# TRENDS AND IDEAS OF HUMAN-MACHINE SYSTEMS IMPROVEMENT IN AVIATION

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*The article contains a survey of some approaches to integration of machine and human components of socio-technical system in conditions of growth of automation capabilities. Some data concerning the perception of a pilot in a highly automated cockpit presented. The article considers a number of promising areas of innovation. In the article offers the idea of tuning onboard systems to individual-typological characteristics of the particular operator in addition to adaptation of interfaces to the current condition of a man. The paper discusses the language modality perspectives of a man-machine interaction. The autor believes that the personality-centered approach is the best basis to psychological weltanschauung of aviation developers in the present conditions and especially in the long term given the structure of a pilot's psychological difficulties in the high-level automated cockpit.*

***Keywords:*** *human-machine interaction, man-machine interface, heuristic problems, speech modality, personality approach.*

## Introduction

Improvement of human-machine systems is associated not just with the improvement of machine is on the one hand and training person on the other hand. It is about ensuring the best consistency between machine and human units whose properties are fundamentally different. As experience shows, in spite of these differences, it is possible to achieve the necessary consistency of human and machine components in relation to the specific tasks of the system and content of human-machine interaction.

S. Gerathewohl spoke about a sensitive display of psychological coupling of a man and an aircraft admitting that a piloting man experiences special mental conditions and feelings, which provide the best human-machine interaction.

At an early stage of computer hardware development J.C.R. Licklider’s vision was that humans and machines could be coupled together and work interactively. He wrote: «Man-computer symbiosis is an expected development in cooperative interaction between men and electronic computers. It will involve very close coupling between the human and the electronic members of the partnership. The main aims are 1) to let computers facilitate formulative thinking as they now facilitate the solution of formulated problems, and 2) to enable men and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs. In the anticipated symbiotic partnership, men will set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations… Preliminary analyses indicate that the symbiotic partnership will perform intellectual operations much more effectively than man alone can perform them». (Licklider, 1960, p. 4).

A movement to such a partnership in the era of information technologies expansion not only accelerates but become more controversial. It needs a comprehensive assessment of a sense of any ideas and constructive decisions related to the information technologies implementation to support and make a man-machine interaction more profound in aviation.

## A Need for Innovation

So, the key manifestation of man-machine symbiosis is shown in achieving high efficiency by a man and reducing psychological costs of the work done by him.

It is known that a man in highly automated cockpit faces a lot of difficulties and a total psychological load on a man at certain periods of time can be even higher than in cockpits having lower level of automation.

The problem of man adaptation to activity conditions in highly automated cockpits can be solved by introducing an elaborate training system for men. Nevertheless, it is not completely tackled. We have conducted a survey (2013) questioning pilots of airlines based in Ukraine and flying Boeings 737-500. The pilots were offered to assess how modern level of cockpit automation has influenced their work using bipolar scales (Figure 1). General picture is positive taking into account average data. On the other hand, the grades of separate respondents proved that the problem is obvious (it is seen from a great difference in grades shown in the figure). It is important that according to the scale "more stressful – calmer work" some respondents put two marks at opposite sides despite given instructions.

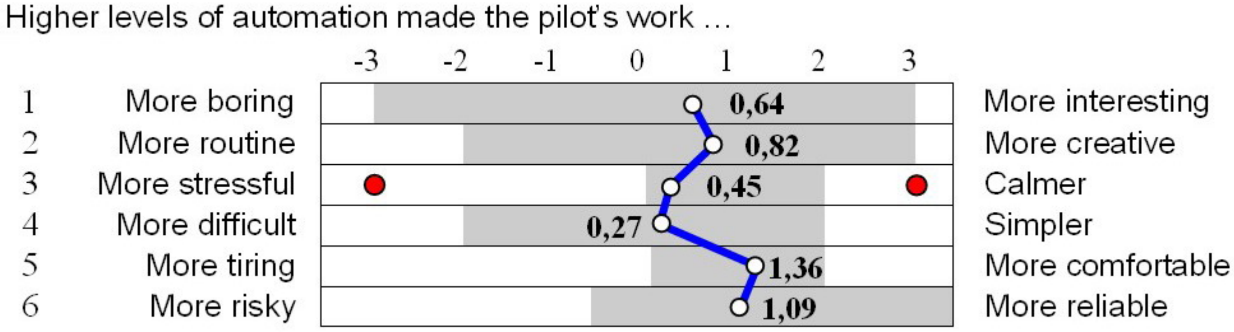


*Figure 1.* The perception of the pilots in a highly automated cockpit.

