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CONTINUING AIRCRAFT AIRWORTHINESS (ICAO Doc 9760)

Term Paper Method Guide
for the Students of the
Field of Study 27 "Transport",
Specialty 272 "Aviation Transport",
Specialization 01 "Aircraft and Aero-Engines
Maintenance and Repair"

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Містять рекомендації з аналізу даних експлуатації, оцінки експлуатаційних властивостей заданої функціональної системи, її удосконалення, обґрунтування вибору стратегій технічного обслуговування її елементів та елементи наукового дослідження.

Для студентів спеціальності 272 «Авіаційний транспорт», спеціалізації 01 «Технічне обслуговування та ремонт повітряних суден і авіадвигунів».

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The METHOD GUIDE contains recommendations on operational data analysis, a given functional system operational properties estimation, the system improvement, the system's elements maintenance strategy choice substantiation, and scientific research elements.

Designed for the 1st year students of the Field of Study 27 "Transport", Specialty 272 "Aviation Transport", Specialization 01 "Maintenance and Repair of Aircraft and Aircraft Engines".

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INTRODUCTION

This **METHOD GUIDE ON THE COURSE PROJECT (CP)**, is given after and following the reference [1].

The *Method Guide* of the reference *Dokuchaev et al. 2003*, [1], contains recommendations on operational data analysis, a given functional system operational properties estimation, the system improvement, and the system's elements maintenance strategy choice substantiation.

The presented herewith **METHOD GUIDE** is designed for the 1st year students of the Field of Study: 27 "Transport", Specialty: 272 "Aviation Transport", Specialization: 01 "Maintenance and Repair of Aircraft and Aircraft Engines".

Special attention is drawn here to the scientific component of the projecting work.

The **METHOD GUIDE** combines the development of the methodical recommendations for the former Specialist's Level training, previously contemplated at the reference [1], and herewith the ongoing evolution to the **SCIENTIFIC RESEARCH ELEMENTS**, since it is deemed to be done by the **MASTER'S DEGREE** students.

During the CP accomplishment process, it is necessary to use the **RECOMMENDED LITERATURE SOURCES** (the list is presented, but not limited to it). The **LIST OF LITERATURE** at the end of the **METHOD GUIDE** is basic (major) and compiled in the order of supposed (assumed) importance.

As it is generally accepted the entire **REFERENCES LIST** is presented in two Sections: *Main* [1-27], in accordance with the initiatives of the original reference [1-10] plus the amendments which are considerable in the view of this newest publication targeted upon English speaking students pretending for the **MASTER'S DEGREE** [11-27], and *Additional* [28-38], in the alphabetic order.

The **REFERENCES LIST** is selected, set in the order [1-38], does not pretend for completeness, but instead it is aimed at developing the students' abilities of thinking and to analyze, contemplate in the specified directory rather than their abilities to know and memorize. However, these are very significant too.

Actually, in the contemporary informative boom world, the needed or required data can easily be retrieved from the internet, found in multiple references, studies [13-17, 33], dictionaries [34], comprehensive books [1-3, 11], or guidance materials [4-12] etc.

OBJECTIVES AND TASKS OF THE TERM PAPER

This **METHOD GUIDE** is an attempt to create the motivating conditions for the **MASTER'S DEGREE** students to achieve valuable results that can be useful in their further scientific careers.

The purpose of the CP is to acquire the practical skills by the students to solve the engineering tasks, mentioned in reference *Dokuchaev et al. 2003*, [1], and research problems on **AIRCRAFT (A/C)** technical operation. Course projecting is one of the stages for a creative application of the knowledge obtained during general-engineering, special, and profile academic studies, [1, Section 1, p. 3].

The theme of the CP is “**IMPROVEMENT OF THE AIRCRAFT GIVEN FUNCTIONAL SYSTEM MAINTENANCE PROCESS**”. The CP task is to develop some separate **MAINTENANCE (M/T)** system elements, of certain aeronautical engineering units (items, parts, products), based upon the A/C systems reliability, failure-free operation, functional significance, and operational technological facilitation [1, Section 1, p. 3]. In addition, the CP should highlight the content of the A/C crew preliminary and preflight preparations, as well as the crew conduct procedure in special flight conditions and events. This list is given in the CP Appendix (Ap), Section 5 (Ap 5) of the reference [1, Appendix 5, p. 53].

