communicative processes, a guide to observe to what extent those processes were accomplished, and a definition of the settings needed for evaluations. Our objective was to verify that the grades resulting from the evaluation had to reflect meaningful differences in the examinees' abilities. In order to achieve these goals, it was necessary to obtain and analyse a number of measures through the assessment model to conclude that the evaluation guide measures what has to be measured. So we have, at this point, a fourth research problem:

Research Problem 4.
What kind of test and criteria provided the validity and the reliability of an assessment instrument comprising the simulated setting and the observation guide?

Since authentic instructions were delivered to the pilot following a pre-designed script, and as language production became increasingly difficult, we were able to obtain an integral perspective to detect ineffective usage of the second-language, and yet maintained the overall picture of the communicative processes. The assessment model fixed its attention on discourse performance, where some erratic control of language may occur. At the same time, it analysed whether segments of the dialogue was not interfering in the successful communication as a whole. All these had to be possible within the ICAO language proficiency rating scale framework.

The ultimate goal was to evaluate the actual communicative proficiency that ICAO has established as a safety factor, and to ensure impartiality in all evaluations. Below, there is a list of the assessment criteria which resulted from its implementation.

2. Distinctive Characteristics of an Integral Assessment for the Evaluation of the Communicative Proficiency in English Language

Evidently, the main characteristic of the Aviation SIMCOM-ATC instrument is the emphasis on the cooperation between pilot-examinee and controller –who generates the interaction process– to exchange messages within the context of aeronautical communications. It is in this simulated space–which resembles the pilot's work when flying in real, international airspaces– that the examinee tacitly assumes his/her communicative responsibilities. Pilots have generally shown their approval towards this basic structure, since it allows them to demonstrate, in a familiar context, their actual level of English language according to the aims of aeronautical communications. That is:

i. To transmit and to receive information on navigation, control, and flight conditions;
ii. To negotiate and to agree upon courses of action in various circumstances;
iii. To verify the communication itself;
iv. To take aeronautical decisions (these are not graded).

In order to stimulate the pilot's perception and awareness prior to becoming the role player, he/she accesses to:
An introductory video
A flight profile video
A live briefing on the flight
Navigational maps and charts
Weather and fuel information
Some of the most relevant data of the event

The characteristics of the interactive communication design between a real-time controller and the pilot-examinee, along with some simple representations of flight data included in the setting offered different opportunities for pilots to demonstrate their English language proficiency.

2.1 Characteristics of Aviation SIMCOM-ATC assessment tool:

Noble: Since it was designed and implemented on a pilots' initiative, this instrument offers a dynamic character that pilots themselves regard as authentic and reliable. These characteristics resulted from a solid research accredited and supported by an interdisciplinary group of academics. Linguists, anthropologists, sociologists of aviation and other professionals participated in this research. We firmly believe that these are the reasons which have made our assessment increasingly popular in Mexico's aeronautical community.

Reliable: The results have shown stability because the assessment model has systematic settings, and an examiner's guide which directly registers, with a high degree of objectivity, all the criteria involved in the pilot's communicative proficiency in English, according to the ICAO standards. As of today, we have only received two requests for assessment revision available upon request.

Valid: The interaction between pilot-examinee and controller is highly realistic. That is, there is a thorough correspondence between the communicative functions within the flight context–developed and generated by a script the controller has to follow– and the examinee's oral production, which is recorded in a digital audio and analysed prior to issuing the final result.

Suitable: This assessment model generates real-time, dynamic interactions (with realistic communications among other aircrafts), and gradually gives way to usual and unusual radio-communication conditions. In this way, we thoroughly observe whether the pilot-examinee manages to deal with communicative interactions in routine, non-routine, and even emergency situations. These conditions accurately fulfil one of ICAO crucial requirements: An English assessment for the aviation industry should respond as much as possible to the communicative requirements of the aeronautical work[2].

Brief: The assessment has a reasonably short length and can be easily graded (by means of the evaluation questionnaire that guides the examiner). The interaction within the simulated space does not take longer than forty minutes, with an average time of twenty-two minutes.

Acceptable: According to our quality survey, pilots have generally shown their approval, and liked the instrument's realism. With 99% of favourable opinion, pilots have also highlighted the assessment's virtues on the blank space for comments (this survey is given to the examinee after the exam).

Professional Ethics: Unlike other instruments, we use an evaluation guide that is an essential resource that allows examiners to determine the definite grade in a highly objective and ethical way.

Sensible: We do not evaluate the knowledge of English language nor its grammatical rules, but how the pilot-examinee deals with the communicative challenges resulting from usual, unfavourable, and non-planned flight conditions. Aviation SIMCOM-ATC evaluates the pilot-examinee's capability to transmit and to receive flight information, negotiate and agree upon courses of action with the controller, and how successful his/her overall communicative proficiency is.

Transparent: Those unsatisfied with their final grade have the chance to request an assessment revision. Two examiners will listen to the recorded audios in presence of the examined pilot, and carefully explain him/her the procedures of the evaluation. This revision takes place within a context of transparency and impartiality.

3. Results

Up to May 20th 2008, two hundred and thirty six pilots have been tested with the Aviation SIMCOM-ATC assessment tool. Seventy-two percent was the passing rate of the overall population obtaining ICAO language proficiency levels four, five or six. Thirty-seven percent obtained ICAO minimum operational level four. Thirty-one percent scored the extended level five; and only six percent reached the expert level six. Needless to say, Mexico is a Spanish-speaking country where learning English as a second language is not compulsory. However, the closeness to the U.S. and its culture has made the English language accessible, and easy to improve. Mexico uses Spanish-speaking radiotelephony communications, unless some flight crews decide to communicate in English.

Out of the twenty-eight percent of the overall population that obtained language proficiency level lower than the minimum operational, twenty three percent scored a level three. According to the results of the exams, pilots' weakest and least inadequate abilities are comprehension and vocabulary proficiencies, while pronunciation and interaction seemed to be in a regular average.

Conclusions

The International Civil Aviation Organization has been trying to standardize language proficiency for flight crews and air traffic controllers after determining that language misunderstandings have been contributing factors for accidents and incidents worldwide. After analysing the recommendations given by ICAO, *Aviation SIMCOM-ATC* and *El Colegio de Pilotos Aviadores de México* developed an assessment model that allows Spanish-speaking pilots to simulate flight communications in English language with a live air traffic controller. Since the virtual setting takes the pilot-examinee from routine to non-routine, and even hazardous conditions, pilots need to use all their linguistic skills to negotiate information during the interaction, as required by previously planned aeronautical constrains. Hence, second-language production becomes increasingly difficult as the pilot participates in specific situations for the cooperative construction of the aeronautical discourse according to prototypical structures.

The SIMCOM assessment instrument is considered to be noble, reliable, valid, ideal, suitable, acceptable, ethical, sensible, and transparent. A key element of this assessment is an evaluation guide that determines language proficiency according to the actual communication difficulties based on the processes and the elements of language structure. This testing procedure along with different flight simulated settings ensures objectivity and consistency when evaluating the English language comprehension and production.

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Oleg Budnikov, Kiev

THE IMPACT OF THE SPECIFIC PROFESSIONAL EXPERIENCE OF PILOTS FROM THE FORMER SOVIET REPUBLICS ON THE IMPLEMENTATION OF INTERNATIONAL FLIGHT MANAGEMENT STANDARDS

Cold war has gone and now we enjoy great possibilities that have arisen after the Iron Curtain between civilizations had fallen. Aviation as one of the most science intensive and technological branches of human activity and one that link now the civilizations gives airmen additional advantages in the process of "interpenetration" of the cultures in all ways. But time spent in isolation actually caused a lot of problems to national aviation because there appeared a gap in mentalities of native and western airmen. This gap is clearly demonstrated by flying activity that is strained with flight safety requirements and is specifically conservative in interpersonal and production relationships. The reason of that gap existence may be found not only in distinctions as to natural historical and ethnic factors but also in social and economic conditions of forming of psychological patterns and value system differences.

That's why it's essential to adapt general flying standards (such as Crew Resource Management) used worldwide to the post-Soviet aviation. There are an awful lot of aspects concerning connection of an adaptation process of training programs and normative documents that regulate flying activity to the flights safety and regularity levels.

New relationships with modern aircraft and equipment manufacturers give native airlines great possibilities to update aircraft fleet. But take into account that when we buy or lease new equipment we also need documents, manuals etc. Now it's clear how new overall methodological, technological, organizational and relative production ideology was imported in Ukraine during a short period. That's natural to use methods and technique of countries that made their way in successful development and that actually produced the equipment we lease. Unfortunately this process in general was a blind copying without considering essential difference between western producers' and native airmen' mentalities. New economical conditions required new kind of management so we copied not only documents that regulate flying activity but all adjacent spheres documents too. Almost all types of normative documentation were renewed, among them: Company Operation Manual, Standard Operational Procedures, Flight Crew Operation Manual, Training Manual etc, but the mentality of native airmen remained unchanged as it became evident from the flight safety analysis. Flight safety level in our airlines was much less than that in western airlines which utilized the same equipment and had similar documents.

The reasons of such a situation may be explained taking into account not only economic factors but psychological factor too. The mentality of post-Soviet airman doesn't fit to the requirements of western aircraft manufacturers. Firstly, the manufacturer set complete obligatoriness of requirements and restrictions given by him in Aircraft Flight Manual. Western manufacturers in fact weren't informed that Soviet pilot got accustomed to sufficient safety factor of Soviet aircraft and because of this fact he got used to pay less attention as it's necessary now to such principle restrictions as maximum take-off weight, temperature restrictions etc. Moreover, for post-Soviet person mentality it's not always obvious that such basic values as his life are more important than momentary economic or emotional interests.

The fact, that western aircraft bought or leased for our national airlines had new ergonomic, methodical and also technical features, gave us additional problems. That aircraft were of next generation. Flight Management Computer Systems allowed decreasing practical activity of the crew to computer operator functions level in many processes. That led to reduction of cockpit crew members to only two persons but increase of received information load by them. And as the result another requirements for pilot's professional skills appeared. Being highly appreciated for a long period such skills as Chkalov pilotage qualities, ability and inclination to make volitional decisions came to the background. Technological discipline, technical competence, ability to train and change approaches quickly are in great value now. Many native pilots are not ready for such reality. But there was no equivalent for them because famous in the old days Soviet flight school was practically paralyzed by that time. So we met a demand for creation of new modern flight crew training system which would meet all the requirements of time and world standards.

Another essential methodological difference in flying organization is the responsibility distribution between flight crew members. The captain in “Soviet” crew was responsible for flight safety no matter who controls the plane in concrete flight. Captain used to make a decision and he could interrupt in any technological procedures that were being performed by other crew members on the basis that “captain is always right”.

In modern western airlines Pilot Flying is responsible for decision making according to functional principle. And Ukrainian airlines that utilize western aircraft got used to copy this principle of flight crew responsibility distribution. Meanwhile following the normative documents is absolutely prior. So the basic principle of democratic community has found its practical application: every person makes decisions according to his competence and bears responsibility for his decision and its realization. Every person acts precisely according to the instruction and makes a decision within his competence. Interference of captain in this process is only permitted in abnormal situations and is an issue of following investigation. Such status quo is usually painfully accepted by the captains who worked for a number of years in Soviet airlines. Therewith First officer is not always psychologically ready to make a decision and often subconsciously wait for captain’s command. As a rule an absence of a decision is a decision too but in the majority of cases an incorrect one. From the psychological point of view the First Officer is hard up. On the one hand he is responsible for strictly regulated procedures implementation and decision making within his part and he has right to act according to the requirements set in the international aviation community. On the other hand he possesses previous work experience that prompts him to admit captain’s authority and act taking into consideration his opinion. From the legal point of view captain is in strained circumstances. Traditionally he carries complete responsibility for the flight safety no matter what is function distribution during various flight stages. That’s why captain has a dilemma: either to follow the Standard Operational Procedures or to interrupt into First Officer’s actions at first slightest mistrust in his ability to provide safety and own calmness. Acting like this captain contradicts international standards of operation in crew and technological documents demands.

Crew forming principle is one more methodical distinction in organization of flight operation. During Soviet time the crew was stable and normally it didn’t go through any changes. It means that the crew was like a one whole family where captain is a guardian of professional, emotional and moral state of his crew members and he was making his best to maintain these states on a sufficiently high level. And as a result of his actions there was usually complete mutual understanding and congruence in the crew. Captain knew perfectly the abilities and what’s more important peculiarities including psychological characteristics of any crew member what allowed him using this knowledge most effectively. But that fact meant difficulties in the process of flight crew membership changes. Because any new crew member was accepted originally as an alien and he brought a bit of discomfort and finally made the operation of flight crew more complicated.

The modern principle of flight crew forming is based on pilots’ equivalence and interchangeability. This principle means absolute standardization and unification of all airline active procedures and certainty and identity in mutual understanding and execution of technology by all airline specialists. This means that every crew member consider any other crew member only as a part of strict technological process that has no personal characteristics. On the basis of any procedure stands obligatory Cross Check. It means that no action cannot be performed without another flight crew members’ confirmation. This kind of control can be realized by aircraft control verbalization which means that every crew member announces his actions-to-do and call out any changes in flight mode to concentrate another crew members’ attention. It seems to be quite natural and useful to use verbalization but in practice it faces unacceptance from crew members that have an experience of working in the airlines where authoritarian ideology dominated. It’s almost impossible to convince such a captain to inform the First Officer about all his own actions concerning control of aircraft and systems. Such a demand is interpreted by the captain as an attempt to humiliate his significance in the crew. That's because he used to give instructions and ask other crew members for information but, bless the mark, not to report to them his own actions! In practice captain usually ignores verbalization when not inspected. Finally such captain's disapproval to follow verbalization causes discipline level weakening and creation of a real threat to flight safety because the First Officer may not have all necessary information about current aircraft processes and captain's intentions. Also all these factors lead to the demolition of actions stereotype, information interpreting and correspondingly decision making in case of dangerous situation appearance.

Unfortunately I may continue the list of examples that describe all the distinctions and disparities in flight management, an influence of flight training programs unadapted to actual social and production conditions on flight safety level control. Moreover there is language barrier. But to my mind in my report there are represented a lot of them and they demonstrate clearly the amount of needed changes and elaborations in sphere of flying management which would actually help native airlines to progress in the process of adaptation to international standards. And nowadays a lot of work is already done and a great lot of work will be done by Ukrainian principle airlines and aviation training centers such as: "AeroSvit – Ukrainian airlines" airline, Ukrainian International Airlines, International Aviation Training Centre, and National Aviation University. There are elaborated and developed aviation specialists training programs which meet the modern standards requirements. But still there is a lot of work to be done in this sphere. Quite positive results are gained after joining foreign specialist and our compatriots who trained abroad and worked for a certain period of time in famous foreign airlines. That effects positively on the process of adaptation of Ukrainian airlines to the international standards. And the number of such examples of influence grows day by day. More and more Ukrainian pilot try to obtain a position in foreign airlines and actually they do that. It seems to me it is a good fact for those who think over problems of personnel shortage in international aviation and watch the great resources of Ukrainian aviation for this reason. Obviously Ukraine may become a personnel supplier for not only Ukrainian airlines when the right approaches (including psychological) are used for the forming of personnel. But it's not that easy to find out those approaches indeed.

Yeah, the age of changes is difficult one. But maybe just because of this it's interesting?

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Vladimir O. Kasyanov,prof.dr.of sci. (*National Aviation University*)
Yuriy T.Guz, can.of sci.(*National Aviation University*)
Valeria V. Pakhnenko, can.of sci. (*National Aviation University*)
Iryna V.Prohorenko, the post-graduate(*National Aviation University*)

THE ELEMENTS OF THE SUBJECTIVE ANALYSIS, THE POSSIBILITY OF THE TRAINING PROCESS PROBLEMS APPLICATION

In the article methodological constituents are examined in relation to the decision of problems of improvement of quality of studies

Putting of the problem

The training process is considered as the problem-recourse situations solving of converting the student and teacher recourses consisting of three components: the information transmission, the modification (the intellect features development), and the modification of its ethical issues of upbringing. It is said that the subjective analysis may appear as the probable effective basis of the training process analysis and synthesis.