Giving answers to the question about difficulties occurring in the process of transition training for this type of an aircraft the respondents admitted they had some in the training process:

- Difficulties to understand logics of automation interaction (45% of respondents);
- Difficulties to transfer from multimember to two-member crew because of functions redistribution (12% of respondents).

Moreover, respondents claimed adaptation difficulties to a great number of control functions instead of executive; difficulties of visual information perceiving; doubts in automatics reliability.

The data we got prove that a pilots training system is not a comprehensive mean to solve the problem related to automation. It is obvious that the system is effective, but hardware and software development allowing better man-machine interaction is really needed. Consider guidelines for continuing innovation.

## The Development of Man-Machine Interfaces

The higher the level of aircraft cockpit automation the harder to assess risk of crew activity failure under the work conditions with patterned control procedures.

We are watching purposeful efforts of leading scientists of the world aimed at creating Cognitive Adaptive Man-Machine Interfaces (Dorneich and others).

Interfaces control is done taking into account instruments data about current man state in line with data about the condition of a controlled object, environment, situation which allows to avoid man's information overload and harmonize his interaction with the machine.

Our studies are aimed at exploring possibilities of man-machine interaction 'adjustment' to typological characteristics of an operator.

Thus, while CAMMI approach allows us to identify the moment of operator overloading, our approach is aimed at creating a system that will raise the level of human capabilities at the expense of individualization process presenting information.

To solve the problem the regularities of different psychic functions interference must be studied and formalized as well as individual and typological differences of such interference. Finding out these regularities will allow us not only give a current assessment of crew reliability but realize adaptive information models aimed at minimizing risks of faulty actions connected with informational overload of a man.

We were interested in two principal cases involving the process of voice interaction in conditions of doing some background cognitive task requiring psychomotor response. The first case consisted in that a man was making the different voice messages (Figure 2), and the second case consisted in that a man was perceiving and processing the different voice messages (Figure 3).