One of the essentials for the **MASTER'S DEGREE** nominee is the **SCIENTIFIC RESEARCH ELEMENTS** fraction of the CP work. It has to prove somehow the effectiveness of the developed in the CP improvement of the M/T process of the aircraft given functional system.

In addition, it is an important task of the CP carrying out, that students should acquire abilities to work with, search for, and use the scientifically elaborated **LITERATURE SOURCES**, likewise pointed out in the **REFERENCES** Sections, and even beyond the **RECOMMENDED REFERENCES LIST**.

Such approach creates an aid to conduct independent scientific investigations and develops that necessary skills required for the **MASTER'S DEGREE** graduates.

ASSIGNMENT FOR THE TERM PAPER

The full-time learning students receive a CP assignment (task) variant at the **AIRCRAFT AIRWORTHINESS RETAINING DEPARTMENT (AARD)** according to Ap 1, [1, Section 1, p. 3 ... , Appendix 1, p. 35]. The extramural students of **EDUCATIONAL AND RESEARCH INSTITUTE OF CORRESPONDENCE AND DISTANT TRAINING** are to choose the variant from Ap 1, [1, Section 1, p. 3 ... , Appendix 1, p. 35] by the last figure of their credit-book number with taking into account the type of A/C at which the student works. If a student does not work at the pointed out types of A/C, she/he is given an individual task at the AARD during the fifth year of education session period.

The name of the functional system and the initial data for the functional failures, causing the flight special situations, probability calculations is to be chosen by the number of the variant from Ap 2, [1, Section 1, p. 3 ... , Appendix 2, pp. 36-45].

PROJECTING WORK ORGANIZATION

For example, [1, Section 1, pp. 3, 4], a student works with the Tu-154 A/C type. The number of her/his own credit-book is M-844212. Accordingly with Ap 1 the student should accomplish the 22nd variant of the task. In the given case, the theme of the CP is **“Improvement of the Tu-154 Aircraft Hydraulic System Maintenance Process”**. In Ap 2, the initial data of the task 22 variant refer to, [1]:

– Hydraulic system (pressure sources and the circuit of the landing gear retraction-extension).

The functional reliability of the hydraulic system is estimated to control the landing gear retraction and extension function, [1].

The given values of failure rates $\lambda(t)$ are distributed among the system elements depending upon the failures consequences. So, for instance, if a failure of an element can cause a complication of the flight conditions (R1 situation), then one chooses the value of $\lambda(t)$ of the given variant from the corresponding column of Ap 2. In an analogous way, one chooses the values of the elements failure rates for a difficult (dangerous) (R2) and emergency (R3) situations, [1, Section 1, p. 4 ...].

After determining the CP variant (Ap 1), [1, Section 1, p. 3 ...], a student (at her/his own discretion) determines the number of one of the

flight special conditions and events (Ap 4). Thus, the variant 22 corresponds to the special condition 7 “Flight in a poorly oriented location” and special event 7 “Landing with the faulty state landing gear (chassis)” (Ap 5), [1].

The project **EXPLANATORY NOTES** (EN), in accordance with the **STATE STANDARDS OF UKRAINE** (SSU) requirements, [1, Section 1, p. 4 ...], must be written in a readable handwriting, distinguishing the sections', subsections' titles and paragraphing. It is obligatory to present calculation formulae and cite literature sources (the formulae numbering should be indicated in parentheses (round brackets), while the literature sources must be referred to in brackets numbers [square brackets]). Graphics, diagrams can be drawn on the millimeter paper (e.g. the A 4 format for the representative conveniences and perceptions easiness), [1].

The **REFERENCES** citations must be as precise and detailed as possible.