The analysis of some researches and publications

The sufficient intensification of attention to the training quality assessment in the systems of the training process management took place after the substitution of traditional form of the training assessment for the training assessment form based on the rating system of the knowledge assessment as well as the credit-module system as the priority knowledge assessment system of the leading countries. Though this system is a kind of forward movement, it still has some essential drawbacks in its present form.

The direct attack of the state Regulations concerning the management and quality system certification into all industry spheres also touched upon the training process in which the result product in the educational services provision is a future competitive specialist.

The analysis of some researches and publication concerning the establishment of the training quality assessment in the training process management systems has determined the direction of the work, namely, the influence of new training information technologies into the stirring up of training cognition activity of students. In the work [6,7] the idea of the problem-resource technology implementation into the training process is presented together with the subjective information implementation into the problems of the training process planning and diagnostics, and ultimately to its management.

Establishing the article aims

It is necessary to consider main aspects of the training process (forecasting, planning, effectiveness and quality assessment, developing of the training process managements programs and means, and its improvements) that are considered in the view of the subjective analysis, well-developed instruments and appropriate methods. And here the research subject essence is the sequence of the problem-resource situations according to which it is possible to structure the training process.

Main aspects of the problem

The problem-resource technology concept is based upon the well-developed problem-resource methodology that enrolls organically into active systems analysis. The central element of active systems is the subject the individual that takes decisions and manages.

Being based on (евристичному) understanding of active systems is meant as the present system in some definite space and time restrictions taking into account that the subject (a person, a group of people) are enrolled into system functioning and its management using their own resources (material, energy, information technology, production tools).

The naturally understood imperfectness of such abstractly determined active systems is caused by the (evristichnist) of the present problem research concerning management and self-management in the training process active systems.
The suggested approach has some common features with those approaches that are distinctive for synergy [1], where the notion of relative significances P_i attractors was introduces by G. Hacken, and multitude P_i is rated for the unit. Similar to it, the Shannon theory is studied in the work that is reflected through the advantages that are also ranked similarly to the results received by R. L. Stratonovych [2]. Hacken offers to consider the principle of information maximum with the restriction like

$$f_k = \sum_{i=1}^{n} f_i^k P_i \tag{1}$$

and considering also conditions of ranking

$$\sum_{i=1}^{n} P_i = 1 \tag{2}$$

receiving the canonical division for P_i. In our case in the quality of the function $f_i^{(k)}$ the parameters of recourse flows are studied which interact with one another and with the training process subjects taking into account the human psychology recourse as well as formation of two utilities complex if there is the known probability for every structured pair of alternatives. It is offered to consider the assessment probabilities as objective determinants even when the subject connects them with taking decisions, and the advantages are the appropriate quantitative measures that are determined in the intuitive level could be considered as subjective determinants.
So, we have approached to utility theory application that was established by Wilfred Pareto and further it was developed into the strict theory thanks to John Neiman, Oscar Morgenshtern [3], P.S. Fishbern [4], Arnes and Zines [5]. The thematic direction of the work is connected with the utility theory but the problem is considered according to other point of view.
The distinguishing feature from the above-mentioned work lies in the resource-problem approach application and, partially, in the different relation to the probability analysis and determinants. The analogy between rating advantage functions and probability division is being used but it is thought here that the advantage distribution is not the probability distribution, and in this connection, some correlations are postulated being different from the probability theory. According to the method developed, the central chain of active system is the training process subject. It is worth adding to the above stated that the work does not set the task of making some “model of a person” as the chain in the management system similarly to the technical tasks (flight dynamics, ergonomics etc.). Avoiding the cumbersome of the material presentation, some features of this chain will be given in the work, due to which the general subject behavior layout in the different problem-resource situations is formed. The following must be considered as factors that influence decision-taking by the subject as well as the additional subjective factors during the objective assessment determination: the double exposure of a subject as individual and a public person, the activity problem-resource structure, “minimum” of resources for his physical existence maintenance, aspiration to additional resources mastering, own character, personal problems, correlation of the different individual’s problems, existence in the environment of the similar individuals, correlation of individual and collective problems. The (evristichnist) perception of each factor gives the right to state that every subject continuously finds itself in some problematic situation. And if to speak about the group of individuals, then we have a kind of “material” made of the present problems. The study of this problematic “material” is essential for distinguishing and classification of the groups united with this material. The joining extent of individual problems with some collective problems is determined by the extent of their unification or non-unification between themselves and by the problem “material” in general that “covers” some resource total combination. If to express the “sum” of all existing problems in the quantity terms connected with resources, then this “sum” will be more than the present one, the “sum” of resources which somehow signifies the difference of this approach from the notion of demand and supply in economics. The further concept

development requires its main topic exploration, namely, the creature of the problem-resource methodology.
As it was mentioned above, a person is simultaneously individual creature as well as social one having its social nature established in its biological level in his physiology and psychology.
The set of existing individual's problems does not coincide with the set of problems, which the society generates, and is not restricted to them. Figuratively speaking, these two problem total combinations may intersect but not coincide. Thus, comparing with traditional assessment of the training process, the principal difference was discovered and simultaneously the mechanism of correlation between individual and collective was established, like in the individual and group psychology. Such point of view sets up the problem hierarchy notion establishment as well as problems of coordination and difference, the mutual influence of the subsystem problems of active system. The hierarchy of problems must be considered taking into account the fact that each problem has its personal carrier in psychology. Due to this fact, fro the work purposes achievement it is quite necessary to take into account the following separate fragments individual psychology processes: "inertia" law, the least action principle, the most result principle, attainability principle, the person solves only his "own" problems, inequality is the problem source, principle of reverse proportion of the distance between subjects.
In the purpose of authenticity of quality and effectiveness criteria determination in the course of problematic situations solving, as we consider, it is worth taking into account the fundamental element of social psychology, social truth concept that, in its tern, would provide an opportunity to set up the category notions basis of problem-resource analysis and, vice versa, would comprehend social categories form the point of view of the problem-resource analysis. The problem-resource method is the universal method of "active systems" analysis and synthesis independently from political, economical, ideological society basics. The method is based upon the use of such categories as: "problem", "purpose", "resources" establishing the bias between them and being sure that almost any situation can be treated as some problem solving through the purpose resource implementation. The specific feature of the method is that it established bias between categories and both ideas and material objects and processes. The problem-resource method in practice is used as the method of judgments regulation and analytical activity completion during the alternatives selection and decisions taking by the training objects. Our suggestion about the formation of advantages on the basis of (entropy) variation principle, gives us an opportunity to receive the models of advantages distribution functions.
The advantages of the first kind (subject advantages π_i) are set in the total combination of subject alternatives, the advantages of the second kind (rating advantages ξ_i) emerge in the subject groups. The advantages of the 1st kind, as well as of the 2nd kind, are determined by the utilitarian and ethical factors. In the role of subject non-determination the appropriate subjective entropies H_π, H_ξ are used. The subjective information is determined as entropy increase

$$J_\pi = H_\pi^0 - H_\pi(A) \tag{3}$$

where A – is any case that changes the advantages distribution.
The set of schemes of active systems dynamics simulation as the subject and rating advantages dynamics is offered in the work, as well as emergence and disappearance of stressful situations. The existence of analytical expressions of the advantage distribution gives us an opportunity to characterize the elasticity and strictness of the advantages relating to different factors, and also to treat them here as "elasticity" and "strictness" of psychology.
It is set by the algorithm that the subject analyses some definite quantity of alternatives in every moment and established the advantages distribution on this basis. The entropy of the advantage distribution characterizes the extent of abstractness of the distributed advantages. The hypothesis is accepted that every time the advantages distribution appears to be relative in terms of some functional, the main part of which is the advantage entropy. In this case the version of the subjective analysis considers two types of advantages: subject and rating.
Subject preferences or preferences of the first type are assigned on a number of alternatives

σ_i and are standardized by the expression

$$\sum_{i=1}^{N} \pi(\sigma) = 1 \tag{4}$$

N – the number of alternatives under study, the standardization of which can be justified from the point of view of psychology and is not obligatory single, however, to simplify the task, it will be considered as a single standardization. The entropy H_π of preferences is assigned by the formula:

$$\mathrm{H}_\rho = -\sum_{i=1}^{N} \pi(\sigma_i) \ln \pi(\sigma_i) \tag{5}$$

and by form coincides with the Shennon's entropy, but the function $\pi(\sigma_i)$ – is not the probability

$H_{\pi \max} = \ln N, \ \pi(\sigma_i) = \dfrac{1}{N}$

The effectiveness function is introduced to the structure of the functional as:

$$E = \sum_{i=1}^{N} \pi(\sigma_i) F(\sigma_i) \tag{6}$$

The function E – defines the essence of the assigned task being accomplished at the moment. It can be expressed through the resources or the probability of undefined events or through the utility. The criterion is defined by the expression:

$$\Phi = -\sum_{i=1} \pi(\sigma_i) \ln \pi(\sigma_i) \pm \beta_1 \sum_{i=1}^{N} \pi(\sigma_i) F(\sigma_i) + \gamma_1 \sum_{i=1}^{N} \pi(\sigma_i) \tag{7}$$

The effectiveness function can represent a risk, at the same time $\Phi(\sigma)$ is defined by a possible loss as a result of the choice of this or that alternative. In general $\Phi(\sigma)$ is determined by rational, utilitarian, ethic factors that is one of the differences of the present version of the subjective analysis, for example, in respective problems in the information theory. The utilitarian factors include resources of different types and are considered as the resources implemented in the training process. From the point of view of the "belonging" of resources the notion of active r_a and passive r_p resources is introduced, where active resources are "personal" resources of the subject of the system allowing him to act, to run the system, to carry out operations for the system to exist and to develop, being the instrument for solving "his" permanently arising problems. Passive resources r_p are resources in the system, within the limits of the subject which he can direct at "his" problem solving.

From the point of view of the place of these resources during solving this or that problem in the training process resources at subject's disposal R_{disp} and resources used R_{req} are analyzed. The resources R_{req} are almost always specialized.

The resources at subject's disposal R_{disp} may be both specialized and universal (time, money). The training process in this work is considered to be the process of transformation of resources, the main objective of which is the increase of active resources of that what is studied and providing it with a set of alternative resources (which can be used by the subject in his professional activity).

In the transformation with a transition of one type of resources to another the resources of two subjects are used

Along with preferences of the 1st type preferences of the 2nd type, or rating preferences $\xi(j), \xi(j/i), j, i\in 1, M$ are introduced, which are also an important element of the training process while speaking about preferences in student's groups. The task of the analysis of the aggregation of subject preferences and rating preferences arises.

Rating preferences are supposed to be the solution of a variation problem with criteria the main component of which is the rating preferences entropy.

Especially for … the criterion is:

$$\Phi_{\xi} = -\sum_{j-1}^{M} \xi(j/i) \ln \xi(j/i) \pm \beta_2 \sum_{j=1}^{M} \xi(j/i) U(j/i) + + \gamma_2 \sum_{j=1}^{M} \xi(j/i) \tag{8}$$

$$\sum_{j=1}^{M} \xi(j) = 1 \quad \sum_{j=1}^{M} \xi(j/i) \tag{9}$$

Solving variation problems, concerning the criteria mentioned above, we obtain the following distributions:

$$\pi(\sigma_i) = \frac{e^{\pm\beta_1} F(\sigma_i)}{\sum_{q=1}^{\wedge} e^{\pm\beta_1} F(\sigma_q)} \tag{10}$$

$$\varsigma(j) = \frac{e^{\pm\beta_2 U(j)}}{\sum_{\rho=1}^{M} e^{\pm\beta_2 U(\rho)}} \tag{11}$$

$$\xi(j/i) = \frac{e^{\pm\beta_{2i}} U(j/i)}{\sum_{\rho=1}^{M} e^{\pm\beta_{2i} U(\rho/I)}} \tag{12}$$

The next important supposition is that of the availability of individual entropy thresholds where is provided, for example, the entropy threshold value H_{π}^{*}, meaning that if the current entropy exceeds the threshold $\mathrm{H}_{\pi(t)}^{*} \geq \mathrm{H}_{\pi}^{*}$, the level of uncertainty is high, and the subject cannot make his choice. The necessary condition of the choice is the inequality: $\mathrm{H}_{\pi(t)} \leq \mathrm{H}_{\pi}^{*}$

The entropy layer $[\mathrm{H}_{\pi}^{*} \ \ \mathrm{H}_{\pi \max}]$ can be named the area of discussion or conventionally "kingdom of freedom" in which possible solutions are formed and are put into practice outside the "kingdom of freedom". In the dynamic interpretation the training process is connected with repeated transition of those who study through the limit H_{π}^{*} top-down and bottom-up. In this conception it seems to be an attractive explanation and organization of some important ideas of subjective analysis, particularly, it concerns the formalization of notions "problem training ".

This work presents experimental results with the definition of preferences of the 1st and the 2nd type of students, the objective of which is the processing of the questionnaire structure and the attempt to identify theoretical subsections of subject and rating preferences. The result obtained is based on the research conducted by testing the students of 203, 401, 402 groups of Aerospace institute to identify preferences subject levels of disciplines and rating estimations of student's mental facilities.

Subject – defines the level of preferences of different disciplines of the curriculum.

Rating – determines differential ratings in the students' group. The results of testing are received after primary statistic data processing of testing according to the theory of testing. The algorithm of the statistic handling of matrix of testing results is conducted in that way:

1.Individual scores of the subjects under testing $y_i (i = 1,...n)$ are calculated and the result of carrying-out the test by every subject is defined.

$$y_i = \sum_{j=1}^{m} x_{ij} \tag{13}$$

2. Average results of total scores of testing $\bar{y}$ are calculated:

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{14}$$

3. The dispersion $S_y{}^2$ and standard deviation S_Y of total scores are calculated:

$$S_y{}^2 = \frac{\sum_{i=1}^{n}(y_i - \overline{y})^2}{n-1} \qquad (15)$$

$$S_y = \sqrt{S_y^2} \qquad (16)$$

4. Test characteristics or correlation is defined, which represents the level of the linear dependence between two multiple data, where the correlation factor is defined as:

$$\tau = \frac{\sum_{i}^{n}(x_i - \overline{x})^2(y - \overline{y})}{n-1} \qquad (17)$$

The identification of distribution of subject preferences is based on the test tasks that intended according to 100 scores to give the estimation of the importance of each discipline for the subject during training. The choice of disciplines of the experimental testing is exercised according to the curriculum and are conventionally divided into *universal* that contain sufficient number of didactic invariants of high rank and *special* that contain for the most part didactic invariants of 1 and 0 ranks. The disciplines ranks or the level of the universality of disciplines are defined by the value conventionally introduced by us for certain specialists and are graphically presented on the scheme of disciplines rank definition (fig.1).