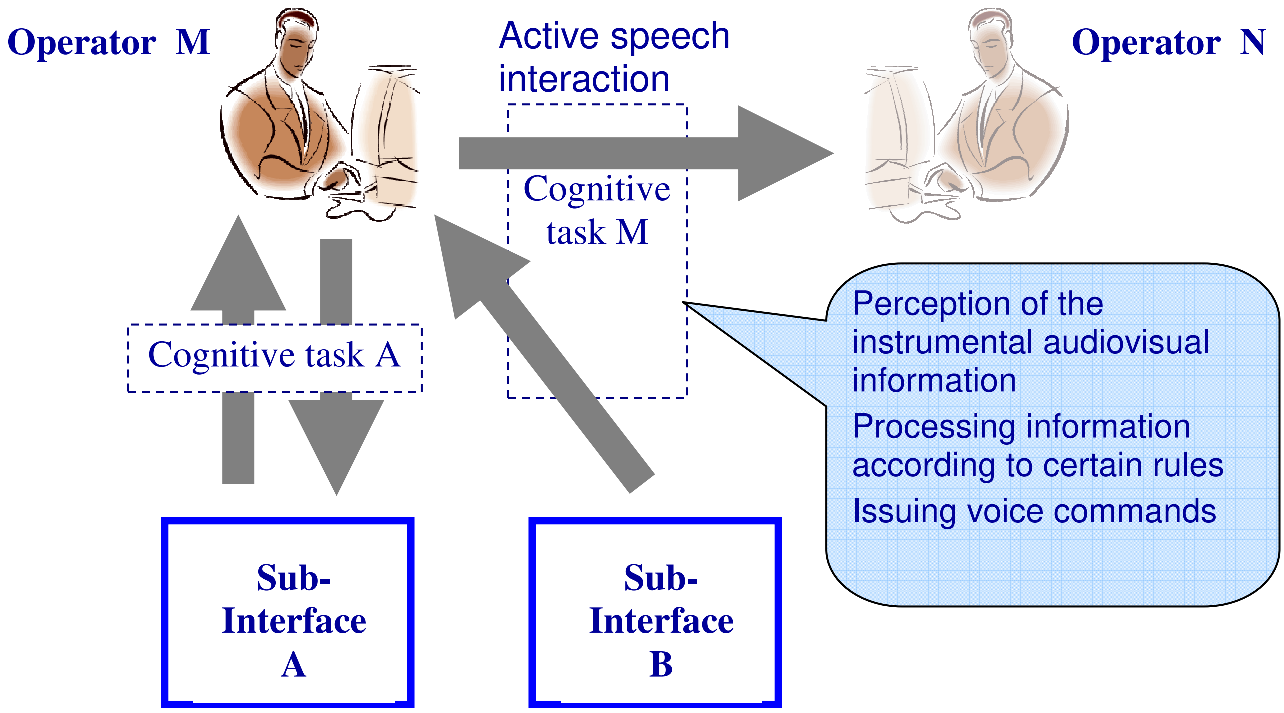


*Figure 2.* The case when a man was making the different voice messages in conditions of doing some background cognitive task requiring psychomotor response.

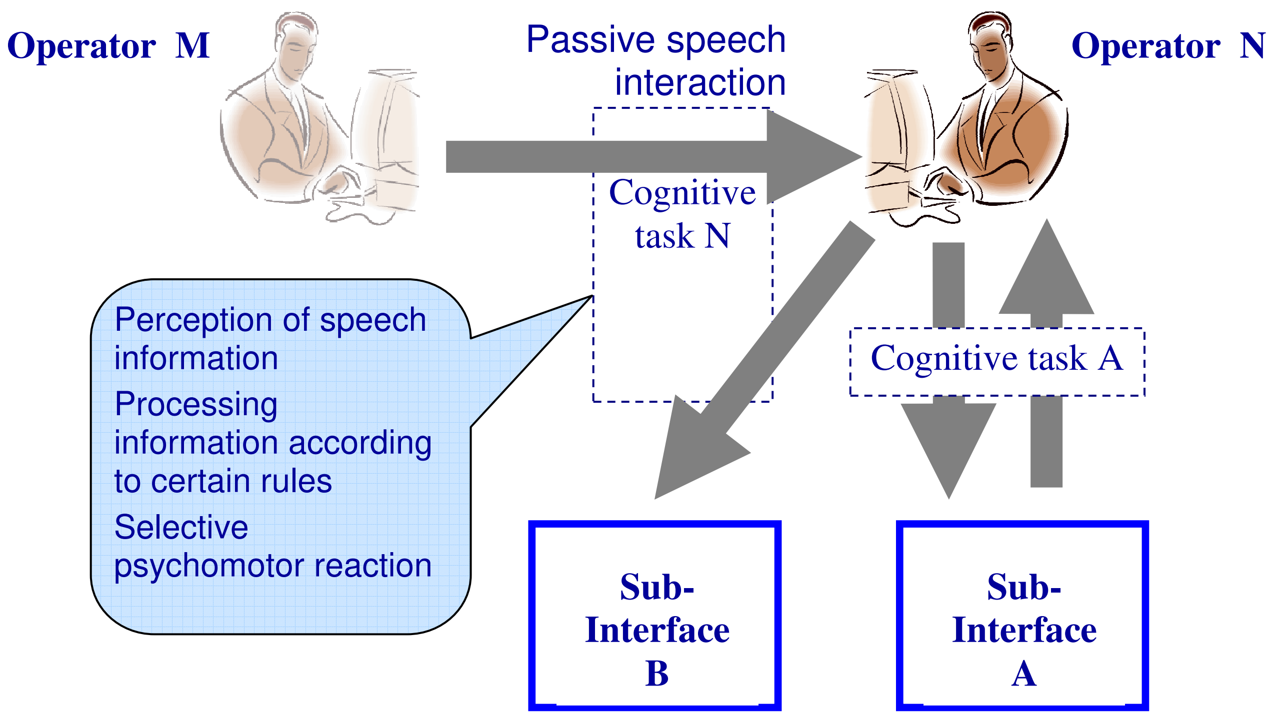


*Figure 3.* The case when a man was was perceiving and processing the different voice messages in conditions of doing some background cognitive task requiring psychomotor response.

To conduct our survey we use integrated stand giving an opportunity to simulate joint work of two operators. Each of them is engaged simultaneously in different contours of control and processes information of different modality performing combined tasks of different goals under the conditions of current language interaction between partners (Figure 4). Two experiments were here integrated into a single experimental situation as complementary elements.