Figures and schemes should have necessary explanations of the depicted items, [1, Section 1, p. 5]. Every table and figure must have its number and title (name). The project EN contents table has to be placed at the beginning of the EN description whereas the list of the literature sources used in the CP by the end of the CP EN. The completed notes are required to be filed and page-numbered; the front title-sheet must be formed, [1]; and the author of the project is to sign herself/himself her/his own work performed and put the work execution final date prior to submitting the CP materials to defend in the **EXAMINATION BOARD**.

The drawings created for the CP **GRAPHICAL PART** (GP) are to meet the SSU requirements. They may include the improved functional system scheme, general view, or assembly drawings of the functional system items being improved, [1, Section 1, p. 5].

The general view drawings as well as the assembly drawings of the functional system items must have their own dimensions, cross-sections, text fragments, and descriptions. **PRINCIPLE SCHEMES** should be drawn separately from the items drawings, [1].

CONTENT, SCOPE, AND STRUCTURE OF THE TERM PAPER

The CP scope has to compile up to 20-30 pages of A 4 format of the handwriting text of the EN and at least one sheet of A 1 format of the

GP. The EN text is allowed to be either typed or set on a computer and then printed, [1].

The **TASK** (assignment) sheet should be provided as the second (already numbered with the put, counted number, # 2) sheet of the CP EN. It is unlike the **TITLE** (front, cover) sheet of the CP EN, which is counted as # 1, the number is not put on the **TITLE** (front, cover) sheet although, [1].

The project EN ought to encompass the following Sections, however not constrained (limited, restricted) only to those:

- Contents table;
- Concise (short, abridged, brief) description of the A/C functional system considered in the given CP (it is optionally that this material might be included into the **INTRODUCTION** Section of the CP EN);
- System functional reliability assessment (estimation, evaluation);
- System structural design improvements;
- System elements M/T strategy choice;
- A/C crew preliminary and preflight preparations to the forthcoming flight;
- A/C crew conduct procedure in special flight conditions and events, [1];

AND PARTS INDISPENSABLE FOR THE MASTER'S DEGREE, applicant students:

- **SCIENTIFIC RESEARCH ELEMENTS:**
 - **AIRCRAFT GIVEN FUNCTIONAL SYSTEM MAINTENANCE PROCESS IMPROVEMENTS CRITERIA (INDICES, MEASURES) CHOICES;**
 - **MEASURES DESCRIPTIONS;**
 - **EXPLANATIONS;**
 - **SUBSTANTIATIONS;**
 - **STATISTICAL INVESTIGATIONS (OBSERVATIONS, DATA COLLECTIONS, DATA PROCESSING ETC.);**
 - **HYPOTHESES (STATEMENTS, PROBLEMS);**
 - **PROOFS (DERIVATION, SOLUTIONS, TESTING);**
 - **EXPERIMENTATIONS (TRIALS ETC.);**
 - **GRAPHICAL REPRESENTATIONS; AND**
 - **EXTRAPOLATIONS;**
 - **SIMILAR SCIENTIFIC RESEARCH STUFF;**
 - **SCIENTIFIC RESEARCH CONCLUSIONS;**

- Repeated computations after the proposed improvements would be implemented and scientific research have been conducted;
- The achieved or foreseen results comparison with the initial maintenance system provisions;
- Course Project Conclusions;
- List of References.

METHOD GUIDE ON THE EXPLANATORY NOTES

As mentioned in the **GENERAL GUIDELINES** of previous Sections, the developed herewith **METHOD GUIDE** on the CP has been aimed at the *MASTER'S DEGREE students*; hence, the **METHOD GUIDE** should inevitably contain a certain scientific research portion. This is the **EDUCATIONAL AND PROFESSIONAL PROGRAM** requirements; therefore, it is essentially to the herein **METHOD GUIDE**, being constructed based upon and after the nomenclature of the **BACHELOR'S DEGREE** self-study recommendations although.

Thus, let us first dwell a bit on the nomenclature, recollecting the theoretical ideas and applied approaches already studied, therefore supposed to be known.

The nomenclature of the presented Section is being given after and following the reference [1, Section 3-8, Sub-Sections 3.1-3.5, 4.1, 4.2, pp. 6-34, (1, 2), Tables 1-10, Figures 1-5] and includes such elements.