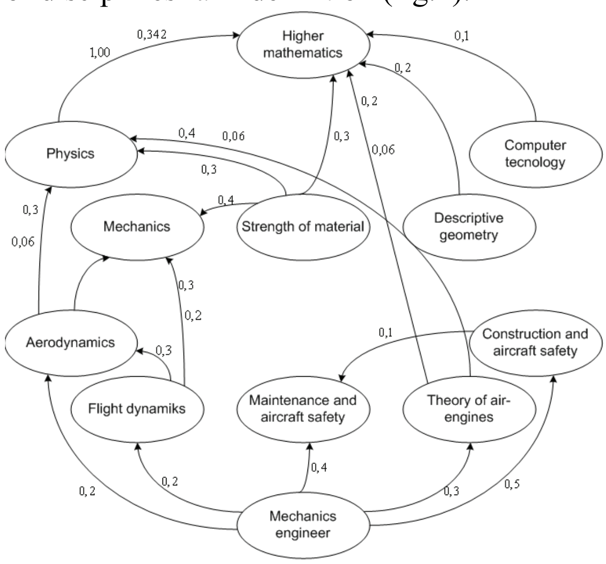

Fig.1. Scheme of disciplines rank definition

The disciplines rank is defined by the formula:

$$R_1, R_2, R_3 ... R_N \rightarrow \sum R_i \qquad (18)$$

A better understanding of the formation of subject's estimation of the training gives the result of processing of the experiment testing that sets the dependence between disciplines rank and time (fig.2)

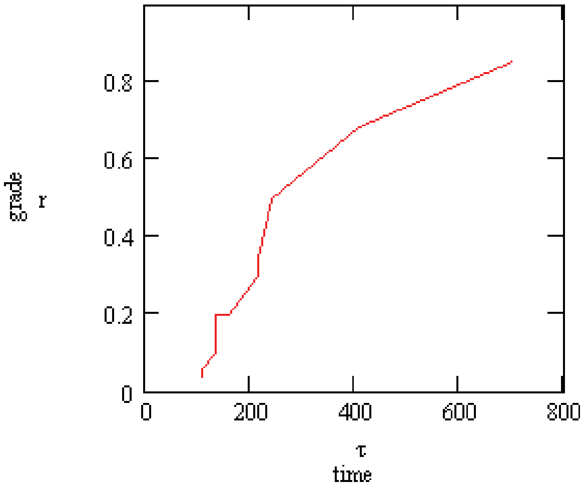

Fig.2. Chart of the dependence of disciplines rank on time
that is spent for studying this discipline (set of disciplines). It should be noted that the time was defined according to the curriculum, and can only casually represent the time really spent by the student. This time can be estimated as necessary by the curriculum for studying a given discipline. To extend the parametric data base and to define more objectively the time necessary to master the discipline *the individual necessary time* is introduced as a parameter. On the chart of the fig.3. the dependence between disciplines rank and subjective rating is shown.

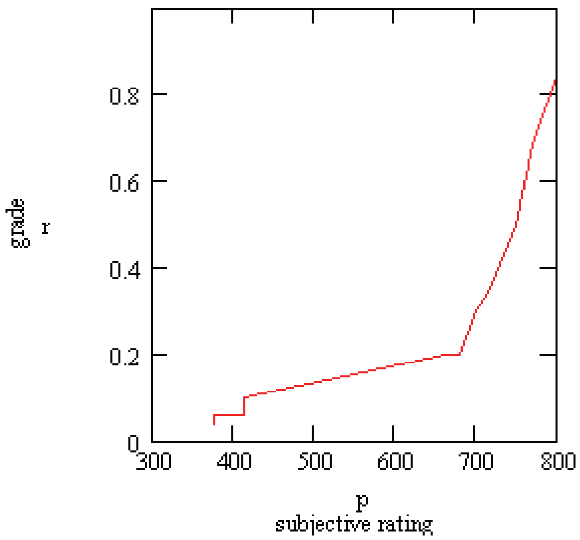

Fig.3. Chart of the dependence of disciplines rank and subjective rating
The analysis of graphic results of the dependence of disciplines rank on the necessary time provided by the curriculum to master the discipline reveals the necessity of its adjustment because the subjective factor of each subject is not taken into account.

The chart of the dependence of disciplines rank and subjective rating shows the ambiguity of subjects' selection. This fact confirms the necessity of taking into account the innate abilities of each subject and the quality of school training.

Conclusion

The use of subjective analysis methods and especially of problem-resource technology as the basis for the study of important problems in the training is proposed. This approach gives the possibility to implement quantitative estimations in this rather undefined area. The notion of didactic invariant meaning the notion of "module" and also the notion of the rank of disciplines subjective rating and their divisions are proposed. The algorithm of subjective estimation formation and the algorithm of rank definition and disciplines rating definition are presented.

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Yu.V. Korchenyuk, teacher (National aviation University, Ukraine)

AVIATION ENGLISH: LANGUAGE REQUIREMENTS

This article addresses to the English language use, related miscommunications, incidents, and accidents, and current International Civil Aviation Organization (ICAO) initiatives for revision of language policies. In addition, a cultural awareness of the variety of English spoken in countries encountered during flight may help avoid misunderstandings and miscommunications due to lack of English proficiency in pilots or air traffic controllers that can lead to disastrous and even fatal catastrophes.

English has been chosen as the official language of flight in the United States and continues to be the recommended lingua franca for international use. While miscommunications between flight crews and air traffic control (ATC) personnel may have been only one aspect of these incidents and accidents, the lack of ability for all parties involved to understand crucial directions via a common English may have been the most important contributing factor leading to these tragedies. Without agreed upon standards for English proficiency and common phraseology, the aviation industry continues to be at risk for future language-related accidents. Air traffic communications often deviate from standard phraseology in emergency situations towards a more conversational style. English proficiency beyond the basic understanding of aviation phraseology may be necessary. The point at which the communication process breaks down is reached whenever a message goes unrecognized or is misconstrued. Lack of comprehension may arise from insufficient language proficiency or from inappropriate use of language. This latter possibility arises when pilots and air traffic controllers lapse into slang or idiomatic speech. Indeed, they run a higher risk of misperception whenever they depart from ICAO standardized phraseology.

Language is a dynamic form of communication. It evolves according to use, and usage varies from region to region. What is common parlance to one group may be incomprehensible to another. The greatest care needs to be taken in deviating from standardized phraseology. The risk of misperception is elevated in an international environment and, increasingly, in a domestic environment used more and more by foreign aircrews. Risk is higher still if there is inappropriate use of language when the proficiency of a pilot or controller may be questionable. This is precisely the circumstance that so often occurs in the arena of international operations. Bandying clever phrases about can inject some levity into the workplace and increase camaraderie. All things being equal, informal language may improve efficiency because workers may be more effective when relaxed. In reality, all things are seldom equal. There is a risk in the operational environment — a high risk — that the listener may take no meaning from the message, or worse perhaps, construe it to mean something unintended. For native English speakers, it is worth reflecting on how English is characterized by anomalies, paradoxes and a host of other inconsistencies that can make it difficult for non-native speakers to comprehend. Native speakers take English for granted, but if we explore its paradoxes, we begin to understand the potential for a non-native speaker to misunderstand plain language. With safety at stake, the least that native English speaking pilots and controllers can do is to strictly limit their messages, whenever possible, to standardized words and phrases that are universally accepted for their singular significance.

Language, especially the English language, is highly amenable to word play. The double meaning, whether intended to be amusing or simply unintended, can represent a serious operational hazard. A transcript of the communications between a tower controller and an aircraft on final approach makes the point. With an aircraft lined up on the runway in preparation for take-off, the tower directed the approaching aircraft to "go around." The captain responded by directing his co-pilot to request permission to "hold," by which he meant, in the vernacular, to request permission to continue the approach. In reply, the controller directed the crew to "just go ahead and hold," a confusing exchange that terminated in a collision on the runway when the approaching aircraft proceeded with landing. In this example, the confusing word usage can be attributed to "code-switching," a phenomenon by which a term that makes common sense in one context does not make sense in another. The word "hold," in this case, was transposed from the pilot's vernacular vocabulary into the context of formulaic phraseology intended for the orderly accident at Cali, Colombia in 1995 highlighted the need to "develop, with air traffic authorities of member States of ICAO, a program to enhance controllers' fluency in common English-language phrases and direction of aviation operations. Code switching sometimes happens when persons under duress, called on to converse in a non-native language, unintentionally revert to the form of their native language. They may transpose a word, a phrase or even a form of syntax, in any case corrupting the meaning of the message.

At the administration and policy level, the new ICAO provisions make operators and air traffic services (ATS) providers responsible for ensuring that pilots and air traffic controllers speak and understand the language used for radiotelephony at a specified proficiency level. It follows that operators and ATS providers should also ensure employee compliance with ICAO standardized phraseology. Improving communication effectiveness is one of the few areas where a significant positive safety impact is possible at an affordable cost and effort. The optimum strategy is not to prescribe, coerce or threaten aviation personnel, but to appeal to the innate responsibility of every controller and pilot. This is best done by impressing on them the truth that language is an imperfect medium that lends itself to sensible misinterpretation, that is, the wrong meaning can be conveyed even though the transmission retains perfectly good sense. All pilots and air traffic controllers need to understand that an imperfect tool such as language requires the utmost care and discipline in its use. In practical terms, this calls for heightened linguistic awareness among controllers and aircrews. Safety managers should treat the attainment of English language proficiency levels; compliance with ICAO standardized phraseology and abstinence from undisciplined communications as components of a broad educational agenda. Language is as important to safety as any operating system or tool. Its practitioners should be just as knowledgeable and skillful in its use as they are in the use of radar, flight control systems and the application of aircraft separation standards. As a matter of policy and priority, the mastery of language needs to be made an intrinsic part of every aviation training program.

ICAO's adoption of a language competency standard in March 2003 incorporates special language scale (table 1). The scale addresses competence in common English; in other words, it concerns the ability to manipulate the structures of the English language to create original sentences in one's own words.

ICAO rating scale for language proficiency at the operational level (Operational Level 4)

Table 1

PRONUNCIATION*	**STRUCTURE***	**VOCABULARY**	**FLUENCY**	**COMPREHENSION**	**INTERACTIONS**
Pronunciation, stress, rhythm, and intonation are influenced by the first language or regional variation but only sometimes interfere with ease of understanding. ** Assumes a dialect and/or accent intelligible to the aeronautical community.*	Basic grammatical structures and sentence patterns are used creatively and are usually well controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning. ** Relevant grammatical structures and sentence patterns are determined by language functions appropriate to the task.*	Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete, and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances.	Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. Can make limited use of discourse markers or connectors. Fillers are not distracting.	Comprehension is mostly accurate on common, concrete, and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies.	Responses are usually immediate, appropriate, and informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming or clarifying.

** Successful pilots and controllers possess this type of specialized literacy. Their respective studies share many of the same topics and themes such as weather, emergency procedures, radio calls, etc. It is exactly this common core of shared knowledge that allows pilots and controllers to speak to one another and be understood by one another. The messages they send are related primarily to their immediate situation, and they expect those messages to be received and understood as they were originally intended.

The proficiency requirement focuses on linguistic competence rather than on the cultural aspects of language. In the aviation context, this means that pilots and air traffic controllers must be able to communicate competently in English. As member States begin to standardize and implement language proficiency requirements for aviation personnel, it is imperative that they understand what it means to be communicatively competent in the aviation context. An important aspect is the role of the English language within the aviation context, particularly as it relates to pilot-controller communication. There are three critical areas of English competency required for safe communications:

• air traffic control (ATC) phraseology;
• English for specific purposes (ESP);
• English for general purposes (EGP).

Together, these three components form a framework for further explorations and discussions on language and aviation. When pilots and air traffic controllers speak to one another in the professional context, the exchange usually takes place in a prescribed, coded language called ATC phraseology (also known as radiotelephony). This phraseology is used routinely all over the world, making it possible for pilots to fly across linguistic boundaries and still be understood by their foreign peers. ATC phraseology is perhaps the most prominent and well studied aspect of the English language. Although ATC phrases may be in English, native speakers cannot understand the intended meanings without overt schooling in both the jargon as well as the corresponding procedures. Besides accommodating for all standard situations, ATC phraseology can be used to resolve conflicts between participating aircraft. ATC phraseology separates itself from plain language by its standardized and non-idiomatic forms and usage. All aircraft flying in controlled airspace adhere to standard procedures that have accompanying standard phraseology. This allows all parties in the air and on the ground to stay informed about the progress of a flight at any given time. Each of the prescribed and predetermined expressions used in this context is self-contained and limited to the set sanctioned by the appropriate aviation authority. The phrases used in radiotelephony are designed to make the communicative function between the ground and aircraft as concise and brief as possible, with the emphasis on accurate content as opposed to linguistic form. As the airspace is increasingly busy, there is little time for chatter or conventional politeness. The brevity and conciseness of the communication is accomplished partly by using formulaic and predetermined sentence fragments as opposed to complete sentences. Typically, grammatical markers, such as determiners ("the" or "a") and auxiliary verbs are deleted, a feature making ATC communications marked, different from natural language. The difference is evident in the following ATC communication:

American Airlines Flight 54, turn left heading one zero zero, intercept the localizer and proceed inbound, cleared for the ILS approach to One Three Right, maintain two thousand two hundred until established. Contact tower on one two zero point six at NOLLA.

The beauty of ATC communication is that all parties know what is expected of them in terms of their performance-related procedures, both technical and linguistic. Thus those who undertake aviation studies with the goal of participating in international operations will memorize this standard phraseology in English, whether they speak the language as a native or not. Within a country's borders, when pilots and ground station personnel share the same language their communication may take place in their native tongue. However, when pilots or air traffic controllers do not share the language of the ground station, both parties are expected to communicate in English using ATC phraseology. By this means all information relayed between ATC and the aircraft is comprehensible to all those involved in related operations. It is crucial to note that the type of language used in the context of international ATC is not tied to any particular culture or local variety of English. ATC phraseology is based on study and mutual agreement. It is a variety of language that uses English as its basic structure, but focuses solely on communicative needs in aviation.

All novice pilots and air traffic controllers begin at the same place, not knowing what the phrases are or how to employ them. With practice, they eventually become fluent in the use of ATC phraseology. The differences and limitations that ultimately emerge in a particular individual's ability to communicate correctly and effectively can be attributed, at least in part, to frequency of practice and amount of experience. Other factors, such as timidity, fear and anxiety can negatively impact communicative success.

Operating personnel are trained to use ATC phraseology to meet aviation's safety-critical communication requirements. Barring unusual circumstances, this goal is achievable for all personnel. Besides mastery of phraseology, pilots and controllers must possess an intimate understanding of their area of study, including its technical and practical applications. When pilots and air traffic controllers first embark on their respective studies, they enter a highly specialized and technical world with its own language, a subset of the larger whole that consists of vocabulary and concepts not readily understood by many lay people. Where English is in use, one must have studied English for specific purposes to understand its specialized and explicit vocabulary and expressions. In the following examples, common English words such as "base," "three o'clock" and "clear" have aviation-specific meanings:

• *Example 1: Turn base now, follow traffic at your three o'clock, cleared for the option.*

• *Example 2: Remain clear of Class Charlie airspace, contact Approach on one two three point six five.*

As with ATC phraseology, aviation personnel must master the ESP jargon. All pilots and controllers start with the goal of becoming fluent in its use. Here again, some of the differences and limitations that ultimately emerge in a particular individual's ability to communicate in English for specific purposes can be partially linked to practice and experience. Excluding unusual circumstances, competency in the use of aviation-specific ESP is an achievable goal for most personnel.

In conclusion, the ability to communicate when there is no prescribed script (i.e. ATC phraseology) is critical for safety. In practice this means that pilots and air traffic controllers must be able to achieve mutual understanding through the use of plain or general language to get their messages heard and understood. Although strict adherence to phraseology is always preferred, situations arise for which there is no adequate ATC phrase, or the phrase needs to be expanded with real-time information. The problem with communication, particularly in global aviation, is that the ability to use general English varies considerably. Some pilots and air traffic controllers can only parrot the memorized ATC phrases, while others are comfortable functioning in English in any situation. All over the world, the ability of flight crews and controllers to use the mandated common language, English, remains generally unexamined. The vast discrepancy in the ability to use plain English is a major concern in international aviation. The new ICAO requirement, with specifications for minimum English language proficiency, targets this particular aspect of language use. It sets out a standardized minimum level of competency in English (see table). It is safe to assume that everyone in the cockpit and tower has mastered at least the basics of ATC communication because it is an accepted and obvious component of their course of study. What cannot be assumed, however, is that these same personnel have basic conversational ability in general English? General-use English has not been commonly regulated in many training facilities.

For aviation communication to be successful, pilots and air traffic controllers must be competent users of all three aspects of English. First, they must have mastery of the professional jargon or phraseology, including its use for standard situations and standard procedures. This type of aviation English study has been a given component of most aviation training programs. The ATC phraseology contains expressions for most functions and they work very well most of the time.

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A.R. Malkhazov, Doctor of Psychology, Professor of the Chair of Aviation Psychology (National Aviation University)

NEW SOLUTIONS TO THE PROBLEM OF THE PSYCHOLOGICAL SUPPORT OF AN OPERATOR'S SAFETY

The article analyses the current situation in the field of psychological support of an operator's safety within the "human – equipment – social-psychological environment" system. The author proposes and explains new theoretical, methodological and practical approaches to the application of the multi-channel computer diagnose system DIK-01.0 which can solve problems connected with the psychophysiological support of operators' successful work.