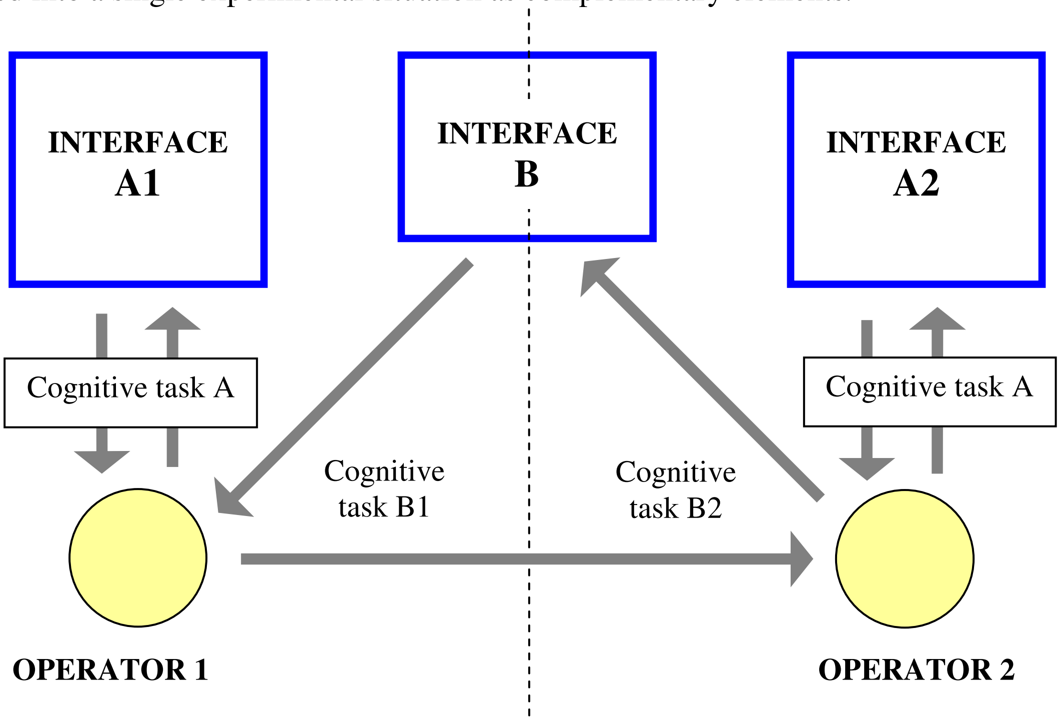


*Figure 4.* A scheme of integrated stand to study interference of different psychic functions of an operator.

Judging by the first results of the begun empiric studies we can suggest that typological characteristics of a man-operator are identified by a wide range of individual peculiarities including individual cognitive style, psychic asymmetry profile, neurodynamic characteristics and some personality features.

Information about typological characteristics of crew members can be used together with the information about a current condition. While a current state is subject to instrumental monitoring, data about typological characteristics can be entered into airborne systems before the beginning of work with the help of personal key together with the information kept in it.

### Transformation of Man Tasks and Requirements to His Features

Creation of adaptive man-machine interfaces allowing to reduce the risk of informational overload of a man is one of the tasks to develop man-machine systems.

In many cases when human factor is a cause of an emergency we can admit a lack of quality of man heuristic activity (scenario forecasting, understanding of a flying situation in general, working out new patterns of behavior, making decisions feeling lack of information). This is an activity which man performs better than a machine but airborne systems can assist a man. It goes not only about unloading a man giving him more opportunities to solve heuristic tasks but providing him with a direct help in the process of their tackling. Achieving such level of interaction between a man and a machine we can speak about a brand new situation when a machine becomes a symbiotic partner of a man and perceives him as another crew member or as an extension of his own mind.

In these cases we deal with special teams which are called hybrid. It was shown that working successfully in highly automated Human-Machine-Interfaces (HMI), i.e. in a "hybrid team", demands different aspects of personality and attitudes than working with a human partner (Eschen-Léguedé, Knappe, Keye, 2011).

## Speech Modality Perspectives of a Man-Machine Interaction

Solving heuristic problems in the cockpit a human usually deals with more generalized levels of reality than levels represented by instrument board indicators. A question arises which means of information transmission can be used more effectively in such situations.

We believe verbal messages are adequate to these levels as speech as means of information transmission is notable for peculiar possibilities of generalizing and informational capacity. That's why the most important element of systems providing help to a human in overcoming flight difficulties can be subsystems of realizing verbal man-machine interaction.