The existing approaches to the organization and realization of operators' psychological support within the "human – equipment – social-psychological environment" system (HES) in Ukraine call for the urgent revision of methodological, paradigmal, procedural and organizational principles. The analysis of the works dealing with this problem [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, etc.] shows that the organization and realization of activities aimed at providing psychological support of operators' safety involve shifting the emphasis from the "human – equipment" vector onto the multidimensional HES space. That explains the necessity of first studying the physical environment of an operator's work, then its psychophysiological, social and social-psychological environment. In view of this, we propose to develop a methodology for the application of special psychophysiological techniques, methods and procedures for professional staff recruitment and further psychological support of their work.

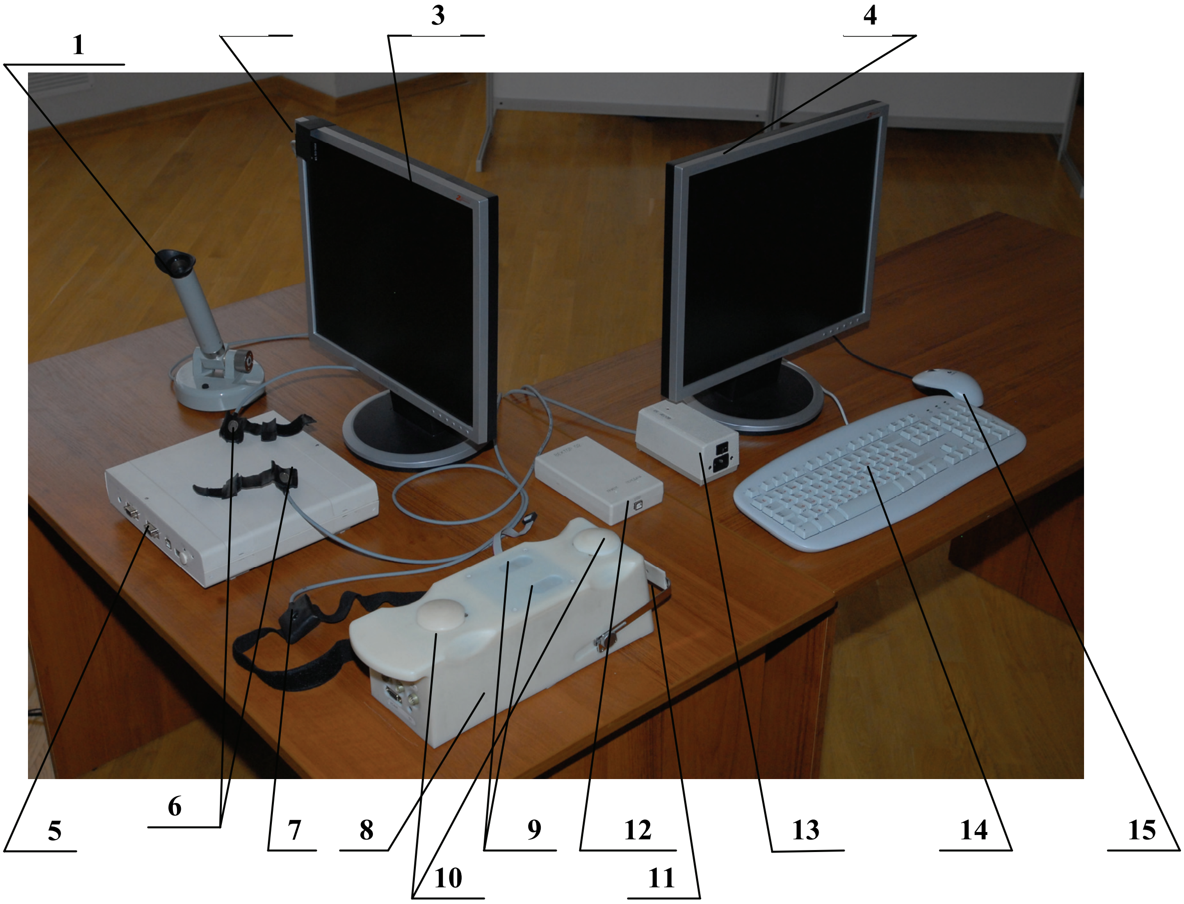
The following tasks are of paramount importance in dealing with the problem discussed:

- development of a methodology, methods and procedures matching the present-day conditions of operators' work;
- development of professiograms and psychograms of operators' work;
- creation of the corresponding legal basis;
- specification of the psychological and psychophysiological content of professional tasks handled by operators;
- development of up-to-date devices, methods and procedures for the high-quality psychological support of operators' safety in the HES system.

In spite of the fact that the human factor's role in air crashes and technogenic accidents is growing, the diagnostic tools used in the world practice for recruitment and psychological support of operators do not meet the current requirements for reliability, sufficiency and comprehensiveness of scientific-methodological and logistical support, being grounded on dated methodological approaches and parameter registration methods. The absence of up-to-date reliable diagnostic equipment makes it hardly possible to carry out staff recruitment and psychological support of their work within the HES system on the proper level. As a rule, activities aimed at improvement of the quality of staff recruitment and operators' psychological support are unsystematic and limited to certain departments or agencies.

One should also point out the lack of well-planned professional training and retraining of specialists in the field of staff recruitment and their psychological support. There are no research institutions responsible both for the development and practical implementation of the newest devices and systems and for training and retraining of corresponding specialists. In fact, there is no regular database accumulation system which could supply data for professional re-standardization of the existing and development and standardization of the new tests and "test batteries", for the development and publication of corresponding manuals, reference books and materials, etc. on the proper scientific level. Such situation calls upon the national government to take managerial and legislative decisions which could bring about an essential qualitative improvement of staff recruitment and psychological support in Ukraine.

To ensure high-quality psychological support of staff and their recruitment within the HES system, the government agency "Central Design Bureau "ARSENAL" and the National Aviation University have developed a unique multi-channel computer diagnose system DIK-01.0, ***which has no match in the world practice.*** The overall view of DIK-01.0 is given in Picture 1.



1 – critical flicker frequency registration unit; 2 – photosensor; 3 – respondent's monitor; 4 – operator's monitor; 5 – respondent's galvanic skin response and voice message registration and processing unit; 6 – galvanic skin response sensors; 7 – respondent's microphone; 8 – chronoreflexometry registration unit; 9 – tapping test result registration sensors; 10 – ergonomic pads for respondent's palms; 11 – limiter; 12 – interface module; 13 – power unit; 14 – operator's keyboard; 15 – mouse

Picture 1. DIK - 01.0: overall view

DIK-01.0 system shown in Picture 1 is used to solve problems involving organization and realization of high-quality psychological support of operators' work and professional staff recruitment. This system can diagnose:

• respondents' psychological, neurodynamic, chronoreflexometric, individual-typological and personality characteristics in three modes: instant diagnosis mode (20-30 min), continuous control mode (2-3 hours) and enhanced diagnosis mode (up to 8 hours);

• individual indicators of the maximum permissible value and the optimal value of load and relaxation (psychophysiological price of work), most likely error zones during task fulfilment, the individual level (potential) of motor abilities, the degree of maturity of complex skills as a whole and their separate elements;

• peculiarities of a person's motivation during job application process, their attitude to drugs, alcohol, the degree of reliability of personal details provided by the respondent, presence of criminal record, etc.;

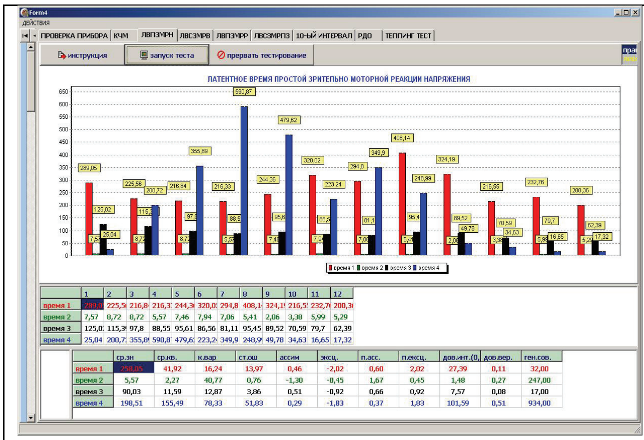
• the maturity of the respondent's skills in controlling and managing emotional states under unfavourable conditions.

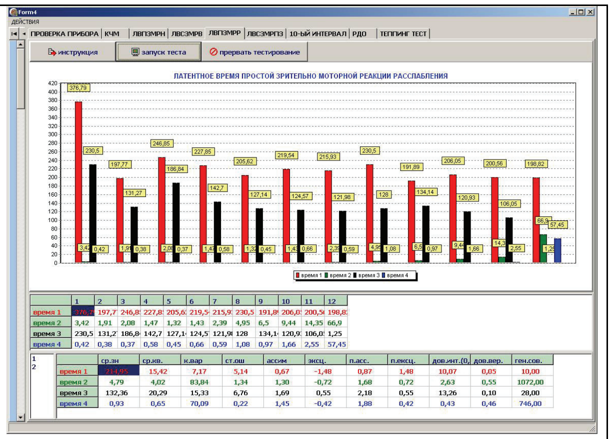
The system can be used to carry out biofeedback, teaching operators to manage and check unfavourable emotional states, detect early vocational deformation and control the effectiveness of psychological adjustment procedures. The system can also register latency time of visual-motor reactions and tapping test results, measure the accuracy of reproduction of given time periods, the respondent's reaction to a moving object (in three modes), register the critical flicker frequency (in two modes) and galvanic skin response synchronically with voice messages (respondent's answers to the expert's questions).

The range of parameters which can be diagnosed by the system makes it possible to perform quality recruitment of staff for work under special conditions (for instance, in peace-support forces).

Regularities of functional systems diagnosed with the help of the DIK-01.0 system open the way for the development of essentially new approaches to the design of simulators and systems controlled by man under time pressure.

Pictures 2, 3, 4, 5, 6, 7, 8, 9 show how time-sensitive information is displayed on the expert's screen.

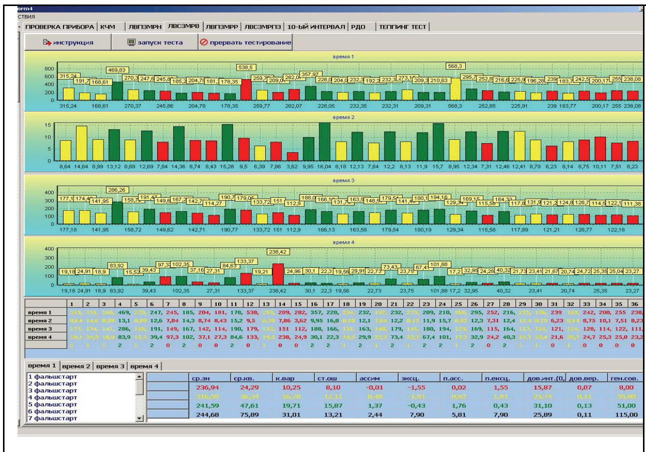


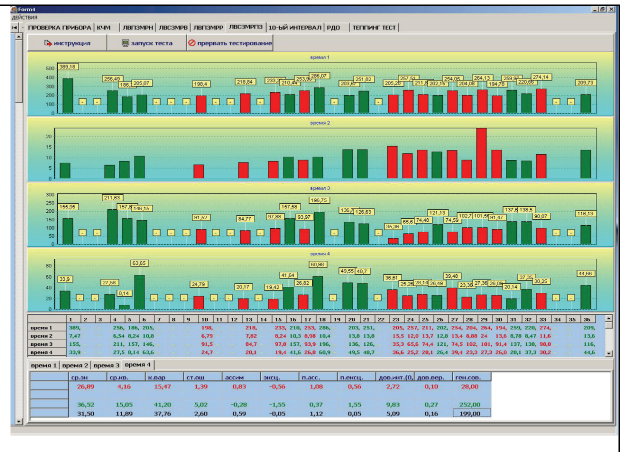


Picture 2 **Picture 3**

Registered latency time indicators for simple visual-motor reactions

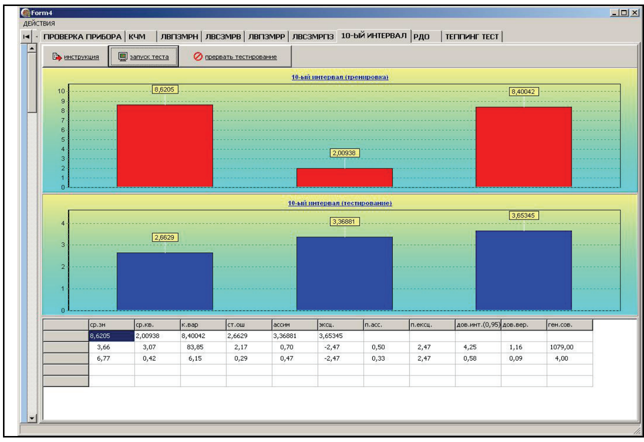
of tenseness (Picture 2) and relaxation (Picture 3).



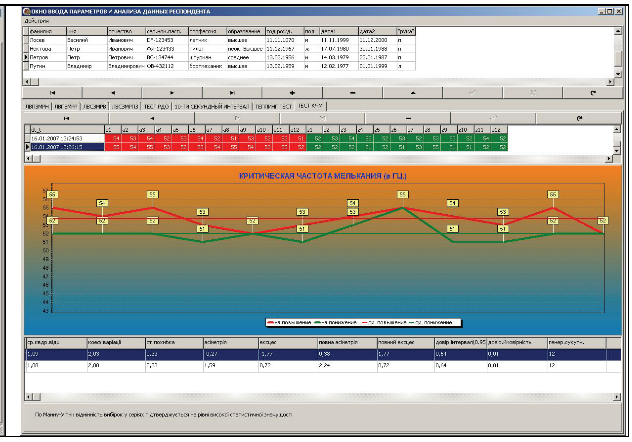


Picture 4 **Picture 5**

Registered latency time indicators for the complex visual-motor reactions of choice (Picture 4) and sign alteration (Picture 5) .

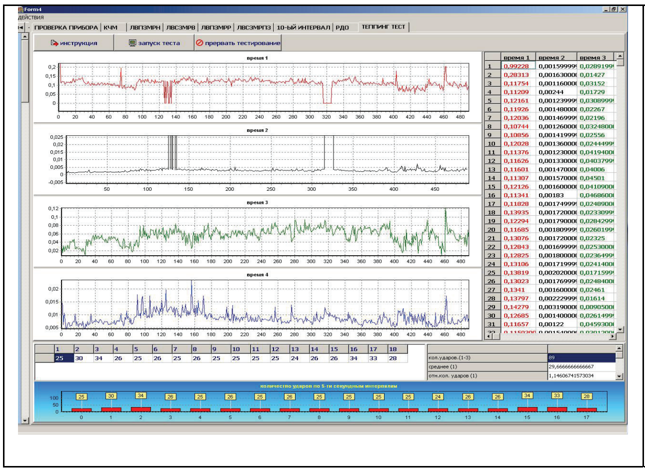


Picture 6

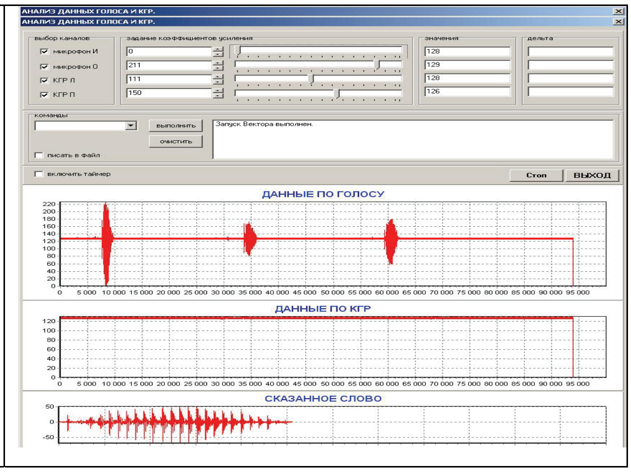


Picture 7

Indicators of the time period reproduction accuracy and of the accuracy of reaction to a moving object in three modification modes proposed by A.R. Malkhazov (Picture 6), indicators of critical flicker frequency registered in two ranges (Picture 7).



Picture 8



Picture 9

Indicators of the tapping test modified by A.R. Malkhazov (Picture 8), indicators of galvanic skin response of the respondent answering the expert's questions, accompanied by synchronic registration of his voice messages (Picture 9).

Conclusions

1. The existing approaches to the organization and realization of operators' psychological support within the "human – equipment – social-psychological environment" system (HES) in Ukraine call for the urgent revision of methodological, paradigmal, procedural and organizational principles. The multi-channel computer diagnose system DIK-01.0 can essentially improve the situation in this field. DIK-01.0 can solve problems connected with the psychophysiological support of successful work within the HES system and can operate in the instant diagnosis mode (20-30 min), continuous control mode (2-3 hours) or enhanced diagnosis mode (up to 8 hours).

2. The system gives the possibility to register people's psychophysiological, individual-typological and personality characteristics. It diagnoses the degree of emotional stress shown by a person when reacting to relevant stimuli, automatically processes and analyses the results obtained, which enables experts to make conclusions about the respondent's professional aptitude, peculiarities of their functional condition and readiness to effectively fulfil their duties. DIK-01.0 can be used to train operators and to carry out biofeedback, i.e. training aimed at mastering skills of managing and checking unfavourable emotional states.

3. The range of parameters diagnosed by the system ensures high-quality selection of staff for work under special conditions. Regularities of functional systems diagnosed with the help of DIK-01.0 open the way for the development of essentially new approaches to the design of simulators and systems controlled by man under time pressure.

4. Resolution of the system's registration units gives the possibility to carry out research in the fields of psychophysiology, psychology, psychohygiene, medicine, sport, etc. The National Aviation University jointly with the Central Design Bureau "ARSENAL" can train experts who will operate the DIK-01.0 system. It is also planned to develop and start serial production of multi-channel group systems for 8, 16, 24 and 32 users.

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V.M. Sineglasov, P.h.D., proff. (NAU, Ukraine), S. P. Borsuk (NAU, Ukraine)

ADOPTABILITY IN AVIATION TRAINING SYSTEMS

The modern aircraft become more complicated system every day and greater amount of possible errors and potentially harmful situations appears. Since flight safety is main goal for most of trainings or skill improvement program – the training systems, educational materials or some other educational means must follow the tendencies of nowadays and even exceed them by improving the self. In sphere of training complexes the adaptability of the complex itself should be involved.

Introduction. The aviation training systems are widely used nowadays in different organizations as it was predicted and described few years ago [1]. The sphere of training systems involvement became even wider including such unusual directions as crew fatigue [2], traffic controllers language [3], and even passengers role in flight safety [4]. All that brings out a lot of questions basically relying to the means of autonomous testing devises or complexes that will be able to combine or unite all required methodological approaches with improved result on preset topics.

The adoptability. Using adoptability in the training systems [5] is modern way to create complicated but efficient mean for educational purposes. Different sources use different adoptability approaches [6] and thus receive different definitions and designations. In this article the adoptability is described with certain working principles of the training system or trainer being changed properly to receive the required effect. As known the basic structure of automated training system may be described as shown on figure 1.

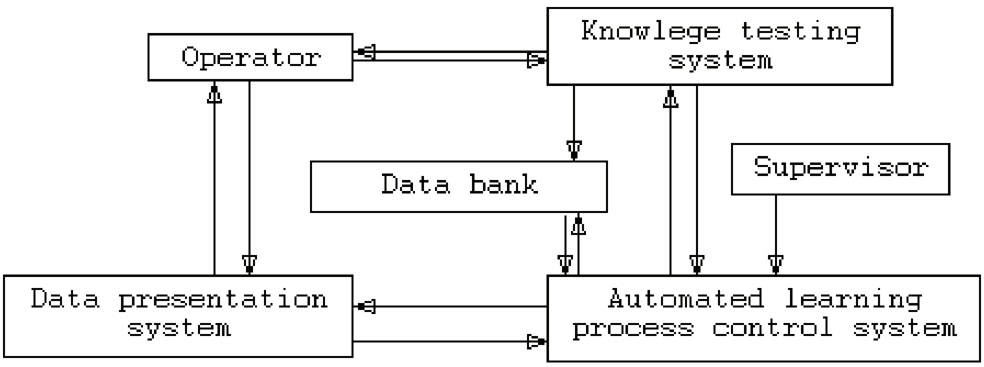

Figure 1. Automated training system basic structure.

The automated learning process control system request the learning information from data bank and then sends information about the study material from data bank to the data presentation system. The data presentation system direct the study information to the operator in required form and send the response about that back to automated learning process control system. When operator finishes the material study automated learning process control system send information about testing topics to the knowledge testing system. The knowledge testing system interacts with the operator receiving his reactions for given control tasks and questions. The result of knowledge testing inputted in the data bank. The main role of supervisor is simply to initialize educational scenario for certain operator. After scenario initialization whole system is capable to work automatically unless the supervisor will input some corrections.

Thus few structural elements of the training system are able to include adoptability features. In this article the described element will be the automated learning process control system that is shown in figure 2.

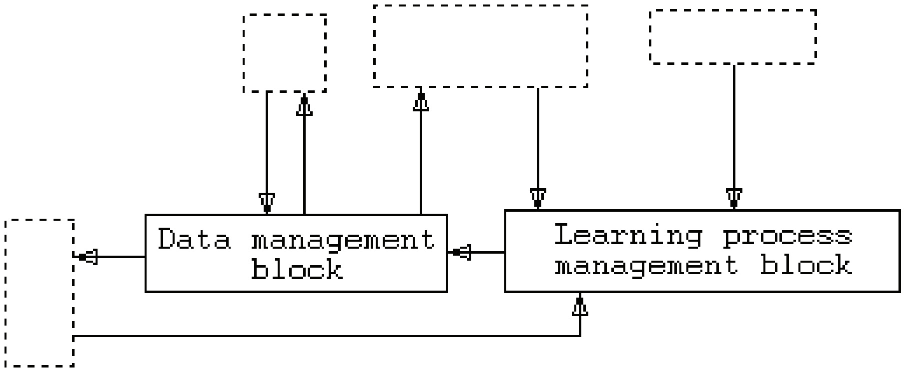

Figure 2. Automated learning process control system.

The learning process management block is receiving information about educational scenario from the supervisor. Initially it sends the commands to the data management block for taking information from data bank and transferring it outside to the data presentation system. The response from the data presentation system proceeds to the learning process management block bringing the information about study process flow. When the educational information is all given to the operator the learning process management block send to the data management block control signal for selecting testing information from data bank. After testing information is received it is sent to the knowledge testing system which proceed with further operations. The information about testing process is sent from knowledge testing system to the learning process management block during knowledge check.

This additional element allows system to manage operator's resources and system resources simultaneously or not. That includes time, study material amount, study material saturation, study material type from both the operator's and system point of view. Though the presence of such block in current scheme it is not necessary to be separated outside of learning process management block and the functions of data correction block might be added to the learning process management block functions with fewer structural changes in this article it is separated for obviousness.

The adoptability features of automated learning process control system may be added with help of special element as shown in figure 3.

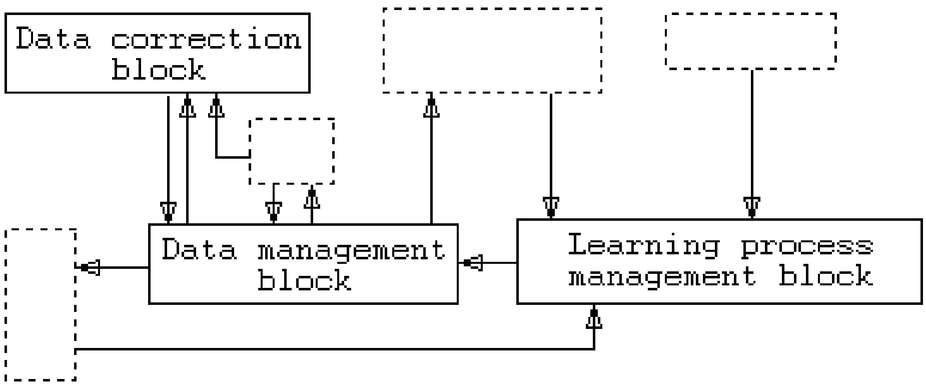

Figure 3. Automated learning process control system with adoptability.

The "time" parameter define what is the single learning unit time length to be used for study. It may differ for every operator, depending on its ability to concentrate on the subject. The "study materials amount" parameter defines the number of single learning units to be given for study daily. It depends upon how many different topics can operator learn during single educational day. The "study materials saturation" parameter defines what amount of new information per single learning unit will be given. It depends on the operator's perception abilities. The way to define these parameters might be pre-study tests given in the very beginning with great variety of questions and answering conditions.

"Study material type" parameter stands separately from the other parameters. This parameter depends on the operator's personal ability to apprehend information given by text, sound, schemes or pictures. Depending on the specific implementation area (i.e. aviation training systems where some sort of information must be given to future pilots in identical way as is) that parameter not simply vary at different operators but shows future possible sources of advantages and disadvantages of the post-graduated pilots at service. Also this parameter show the direction of operator's perception improvement in the ways where it is not enough.

The functionality of data correction block is following. The information about operator personal capabilities received during its testing is transferred to the data bank. Data correction block get this information and basing on certain laws and principles sent correction signal to the data management block. As result data management block will change initial presentation of educational material under influence of operator previous successes and failures. As it was mentioned before all parameters that describes operator and system resources could be determined before the learning process begins. In same way they could be determined during first few learning weeks. The only difference is that in first case operators will be dealing with tasks specially prepared for these parameters definition and in second case parameters will be defined during real educational process.

Anyway when those personal parameters will be determined with specified precision the learning process will become something more than just learning. With help of analysis of operator weaknesses in the material studying the training system will be able to predict its possible marks, successes and failures with certain probability. Moreover the training system will be capable to choose certain educational material order with specific study material type parameter chosen. Thus every operator will receive its own amount and type of educational information as well as testing tasks.

Conclusion. The proposed way to individualize educational process may be used in few cases.

- First of all it is the case when operator is unable to understand one topic but shows outstanding successes in others. In this case the system will be able to redistribute operator learning time for all topics to prevent his misunderstanding or even failure in studying of certain material.
- Second case is when operator shows outstanding results with theoretical information testing but have a lot of problems while solving practical tasks. In this case system will be able to redistribute learning time in order to make accent on the practical implementations of educational material.
- Third case is when operator shows outstanding results working with theoretical information in general but get low marks while working with simulating programs. In the same way time redistribution will be used to prevent low practical skills.
- The last case is the most important. In this case system will give the operator increased amount of educational or testing hours in that educational material topics where the operators success is mostly required and/or expected. This will create possibility to personalize educational process for each operator with increased efficiency in the knowledge gain.

As is described the adoptable training system might be able to control the learning process, to give it an ideal direction and to prevent useless time spending. With some additional structural changes in the part of knowledge testing system the training process may gain more flexibility but this is an open topic for future improvements.

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N. Dreimanis, V. Sestakovs,
(Aviation Institute of Technical University, Latvia)

COMPONENTS OF HUMAN FACTOR

The main components of human factor are examined and analyzed in this Article, including physiological and psychological components. These mentioned components are divided in nine groups, and analyzed interaction between these groups.

Research done by various authors shows that casualties and incidents caused by human factor can be avoided by investigating and providing an aggregate of the most characteristic properties required by a pilot by means of complex integration. It is not sufficient that some authors identify and describe only the individual properties and abilities as the most essential in aviation by investigating and analysing the problems pertaining to the human factor. It is necessary to identify as many properties related to the profession of a pilot as possible and to provide a much in-depth understanding of these properties which are attributed to various levels of hierarchy of the said properties. The research and improvement of some professionally most essential professional qualities of a pilot should materialise in the context of identifying these qualities in a common integral structure covering the human factor. However, in consideration of the latest achievements in science, this research should materialise as a body within a common system, relying on internationally accepted and recognised standards as well as in line with the human biological properties. The most essential groups of properties, which are part of the human factor and may influence safety during a flight, are given in the chart below (Figure 1).

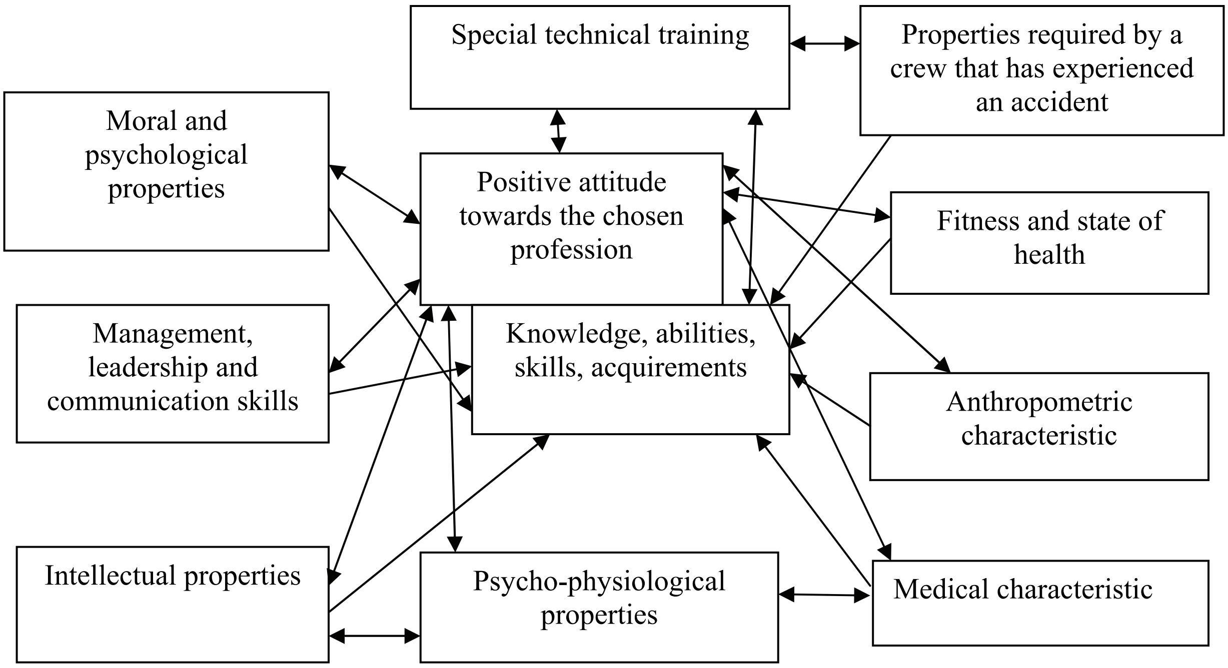

Figure 1: Components of human factor – groups which may influence safety during a flight.

Motivation is mainly professionally significant property that embraces the entire human psyche. Positive motivation in action appears as concentration of attention, a deeper manifestation of feelings, and a much more determined striving for what is related to the profession of a pilot. Motivation activates the processes of perception, thinking and memory, and, to a certain extent, it determines the formation and development of the character of an individual. For this reason, motivation is put as the central group of properties required by a pilot. A strong and permanent interest in aviation is based on pilot's positive orientation into the chosen profession. Investigation of the said orientation and influences on its elements help to ensure a targeted psychological training of a crew.

The first group of properties consists of high moral and psychological properties which are one of the most essential preconditions in the professional activities of a crew. Such moral and psychological properties as discipline, persistence and self-control, persistence and decisiveness, independence, consistence, and others take a significant place in the regulations (rules, statute, law) on the discipline of the employees of civil aviation.

The second group of properties includes management and leadership, teamwork and communication skills, considering their significance in ensuring a flight. Communication skills are important to every member of a crew to ensure a high professional level and a favourable psychological climate within a team, whereas management and leadership are more significant in further professional improvement and management of the entire crew.

The third group of properties consists of intellectual properties of the crew which are related to aviation and are necessary in unexpected situations. In unexpected extreme situations, safety of the crew will generally be ensured by the activities, erudition, and ingenuity of the crew members.