The analysis of possibilities capable to provide such systems and their implementation in aviation and ways of reducing risks was conducted when a level of IT and computers development was far from the up-to-date one (Ushakova, Pavlova, Zachesova, 1989). At that time the creation of hybrid teams was out of question and the interest to interaction of communication channel and technics was connected to systems of speech warning and voice control. Nevertheless, the main defined provisions are still urgent which make a good basis for continuing research in the direction.

Unlike a talk exchange between people which being natural for them because of their nature is used to solve any including the simplest task, a talk exchange between a human and a technical system is mostly beneficial while solving difficult tasks to assess situations and make decisions. To realize such talk exchange it is necessary to use special phraseology expressed in laconic word forms suitable to transfer reliably highly generalized messages concerning different classes of flight situations but at the same time unambiguous in every possible context. There is a need to prevent faulty language commands of an operator and misunderstandings which are likely to occur without taking specific measures.

We questioned pilots flying up-to-date aircraft about their attitude to a possibility of talk exchange with onboard systems. Expecting to get mostly skeptical attitude of pilots to such an opportunity, in fact only 27% of respondents expressed skeptical views. At the same time pilots treated more positively the perspective of developing systems of voice communication of a machine to a human than an introduction of voice systems to control machines. Another regularity expresses positive attitude to a possibility of voice communication with onboard systems which positively correlated with positive attitude to cockpit automation.

Suggesting that the attitude to voice communication systems is stipulated by individual peculiarities of cognitive sphere we compared groups of pilots who treated such systems mostly positively and mostly negatively taking into account individual cognitive style data, verbal and logical thinking and creative abilities. For this purpose we used a cognitive style questionnaire (A.Harrison, R.Bremson, adaptation by A.Alekseev) allowing to assess a level of an individual inclination to synthetic, idealistic, pragmatic, analytical and realistic styles as well as verbal and logical test and verbal creativity test. It turned out that pilot groups who positively and negatively treat the perspective of wide usage of communication systems in man-machine interfaces drastically differ by inclination to analytical cognitive style data (pilots having more positive attitude to using voice communication systems demonstrated higher results of analytical style). There were no differences found in other styles as well as in verbal-logical thinking and verbal creativity.

Moreover, it was found out that pilots giving more positive grades as to the introduction of voice communication systems believe that the work in automated cockpits is more interesting (drawing 1, scale 1) comparing with the work in cockpits of previous generation aircraft. This fact and found correlation of pilot treatment of automation and language man-machine interaction can be interpreted as a proof that the idea of interactive communication systems design in man-machine interfaces correlates with pilots understanding of general trends of cockpit automation and doesn't oppose to their professional psychological outlook.

## The Ideological Aspects of Innovation

Introducing automation systems enables automatics developers to be indirectly present in the cockpit together with the crew.(Golikov, Kostin, 1996). Creating modern sociotechnical systems aimed at a human at a completely new level has special requirements to an integration of developers and operational psychological weltanschauungs. A problem of these weltanschauungs correlation has an objective background connected with different professions owing their perceptional space (Strelkov, 2001).

Technics designers have covered a long way from a machinecentric approach to an anthropocentric one. Nevertheless, it is too early to talk about problem solving. However, designer’s activity pushes a developer if not to a machinecentric approach then to a simplified understanding of anthropocentrism in the psychology framework of cognitive processes.

Professional stereotypes encourage aircraft developers to solve problems caused by automation, using further actions of automation which in its turn leads to further model transformation of cockpit crew actions. Such transformation causes specific difficulties for experienced crews adding to the difficulties characteristic of human activity in highly automated cockpit.

As an example of a field where aircraft developers and pilots positions are coordinated we can take a flight-test unit of aircraft manufacturing plant. So, at Antonov designing bureau we can find examples of fighter pilots taking an active part in position transformation of aircraft developers towards approaching the outlook typical for cockpit crew. To make the matter successful communication between developers and operators must take place at the stage of designing.

## Conclusion

In general we claim that new risks and new opportunities connected with further cockpit automation are integral. Ultimately, the task is to prevent possibilities transformation into risks but to encourage risks transformation into possibilities. For this purpose it is necessary not to lose a personality of a professional as a system-forming phenomenon behind other narrow-specialized issues. Professional outlook, realizing his role and his limits, his heuristic potential are of same importance under the conditions of ‘hybridization’ of social and technical systems as improving of man-machine interfaces and activity algorithms.

Perhaps the widespread using of speech interaction between man and aircraft intellectual systems will be one of the manifestations of real domination this ideology in aviation.

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