The fourth group of properties is characterized by the special technical training which covers a narrow range of special knowledge, skills, abilities and know-how which are part of the everyday work of a crew and without which the professionalism of a crew is not possible.

The fifth group of properties includes the psycho-physiological properties of aviation specialists which in many ways influences successful formation of the qualities of a pilot necessary for flying and safety in foreseeable and unexpected situations during a flight. The group of psycho-physiological properties can be divided into properties required by an operator and the qualities which ensure a targeted action in unexpected and negative situations during a flight. Furthermore, a low level of development of psycho-physiological properties cannot be compensated by other properties necessary for a pilot.

The sixth group of properties includes medical characteristic, namely, the lowest admissible threshold for ensuring the main functions of organs. It is mainly the basis of professional know-how, abilities and skills which are determined in accordance with the admissible standards and reflected in the management documentation. The medical factors characterize the statistical condition of health, i.e. the condition of health of an individual upon the respective health examination.

The anthropometric characteristic appears in the **seventh group of properties**. The fundament of the said properties is based on a successful functioning of the "Pilot-GK" system which can be ensured only when there is a match between each pilot's anthropometric indicators and the structural peculiarities of the aircraft. The said calculation is based on the indicators of an average individual. In cases when the anthropometric characteristic of a pilot does not match the structural peculiarities of the aircraft, the pilot experiences discomfort which can result in a psycho-emotional tension and therefore reduce the working abilities of the individual and labour safety, especially in unexpected and extreme situations during a flight. For instance, an increased body weight suggests of a disturbed metabolic function, which has an impact on human body.

The eighth group of properties includes fitness and health condition. Fitness characterises the working abilities of the crew, and this, in its turn, is the basis of the specific working abilities. Fitness determines the dynamics of the condition of health of an individual.
The properties required by a crew which has experienced a disaster, as one of the components of the human factor, appear in the **ninth group of properties**, and they are necessary for survival in a casualty. This group of properties includes the crew's ability to act in emergency situations and a successful use of the existing knowledge, abilities, and skills.
An insufficient level of the professional properties in only one of the aforementioned group of professional properties necessary for the crew and influencing the human factor may be the reason for mistakes and faulty activities of the crew, and this, in its turn, may cause aviation casualties and incidents.

Human factor model in aviation

The psychological model of the human factor should take a specific shape of professionally most significant properties and characteristics. This means that the model of the human factor in aviation reflects the list of the professionally most essential properties of a pilot.

Positive attitude towards the chosen profession

Social properties:
- pride in the chosen profession;
- humanism;
- intolerance towards lack of discipline and asocial behaviour;
- careful attitude towards the property of the airline.

Moral and psychological properties:
- discipline;
- independence;
- diligence;
- succession;
- persistence;
- decisiveness;
- courage;
- endurance and self-control;
- industry;
- honesty and truthfulness;
- self-criticism;
- development of aesthetics;
- tact;
- simplicity.

Management and leadership, teamwork and communication skills:
- ability to manage and coordinate people;
- ability to practically use theoretical knowledge and experience in everyday work;
- ability to precisely, valuably and neatly formulate thoughts;
- ability to listen to a collocutor;
- ability to to put oneself in somebody else's place, view a problem from somebody else's point of view;
- ability to be demanding towards oneself and others;
- ability to act so that words match the action;

- selflessness at work;
- simplicity, accessibility, placability towards colleagues at work;
- ability to find the best and most correct approach to each member of the crew;
- ability to find the best psychological distance depending on the situation and the individual peculiarities of other individuals;
- interest in the success of the team;
- ability to demonstrate initiative;
- ingenuity, resourcefulness;
- ability to identify problems in the team and to resolve them;
- ability to generate ideas;
- ability to express and substantiate an opinion;
- operativeness in taking decisions;
- individual striving towards self-improvement;
- psychological compatibility with other crew members.

Intellectual properties:
- erudition;
- high level of technical knowledge;
- productive thinking;
- permanently long-term memory;
- ingenuity;
- need to improve knowledge;
- purposeful interests in various fields;
- striving for professional perfection;
- ability to use dialectical methods of knowledge to analyse the processes and phenomena in nature and society.

Level of special professional training:

- knowledge about aviation technology;
- knowledge about piloting an aircraft;
- knowledge of aerodynamics;
- knowledge of means of communication and their radiotechnical supply;
- knowledge of the documentation and regulations related to flight safety;
- knowledge in aviation engineering psychology and flight safety psychology;
- knowledge of regulations for the discipline of the employees of civil aviation;
- knowledge and skills in radio communication exchange and phraseology;
- knowledge and skills in fitness and psychology.

Psycho-physiological properties:

- emotional stability;
- volume of attention, distribution of attention, and ability to switch over;
- operative memory and thinking;
- coordination of movements;
- fine muscle sensitivity;
- ability to perform swift and complex activation;
- ability to act in limited time and shortage of time conditions;
- ability to restructure activities depending on the situation;
- quickness and speed of action;
- orientation in space;
- ability to extrapolate the development of a situation;

- ability to work quickly under pressure;
- high resistance to disturbance (sound and light);
- stability of the hypodynamic regime of action;
- stability during turbulence;
- resistance to overload;
- resistance to hypoxia;
- ability to process additional information along with the principal duties;
- ability to think and react in emergency situations;
- ability to influence action and will in emergency situations;
- low psycho-physiological value in professional activities.

Medical characteristic:

- condition of the nervous system;
- condition of the cardiovascular system;
- condition of the respiratory system;
- condition of the central nervous system;
- sight;
- colour sight;
- hearing;
- condition of the digestive organs;
- condition of the excretory organs;
- condition of the endocrine system;
- condition of the vestibular system;
- overall condition of health.

Anthropometric indicators:

- height;
- weight;
- life volume of lungs;
- bodily condition;
- central force;
- dynamometry;
- size of thorax;
- x-ray of the thorax;
- waistline, abdomen and wrist circuit;
- length of upper and lower limbs;
- body proportions.

Physical properties and health dynamics:

- endurance;
- speed;
- strength;
- agility;
- high productivity at work in complex conditions;
- dynamic condition of health.

Properties necessary for survival after an accident:

- psychological preparedness for possible emergencies;

- knowledge about how to use the rescue equipment available in the aircraft;
- ability to provide first medical care;
- ability to transmit the emergency signal from any place on the earth;
- ability to orientate after landing on water, in desert, tundra, or in other conditions;
- ability to find food and water in nature and ability to use the available means to survive;
- high resistance of the body to unfavourable environment, capacity for work, and stamina.

Conclusion

The list of groups of properties which form the human factor is based mainly on the development of a professional training system and identification and singling out of its tasks and goals.
The research and improvement of the professionally most essential professional qualities of the crew materialises in the context of identifying the said qualities in a common integral structure covering the human factor. Furthermore, according to the results of current scientific research, an insufficient level of initial professional training may be the reason for mistakes and faulty activities of the crew, which, in its turn, may cause aviation casualties and incidents.
Therefore, the research of the most significant components of the human factor should materialise as a body within a united system, based on internationally accepted and recognised standards, as well as in consideration of individual psycho-physiological properties. The most significant property components of the human factor which may have a major influence on flight safety are named and described in this Paper.

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E.Saldeniece, V.Sestakovs,
(Aviation Institute of Technical University, Latvia)

ASSURANCE OF OPERATORS QUALITY SYSTEM

The main goal of operator's quality system is to form basis that would ensure the process is always carried out applying the same methods, information and skills, as well as make sure it is being persistently controlled. System contributes to defining clear requirements, delivering information on quality politics and procedures and improving work of the team.
Operator's quality system shall be designed in accordance with references, comparing to whom the compliance of the processes can be determined and appropriate corrections made. These references originate from The Standard of Quality Management System.
Overall it can be described as documented Quality management system comprising quality management goals, politics, organization and procedures, providing evaluation and showing conformity with the ISO.

Introduction

As already described in article ***Quality Assurance in Civil Aviation*** is a complicated process. Civil aviation companies developing and implementing quality assurance system can face problems of technical, methodological, managerial and psychological nature. To avoid such difficulties legislation has established key elements of quality assurance program and responsibilities of Quality Manager who is in charge of quality assurance program effective execution. Overall internal control of operator is gained by defining most vital areas to be reviewed and evaluated annually. Procedures for review and verification processes are corresponding to the requirements set in ISO standards. Proceeding with the analysis of quality assurance system in civil aviation the operator quality assurance structure will be reviewed.

Operator Quality Assurance Structure

According to EU-OPS 1 operator's quality system assurance is divided into six chapters:

1. **Thesis**

   - Terminology
   - Quality assurance policy
   - Quality system assurance determination
   - Quality Assurance Manager

This chapter contains terminology related to the quality assurance. It includes policy of quality assurance that has to reflect the accomplishments and future plans. Identify whether the conformity to EU-OPS 1 and 3 requirements has been assured, as well as conformity to any other standards being determined for operations. From this follows that quality assurance system has to allow operator to keep track of the appropriate EU-OPS requirements, operator's management ensuring the flight safety and suitability for flight and other standards. Perception of Quality Manager is gained as it is described in the EU-OPS 1 documents, including his duties and responsibilities.

2. **Quality system assurance**

   - Introduction
   - Quality system assurance

- Corresponding documentation

This chapter reflects quality assurance systems. It includes: EU-OPS application, additional standards and procedures essential for operator performance; operator quality assurance policy; operators organizational structure; responsibility for progress, quality system development and management; documentation, including manuals (management), reports and other records; procedures, quality assurance programme; necessary financial, material and human resources; training requirements. Employees have to have constant feed-back to the Accountable manager. Feed-back system has to specify the discrepancies and non-conformances in any particular case and within procedure that keeps track of the corrective action realization in accordance with the schedule.

3. **Quality programme**

- Introduction
- Quality Control
- Audit
- Auditors
- Auditor independence
- Audit Scope
- Audit performance schedule
- Observations and corrective actions
- Report
- Management evaluation

This chapter contains quality assurance programme development, for example, aviation quality assurance programme development.

4. **Subcontractor responsibility for the quality assurance**
   Subcontractors

This chapter reflects questions (mutual) operators and organizations (agents) in case of determination of final functions.

5. **Quality assurance training**

   1. Overall situation
   2. Training aids

This chapter contains operator's responsibility concerning the personnel training related to quality assurance. Quality management courses offer different national and international organization standards. If the operator has sufficient number of personnel, it can provide training within company.

6. **Company with 20 or less employees**

   1. Introduction
   2. Operators classification
   3. Quality assurance system in small airlines

This chapter emphasizes things related to the quality system assurance:
Company with 5 or less full time employees called "very small"; from 6 to 20 employees called "small". Full working day means that employees work not less than 35 hours per week, excluding rest time. Complex quality assurance systems may be unacceptable to the small and very small

companies, as certain effort should be made there is possibility to go out of the resource frames. Therefore own quality assurance system formation is allowed to make it adequate for both kinds of companies and their work specifics complexity, as well as frame of resources. It can be accountancy control, supplementation to the corresponding schedule that requires controlled accomplishment of all positions according to a certain list, audit performance, as well as documents verifying periodic control execution by the top management. Adopted in such circumstances there will be outsourced services or certified organizations. Yet although the system has been built organizationally, operator has to be fully responsible about the quality assurance and corrective actions.

Conclusion

The aim of operator's quality management system is to build the foundation that ensures process is being carried out constantly and using the same information, methods, skills and is being controlled consistently. System has to help in defining clear requirements, inform on quality policy and procedures, as well as improve the team work.
Operator quality management system has to be developed in relation with the references comparing to witch activity conformity can be determined and corrections made if necessary. The basis of these references is the Quality management system standard.
Overall it can be described as documented quality assurance system that includes quality management goals, policy, organization ad procedures, as well as gives assessment and shows conformity to ISO.

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E.Saldeniece, V.Sestakovs
(Aviation Institute of Technical University, Latvia)

QUALITY ASSURANCE SYSTEMS FOR CIVIL AVIATION

Civil aviation companies developing and implementing quality assurance system can face problems of technical, methodological, managerial and psychological nature. To avoid such difficulties legislation has established key elements of quality assurance program and responsibilities of Quality Director who is in charge of quality assurance program effective execution. Overall internal control of operator is gained by defining most vital areas to be reviewed and evaluated annually. Procedures for review and verification processes are corresponding to the requirements set in ISO standards.

Introduction

Rapid development of aviation transport over the past few years and the increasing amount of consignments drawing extra resources towards state controlling institutions is the cause of necessity to make significant changes to legislation of several states. Initially state institution surveillance was directed to the valuation of aircrafts and physical condition of aircraft equipment therefore due to the legislation deficiencies inspectors could be very flexible regarding interpretation and freedom of action.

Aircrafts and their equipment becoming more and more complicated, as well as growing number and size of businesses involved in aviation transport (e.g. airlines, airports, air traffic control companies etc.) was the reason state institutions were practically unable to continue full surveillance of all companies involved in aviation transport.

Solution was found in mutual breakdown of functions and responsibilities among institutions and aviation companies, resulting in fact that institutions are still responsible for development of regulations making foundation for operations safety and overall supervision realization.

European Union Regulations for Aircraft Flight Operations and Technical Maintenance Procedures

European Union Regulations for Aircraft Flight Operations and Technical Maintenance Procedures (EU-OPS 1 and PART-145) include requirements concerning quality system. Principles of legislation are as follows – national law applicable for EU countries will be replaced with the EU-OPS 1 (till July, 16 2008 JAR-OPS 1 in force) and PART-154. EU-OPS 1 and PART-145 is applicable to all EU countries. Those European joint aviation requirements are closely connected and their implementation in Latvia was performed alike it was done in other European Union countries - PART-145 implemented in the first place did not cause any difficulties with regards to national legislation. Though implementing EU-OPS 1 changes to aviation law had to be made, initiation of changes can be done by local CAA or aviation department, afterwards Ministry of Transport submits them to the Cabinet of Ministers which forwards them to the Saeima where they are reviewed and adopted accordingly. Hence EU-OPS 1 and PART-145 is applicable to Latvia as well and so are the requirements about quality system development for the operators. Internal quality assurance system has to build on company developed structured quality assurance procedures being accepted by the state institutions. This is the way how operators and technical maintenance organisations gain the conformity to the aviation safety requirements being highlighted as the main goal of the quality assurance and primary function of the quality system. Therefore state institutions performing surveillance more and more focus their attention on evaluation of operators and technical maintenance organization conformity to the requirements of their internal quality systems. Since April 1, 1998 the development of internal quality system is mandatory for commercial aviation transport in EU countries.

Basic Principles of Quality System

One of the fundamental requirements of EU-OPS 1 and PART 145 is development of respective organisational structure including independent quality manager (Chart 1)

Most essential elements of quality system determined by legislation:

- Operational requirements
- Additional standards operational procedures of the operator
- Quality policy of the operator
- Organisation structure of the operator
- Responsibility for the development , implementation and management of quality system
- Documentation, including manuals, reports and instructions
- Quality procedures
- Quality assurance programme
- Necessary financial, material and human resources
- Training and term requirements

Accountable Manager is responsible for the development and performance of the quality system, Quality manager holds responsibility for the effective work quality assurance programme.
Quality manager:

- has to make sure that manager responsible for non-conformity is taking corrective actions to avert it;
- has to make sure that corrective action includes all the activities concerned;
- has to monitor the non-conformance at the start and final phase;
- has to give independent evaluation of the corrective action start and final result to the top management;
- has to evaluate the effectiveness of the corrective action performing recurrent inspection.

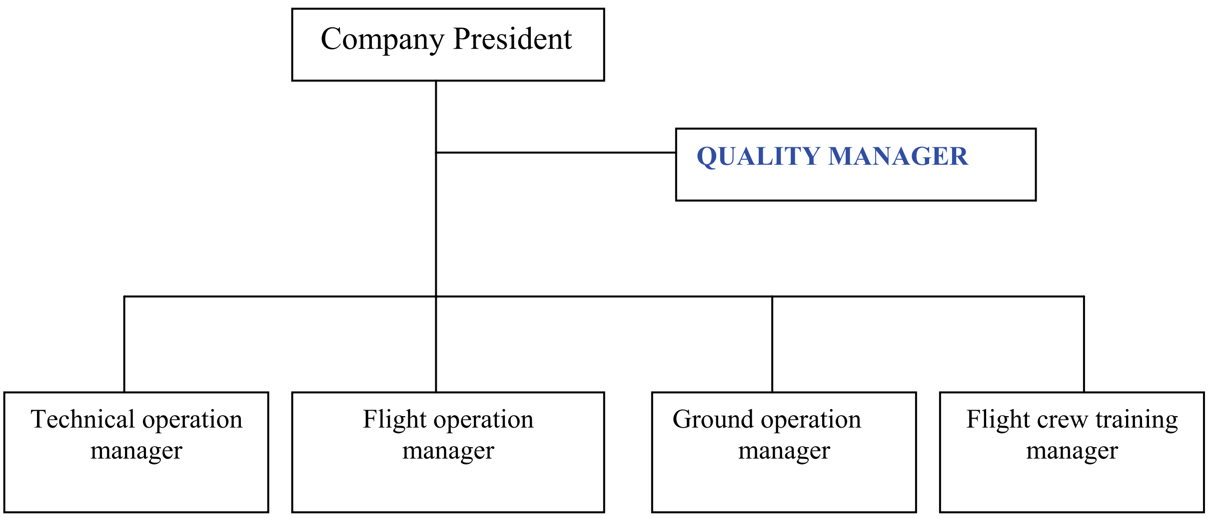

Chart 1. Structural scheme of Quality manager responsibility

Quality manager responsibility

Overall internal control of operator is gained by defining most vital areas to be reviewed and evaluated annually:

- Organization;
- Company plans;
- Flight safety;
- Aircraft operation certification;
- Control;
- Aircraft describe;
- Flights in any weather;
- Communication and navigation equipment and exploitation.;
- Weight, centering and air ship loading;
- Instruments and safety equipment;
- Manuals, Technical log book and documentation;
- Flights and discharge of duties limitations, rest time requirements and planing
- Aircraft maintenance and flight operation interworking;
- Minimal equipment list (MEL) operation;
- Maintenance programme and nonstop airworthy maintenance;
- Airworthy directive control;
- Technical maintenance performance;
- Defect rectification hold over;
- Flight crew;
- Flight attendant;
- Dengerous goods;
- Aviation safety;
- Training and instructions.

Procedures for review and verification processes are corresponding to the requirements set in ISO standards. Typical operational areas to be the subject of quality inspections are as follows.

- Flight exploitation;
- Aircraft anti-icing and de-icing measures on ground;
- To Flight correspondents;
- Loading control;
- Technical maintenance;
- Tehnical standards;
- Training standards.

Audits should include following procedures and processes:

- Notification explaining the scope of the audit
- Audit planning and preparation
- Evidence to request collecting and documenting

Quality documentation contains respective chapters of flight operations and technical maintenance instructions that can be included in a separate quality manual. In addition to already mentioned quality documentation should include the following:

- Quality policy;
- Terminology;

- Determined exploitation standards;
- Organization description;
- Distribution of responsibility;
- Exploitation procedure to ensure conformity to the set requirements;
- Incident prevention and flight safety programme;
- Quality assurance programme that includes:
- Monitoring of process plan;
- Revision procedures;
- Reporting procedures;
- Recurrent control and corrective actions procedures;
- Results documentation system;
- Training and instructions programma;
- Documentation and data control.

Conclusion

Quality assurance system (Chart 2) in civil aviation industry is a complicated process. Civil aviation companies developing and implementing quality assurance system can face problems of technical, methodological, managerial and psychological nature. To avoid such difficulties legislation has established key elements of quality assurance program and responsibilities of Quality Director who is in charge of quality assurance program effective execution. Overall internal control of operator is gained by defining most vital areas to be reviewed and evaluated annually. Procedures for review and verification processes are corresponding to the requirements set in ISO standards.

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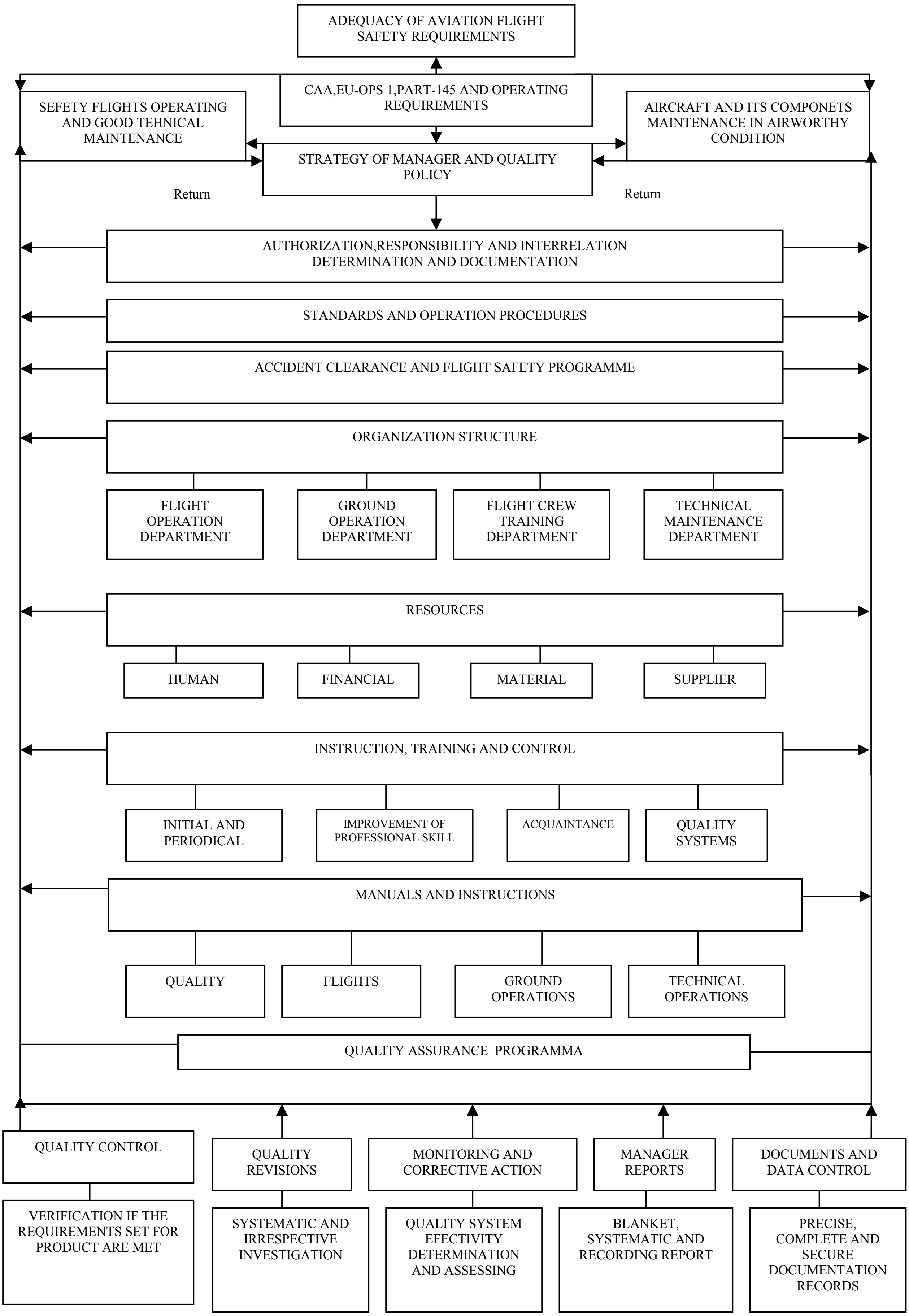

Chart 2. Quality system

G. Fesenko (National Aviation University, Ukraine)

EFFICIENT COMMUNICATION IN AVIATION: LINGUISTIC CONTROL OF SHARED PROBLEM SOLVING

This review focused on the use of Aviation Phraseology and English in flight communication. It attempts to analyze miscommunications from the standpoint of communication competence in pilots and air traffic controllers. The objective was to describe the linguistic characteristics of communication failures between pilots and air traffic controllers.

Introduction

Language is an imperfect medium for communication, but with greater awareness of basic linguistic principles, operating personnel can be motivated to adhere more closely to standard phraseology in all air-ground radio exchanges, thus enhancing safety.

English has been chosen as the official language of flight in the United States and continues to be the recommended *lingua franca* for international use. This applies to all those employed in aviation sectors who are required to communicate with international passengers and customers, pilots, dispatchers, operations centre technicians and regulatory agencies. To facilitate the interchange of information among them, English has evolved to become the global language for all aviation needs and an essential prerequisite for safety, efficiency and effective communication.

There are two different standardized aviation languages: (a) Aviation Phraseology – which accounts for the spoken communication between pilots and air traffic controllers, and has been receiving more attention from scholars; (b) Simplified English (SE), which deals with maintenance documents. An example of a SE rule is: One meaning, one word/One word, one meaning – SE avoids using different words with the same meaning, and, when a word has different meanings, usually only one of these meanings is selected. E.g. *notify*, *advise*, *inform*, *tell*. You must use tell.

Aviation English is not a natural language. Ragan refers to aviation English as "Airspeak" which he characterizes as "idiosyncratic, predictable, and yet problematic in communicating meaning" Aviation English is very dependent on context and a shared phraseology [1]. Unlike conversational English, aviation English is often disjunctive and abbreviated. In routine communications, transactions are very predictable as there is a prescribed protocol for pilots and controllers; however, when speakers deviate from standard phraseology, but continue to speak with their own interpretation of aviation terminology, problems in understanding may occur.

Since this phenomenon commonly occurs, an English proficiency beyond the basic understanding of aviation phraseology may be necessary. In addition, a cultural awareness of the variety of English spoken in the country or countries encountered during flight may help avoid misunderstandings and miscommunications.

Sticking only to the restricted register and phraseology of aviation English may be easier said than done. Aviation communications consultant, Marsha Hunter conveyed: "...aviation phraseology doesn't necessarily follow the linguistic rules we have hard-wired into our brains. `One theory of human language postulates that verbs and nouns fall in certain places in sentences, and that all human languages follow the same basic rules. Aviation phraseology is a technical language concocted by humans, not a language which has evolved over millennia. Clearances don't necessarily follow hard-wired linguistic rules, so we may have to think a few extra seconds to process what we've heard before we respond" [2].

While miscommunications between flight crews and air traffic control (ATC) personnel may have been only one aspect of these incidents and accidents, the lack of ability for all parties involved to understand crucial directions via a common English may have been the most important contributing factor leading to tragedies. Without agreed upon standards for English proficiency and common phraseology, the aviation industry continues to be at risk for future language related accidents.

Our ***main objective*** in presenting this paper is to outline the theories associated with errors in ATC-pilot miscommunication caused by language".

Analysis and Comprehension

Miscommunication can arise just from the characteristics of language itself and from the ways that the mind processes what is heard [3]. Morrow and Rodvold identified that there are three factors in ATC communication: perceptual, linguistic and collaborative. This is because communication occurs through a variety of media organised as several linguistic levels (word, phrase and sentences) and also requires knowledge/rules to govern turn-taking and aspects of dialogue control or management [4].

Language seems to be one main aspect criticised in ATC-pilot miscommunication because it acts as a medium to link people understand each other. Boschen and Jones proposed that causes for confusion in ATC English message particularly by non-native speakers were "Linguistics" (e.g. ambiguities in meaning/harmony, word order and rules of English) and "Numeric" (e.g. non-metric unit and complex configurations) [5]. In terms of linguistics, four relevant subjects: phonology (including prosodic features of speech e.g. stress, intonation, pausing, volume and speech rate), syntax, semantics and pragmatics (including rules and meaning generated by the non-linguistic context), may affect communication errors.

The requirement that technical languages should be sufficiently expressive to distinguish relevant classes of situations means, among other things, that they be neither ambiguous nor vague where this would have consequences for the tasks to be solved. Here, "*ambiguity*" refers to cases in which an expression can be alternatively considered true or false. "*Vagueness*" refers to cases in which an expression can be said to be true to a certain degree; e.g., *The plane lost its fuel* may be considered true, loosely speaking, even if some fuel remained.

Ambiguity is a phenomenon of natural languages and technical derivatives thereof. In certain types of texts, like legal or diplomatic documents, ambiguity might even be welcome. But there are many cases in which ambiguity has led to catastrophic errors. For aviation, Cushing (1994) has reported a number of hair-raising stories.

Ambiguity was involved in the most severe accident in commercial aviation, the collision of two airplanes at a Tenerife (Norte Los Rodeos) Airport in March 1977. This incident centers around the question of whether the phrase *we are now at takeoff* is to be interpreted as "*we are now at the takeoff point*" or as a kind of progressive tense, "*we are now in the process of taking off*".

There are other such word ambiguities or <u>structural ambiguities</u> in aviation language. Cushing mentions the verb *hold*, which in aviation language means "stop what you are doing right now", but in ordinary English can also mean, "continue what you are doing right now" [6]. Acronyms can also be a source of trouble; Cushing mentions the use of *PD* as "*pilot's discretion*" or "*profile descent*". The use of acronyms, such as *ILS* for *Instrumental Landing System*, is the most obvious feature of regimented technical languages for shortening frequent expressions. Economy should be a principle for design of technical languages, but one should keep in mind that economy might result in reduced redundancy and increased ambiguity, both of which may lead to errors in communication. An expression like *Flaps 2*, while short, could be either a statement, or a command.

The effect of linguistic misunderstandings on plane crashes is documented in the linguistic investigations of cockpit-voice-recorder data such as used by MacPherson and Cushing.

There is also <u>syntactic ambiguity</u>: For example, *back on the power* can be read as *[back on] [the power]*, that is, add more poser, or *[back] [on the power]*, that is, reduce the power. Furthermore, there is <u>indexical ambiguity</u>, which is caused by different possible locations of the center of reference: *the lever left of you* is ambiguous in a way that *the lever on your left* is not. The spatial arrangement of the group members, like face-to-face as in the operating room, or side-by-side as in the airplane cockpit, may lead to potential indexical ambiguity. Personnel may be trained to avoid, where possible, such types of ambiguity.

An important ambiguity type not often mentioned is <u>phonetic ambiguity</u> or similarity – an utterance can be understood in two ways because the phonetic realizations are equal, or similar enough, to be confounded. This is especially important in case phonetic realization or recognition is affected because of high workload of the speaker or the addressee, or the phonetic transmission is disturbed, or the presence of background noise. Cushing reports cases like *climb two five zero* understood as *climb to five zero*, and *Cleared to eleven thousand* as *He's clear at eleven thousand*. Phonetic ambiguity can sometimes be reduced, as in the realization of *three* as [tri:] instead of [θri:] in aviation, which avoids the high frequency noise of the *th*-sound [θ] that is transmitted incompletely in narrow bandwith transmisstions, or, in German, the use of *zwo* [tswo:] instead of the standard *zwei* [tswai] "two" to distinguish it from *drei* [drai] "three". As many of such ambiguities can hardly be foreseen in advance, it is important to identify them, to keep a record of them, and use this for gradually improving terminology and technical communication.

As for vagueness, we generally can observe that the reduction of vagueness increases the task load of the speaker: If one wants to be precise, more information has to be gathered, and verbalized, which runs against economy. But vagueness also increases the task load of the addressee, because more information has to be understood and integrated. So, a crucial question is whether the excess work of being more precise is worthwhile. In many cases, it might be sufficient to talk about *a steep ascend* instead of an *a 12 degree ascent*. One conventional way of indicating vagueness with measure terms is the use of rounded numbers; a term like *one thousand feet* generally allows for a more vague interpretation than *nine hundred sixty-five feet*. It may be necessary to indicate explicitly if a precise interpretation of a round number is intended, such as *exactly one thousand feet* [7].

One obvious important factor in the efficiency of communication is the development of an adequate terminology to deal with. This terminology should be expressive enough to clearly distinguish classes of such situations wherever necessary, and in particular when misunderstandings would lead to serious consequences.

Common, non-technical language and rules of communication are adaptively optimized for everyday purposes, typically without rules that are stated explicitly or terms that are formally defined. More specialized fields need specialized languages and communication procedures that often are explicitly standardized. Technical fields differ in the amount of standardization required or expected in communication. While all of them have specialized and standardized terminology, they differ in the extent of standardized communication procedures. The level of standardized communication procedures is high in aviation.

In aviation communication, the use of standardized phraseology in communication is most highly developed, and generally considered something that pilots should strive for. Also, certain formal rules of communication have been established that strive to minimize misunderstandings, like acknowledgments by the addressee that a message has been properly understood, often by "reading back", or paraphrasing, what has been said. Also, there is a rule of "sterile cockpit" in effect if the plane is below 10,000 feet, which means that only task-related communication is supposed to take place.

As the pattern of English language implemented in ATC-pilot communication is unique, Philips studied differences between ATC phraseology characteristics and natural English. He identified that there were two sub-systems of aviation phraseology: English as a sub-grammar, and a context and domain dependent speech community [8]. As such characteristics of ATC phraseology, non-standard phraseology was identified as a most commonly reported factor in miscommunication (e.g. Air Transport Association, 1992; The NASA Aviation Safety Reporting System, 1996). Even in non-native English speaking country like Italy, through the analysis of ATC-pilot communication, non-standard phraseology seemed to play important role in deviating communication efficiency [9].

One thing could support this subject is not the same standard implemented in each country despite the same international airspace. Some phrases recommended by ICAO and by FAA are different in spite of similar meaning. This also could lead to confusion and danger in communication particularly across cultural/language.

Non standard phraseology associates with a lack of English proficiency and international communication [10]. Analysis of past incidents, revealed that aspect of English proficiency was one contributory factor in fatal miscommunications. Not only influence of insufficient English skill from non-native English speakers is significant, but using colloquial, non-phraseologic and ambiguous English by native English speakers also plays an important role in misunderstanding.

Conclusions and outlook for further research

Our approach is standardisation of the linguistic means to circumvent the ambiguity trap. Repeat, confirm the information addressed to you or at least let the sender know that you could not 'read' his or her message due to workload or other intervening factors. The efficiency of communication is improved by standard communication formats, feedback and redundancy.

This concludes our overview of language and communication in aviation. We could only touch on some of the relevant issues here, partly due to reasons of space, partly because still so little is known in this field. One area we did not deal with here is communication in written texts.

We believe that, this review will make it possible to study more objectively and rigorously that linguistic approaches, like speech act theory, conversation analysis and theories of coherence, which are highly relevant for the study of communication within crews. Communication processes in aviation is a subject worth studying in detail: it poses serious challenges for theoretical notions and forces researchers to considerable refinements of their theories. And sometimes it can save lives.

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T. Tarnavska
(National Aviation University, Ukraine)

PILOTS AND AIR TRAFFIC CONTROLLERS ENGLISH TRAINING

Intended for aviation English teachers, the article provides some ideas of pilots and air traffic controllers training to assure reliable two-way radio exchange in English. Analysis of the real pilot-controller communication errors is considered as the best way to develop the ability to avoid misunderstandings.

The deadline for meeting the new ICAO English language proficiency requirements has been changed and we have some more time to think over the problem. How shall we teach pilots and air traffic controllers to provide efficient flight safety improvement? According to the ICAO Doc 9835, “Language teaching is a professional activity that requires specialized training and is further distinguished from other teaching activities because of the unique nature of language learning: a complex blend of skill, knowledge and cultural awareness, combining physical components with mental and communicative processes” [1]. While operators’ task is to ensure that their aviation personnel achieve the minimum ICAO Level 4 language proficiency, English teachers think of the reliability of their trainees’ knowledge and skills. Unfortunately, testing allows to determine only the level of English, not the ability to conduct reliable radio exchange under any circumstances such as non-routine or emergency situations.

Intended for aviation English teachers, the article provides some ideas of how to train pilots and air traffic controllers to assure reliable two-way radio communication.

Though incidents involving air-ground communication problems between controllers and pilots are quite rare and encompass about 1% of all reported incidents and 23% of ATC related incidents [2], if an accident occurs, it claims too many lives. Therefore the importance of improving communication between pilots and air traffic controllers in order to avoid accidents is obvious.

But analysis of aircraft accidents and incidents show that language skills itself do not provide flight safety feature. One of the causes of the communication failures is not just a low level of the pilots and controllers’ English, but their inability to use developed for standard conditions language skills under stress in emergency situations. According to the Aviation and Space Medicine Institute research, in emergency 20% of pilots are not able to size up the situation and therefore don’t make any decisions, 10% – make wrong decisions, 22% – get into a stuporous state and do nothing, 34% – carry out needless actions and worsen the situation [3]. In emergency, obligation to communicate in a foreign language heightens the psychologic stress, becomes an additional risk and hampers the control of the aircraft.

As the goal of pilots and air traffic controllers English training is to ensure the ability to operate effectively in English under any circumstances, simulating non-routine conditions is an opportune way to get them prepared for the eventualities. Even turning on a dictaphone increases the trainee’s psychic tension and trains the ability to operate under stress.

Another factor is inability to detect communication errors like it was at Tenerife Airport on 27 March 1977 when two people speaking the same language couldn’t understand each other. To avoid misunderstanding pilots and air traffic controllers must be able to recognize ambiguous phraseology in order to request clarification or confirmation of the message.

Aircraft accidents and incidents investigation materials are the well of knowledge about the pilots and air traffic controllers’ language behavior in emergency situations. And analysis of the last minutes of pilot-controller communication before the accident is the best way to develop the ability to avoid misunderstandings. For pilots and air traffic controllers learning by doing is unacceptable way to learn how to avoid an accident. But conducting just a literature study on communication errors also doesn’t provide the ability to detect and avoid them. The most essential thing is that trainees should analyze the records and find the error unassisted. So it would be better not to recommend the trainees to read the books like Steven Cushing’s “Fatal Words: Communication Clashes and Aircraft Crashes” [4]. They are intended for teachers really, rather than for students. You can suggest the trainees watching the video (foe example, “Crowded Skies” when analyzing the accident at the Tenerife airport), listening to the records of the pilots-controller communication, reading the tapescript, but let them find the errors on their own without any prompts.

In accordance with strengthened ICAO requirements, there have appeared a lot o f very useful recommendations such as "Always read back ATC clearances in full" (for pilots), "Always listen carefully to the read-back of a clearance" (for controllers) or "Correct any error in the read-back and insist on further read-back until certain that the clearance has been correctly copied" [5]. Theoretically, these recommendations can considerably reduce the number of accidents and incidents where communication problems are a contributory factor. But the whole point of the human factor is that people don't always follow the rules. So until the ICAO requirements are completely met (if possible), being ready for catching the other party's error is as much important as keeping the rules. And ability to understand people speaking with a heavy accent is as much important as your own good pronunciation. It is vital to be prepared for any eventuality.

Normally, people don't know what we want to say, they just hear what was actually said. So first of all we must clearly understand our own message. That is why exercises like "Compare the sentences" or "Explain the difference in the meanings" must be an essential part of the training. For example,

Put the verb "to check" into the gaps in the correct form. Prove your answers.

(to check)

I always ____________ it before the flight.
I don't need __________it today, because I __________it yesterday.
OK, if you insist, I ___________it immediately.
Don't worry, I _________already _________ it.
I don't think it is his fault, because I'm sure he _______________it properly.
When I saw him before the flight, he _______________________it.
Don't forget ___________ it thoroughly!
___________ you __________ it properly?
He is very scrupulous! He delves into every detail! He ____________it even when it isn't necessary!
Look! That is what I told you! He __________________ it again!
It must ______________ monthly.
How often ____________he ___________it?

Read the sentences and answer the questions:

1. When we came, she was making coffee.
   When we came, she made some coffee.
   When we came, she had made some coffee.
   Where is coffee?
2. Jane talks on the phone.
   Bob has been talking on the phone for an hour.
   Mary is talking on the phone.
   Who is not necessarily on the phone now?
3. Jane left when Tim arrived.
   Bob left when Tim had arrived.
   Tim arrived when Mary was leaving.
   John had left when Tim arrived.
   After Tim arrived, Frank left.
   Who did not run into Tim?
4. Jane is talking in class.
   Bob always talks in class.
   Mary is always talking in class.
   Whose action bothers you?
5. Jane never left Jamestown.
   Bob has never left Jamestown.
   Who is still alive?

If the KLM pilot at Tenerife airport had understood what really his words “We are at take off” meant (their position, not the action they were carrying out), it would have been a good chance to avoid the accident.

Teaching vocabulary is usually paid enough attention, but when speaking a foreign language you always have a risk to get stuck on a word you don’t know, even if your English meets the ICAO level 4 requirements. In this case a pilot or air traffic controller must be able to give an eminently clear, terse, and spirited definition, what is quite difficult to do even in a mother language. Suggest your trainees playing the following game and they will make great progress in speaking clear, concise, and direct.

Ask one of the trainees to sit with his back to the blackboard so that he couldn’t see the words written on the board. The rest of the class will give definitions to the words until the word is guessed. Using key words is plainly required.

cat – a PET that catches mice and can see in the dark;
pen – a WRITING TOOL that is long, thin and is used to write or draw in ink;
problem – a DIFFICULT SITUATION that needs to be dealt with;
landing gear – a PART OF AN AIRPLANE that supports it on the ground ;
satellite – A PIECE OF EQUIPMENT that is sent into space around the Earth to receive and send signals or to collect information;
fuel – a SUBSTANCE that is burned to provide heat or power;
oxygen – a GAS that animals need to live;
house – a BUILDING where people live, usually one family or group;
pleasure – a FEELING of happiness or enjoyment;
pilot – a PERSON who flies an aircraft;
fire engine – a SPECIAL PURPOSE VEHICLE for carrying firefighters and equipment for stopping large fires;
bus – a KIND OF PUBLIC TRANSPORT that carries passengers by road, usually along a fixed route;
noise – a SOUND that is often loud and unpleasant;
language – a TYPE OF COMMUNICATION used by the people of a particular country;
body language – THE WAY you move your body, that shows people what you are feeling;
floor – a SURFACE that you walk on inside a building;
floor – a LEVEL of a building;
mosquito – a small flying insect that sucks your blood;
radar – a SYSTEM that uses radio waves to find out the position of something you cannot see;
missile – an explosive WEAPON which can travel long distances through the air;
signal – A SERIES OF LIGHT OR SOUND WAVES which are sent to a radio or television;
angle – A SPACE between two lines or surfaces that meet at one point, which you measure in degrees;
frequency – THE RATE at which a sound wave or radio wave is repeated;

Another way to improve speaking skills is discussing hot-button issues:

Read the letters (taken from the Internet without any corrections [6]) and discuss the problem.

Letter 1

ARM OUR AIRLINE PILOTS NOW!

According to news reports the Bush Administration has made a decision not to allow Airline pilots to protect themselves, their crews and their passengers with firearms.

The Administration and the Congress should realize now that WHEN more airliners are hijacked and used as missiles against Americans then we shall be getting only what we did not prevent!

The administration and Congress are loosing their voters' trust by not taking all appropriate steps to see that the tragedy of 9-11 is not repeated. You think there is political unrest now, think about charges after 9-11 happens again! Voters will hold President George W. Bush and his Administration and members of the Congress personally responsible.

If a significant number of AIRLINE PILOTS REFUSED TO FLY UNARMED then this incredibly wrong decision would be reversed overnight! Passengers also should demand to have armed pilots.

How many more airline pilots must die by having their throats sliced open before the necessity of arming our pilots and making them the last stop in thwarting a devastating hijack is understood?

In the name of the security of our country I urge you to contact your members of Congress and to notify President Bush that you support the reversal of this decision immediately!

T. D. Ponder
Airline Transport Pilot
Birmingham, AL

Letter 2

Dear Captain Ponder,

I can understand your concern, we all can, but unfortunately arming Pilots will not solve or prevent these horrible attacks. Furthermore it just might make it easier for the terrorists to hijack Airliners since they would not have to carry any arms on board, therefore eliminating the possibility of there early detection.

Training A Pilot or any other person for that matter to use a weapon with great expertise takes many months and requires constant training in order to maintain the skill. This would be highly costly and would create extra workload on the already overloaded Pilots.

While Piloting an airliner you are totally concentrated with your work, faced towards the gages and instruments of the airplane and with your back towards the cabin door. I doubt you would be able to defend your self from the terrorist coming behind you, especially not with a gun. If you had been lucky you would have managed to struggle with the terrorist risking a bullet hole in the sensitive fuselage.

In my opinion a marshal would solve the problem or at least reduce greatly the danger, allowing the Pilot and crew to continue with their skilled jobs and putting in ease the minds of all passengers.

Best Regards,
Michael Judah
Commercial Pilot

Letter 3

Many good points for and against have been posted concerning the use of handguns in the cockpit.

Yes, it may not suit all pilots to carry a handgun, but shouldn't we allow the ones that does to have one? We do all kinds of training to keep us current on the planes we fly, a couple of days on the shooting range a year wouldn't hurt. After all, a hijack is an emergency situation like any other.

Yes, it may sound easier to hijack an airplane if you don't need to bring your own weapons, but nobody is saying that handguns are the only solution to the problem. If you have an armored door it will take more than 30 sec to get trough...would you take the chance knowing the guy on the other side has a gun?

And if nothing else, it gives a feeling of safety knowing you have a last resort, and any man with a gun is a possible treat...even a pilot in a cockpit....facing a terrorist.

Air marshals carry on handguns, but they are only present on 1% of the flights, the pilots are present at 100% (even if only 50% of all pilots qualified to carry on a gun this would be an improvement of 500% from today!!!).

And when people say they would feel safer if they knew the pilots had some means of protection (and the proper training to use it).

I'm sure this debate can go on forever, but talk is cheap, can't we at least give it a try!?
Chris V.

Letter 4

The safety of aircrews should be a primary concern for all of us. I'm not sure arming pilots is the answer though. I feel very secure since Jetblue installed armored cockpit doors on all of our aircraft. The first next generation door equipped aircraft has also just arrived on property from Airbus.

If they can't get into the cockpit then why would I need a gun?
Mark Meade
A-320 Captain
Jetblue Airways

Question making can be successfully trained by doing the exercise "Unusual accidents": "Microphone Kills All 11 Aboard" – *Ask as many questions as you need to find out what happened. (The accident occurred on 2 September 1937 with the United Air Lines DC-3 in San Francisco, California. The co-pilot dropped his microphone which jammed the controls preventing the pilot from pulling out of the glide. The plane crashed killing all 11 aboard.)*

To train speaking, reaction time, speed and timeliness of transmissions, the records of the cockpit warning sounds, for example, can be used: *Listen to the sounds and react as quickly as possible. Describe your situation and intentions in a clear and unambiguous way.*

As "ICAO phraseologies shall be used whenever possible" [1] and the purpose of the exercise is plain English language training, "the controller" (unfortunately, usually pilots and controllers are not taught together) doesn't give any instructions but asks questions to obtain more accurate information about the situation.

In face-to-face communication we can use various mannerisms to support our speech and ease the understanding, but it's impossible in voice-only pilot-controller radiotelephony communication. Therefore the intonation, the speed of speaking and the placement and duration of pauses may also affect the understanding of a communication. One of the requirements ICAO is to produce stretches of language at an appropriate tempo. Ask the trainees to read the extract from an article in a mother language and retell it in English. Ask them:

- ✓ to try not to lose fluency;
- ✓ to keep the rate and slow it down when emphasizing;
- ✓ to maintain a tone, rhythm and intonation;
- ✓ to enunciate the words clearly.

Another kind of activities is a business game aiming to practice initiating and maintaining exchanges, and responding spontaneously. For example, a Press Conference given after an accident helps trainees' responses to get more immediate, appropriate, and informative.

So far as it is hardly possible to solve all the problems of human factor in pilot-controller communications by implementation of the ICAO language proficiency requirements, developing the ability to detect the errors and avoid miscommunication in radiotelephony exchanges is the high priority task.

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CONGRESS SECRETARIAT
National Aviation University 1, Kosmonavta Komarova ave., Kyiv, 03680, Ukraine
Tel: +38044 406-7212
Fax: +38044 406-7212
e-mail: aviacon@nau.edu.ua
Congress homepage:
http://congress.nau.edu.ua