CONCISE TECHNICAL DESCRIPTION OF THE SYSTEM

In the CP EN, one has to provide a short description of the given system, its functions, the principle scheme of the system (the system's elements should be denoted in accordance with the requirements of the **UNIFIED SYSTEM OF DESIGN DOCUMENTATION (USDD)**, SSU), [1].

Then, the student presents the data, available in **CIVIL AVIATION (CA)** organizations and at AARD, on the main failures and faults of the elements ensuring the given function of the system, [1].

Based on the analysis of the system's structural design peculiarities and properties, its elements designations, and the elements' influence upon the system's up state, it is recommended to distinguish the elements with the most functional significance. Such elements of A/C system as fuel pressure and consumption sensors, refueling openings, fuel between-tanks connections may be not considered, [1].

ASSESSMENT OF FUNCTIONAL RELIABILITY OF AIRCRAFT SYSTEMS

The purpose (objective) of the A/C systems functional reliability assessment conduction is to determine the correspondence of the systems' reliability with the airworthiness norms, [1].

The measure (index) of the functional reliability is the probability of a flight special situation in the specified functional failure occurrence. The mentioned probabilities are regulated in reference [8].

A comparison of the computed functional failures probabilities, causing the flight special situations, with those ones normalized at [8] makes it possible to evaluate the perfection of the structural design and, if needed, to implement the elements', system's as a whole design improvements or to change the modes of M/T, [1].

The process of the functional failure, leading to A/C flight situation R_i , appearing probability calculation is preceded with the analysis of the studied system functioning. In order to conduct the analysis it is necessary to use the **NORMATIVE-TECHNICAL DOCUMENTATION** (NTD), which schedules operation of the given A/C type, technical descriptions, instructions on technical operation, **FLIGHT OPERATION GUIDANCE** (FOG), schedules and technological instructions on M/T of the given A/C type, [1].

ANALYSIS OF THE INTERRELATIONSHIPS OF THE SYSTEM'S UP STATE DISTURBANCES WITH THE AIRCRAFT FLIGHT SPECIAL SITUATIONS COMING OUT

There is a considerable number of main and auxiliary systems, ensuring a diversity of the modern A/C consumers functioning. For example, landing gears, flaps, windscreen wipers (window-cleaners), ramps of transport airplanes etc. can be the hydraulic systems consumers, [1].

The consumers up state is characterized with the corresponding parameters of X_i (for instance, the time of the landing gear extension or retraction, angle of the direction rudder deviation) and depends upon the values of the output parameters Y_j of the system itself (the pressure in the hydro-system, total backlash (integrated clearance, looseness) in the A/C control system). In their turn, the system's parameters depend upon the system's elements technical conditions, that is, upon the failures and faults arising in the elements, [1].

The task of the analysis is to establish functional relationships between the state of the system elements and the parameters of

consumers, as well as possible Ri situations, the A/C incurs in case of these elements and systems disruption, [1].

In accordance with [8], special flight situations are classified as follows:

– complication of flight conditions R1 – a situation characterized by the need for the increased crew members attention to the source of its origin (the complication of flight conditions is not associated with the immediate change of flight plan and does not require any emergency operations of the crew for its successful completion);

– dangerous/hazardous (difficult, complex) situation R2 – a situation in which prevention of its transition to an emergency, or catastrophic, can be ensured by timely and correct actions of crew members, including changing the plan, profile or flight mode;

– emergency situation R3 – a situation characterized by either the A/C need for emergency landing or, preventing the transition to a catastrophic one, by the increased physical and psycho-physiological loads on the crew;

– crash (catastrophic) situation R4 – a situation in which the prevention of death of people and (or) loss of A/C is almost impossible, [1].

Beginning with the analysis, it is necessary to study the given system, the design of its elements and the requirements put forward to the structural and functional parameters of consumers of this system of A/C, [1].

The impact of the loss of capacity of consumers on the occurrence of special flight situations should be determined from the relevant sections of the FOG of this type of A/C: "Operation of airplane systems", "Failures and malfunctions of systems and equipment in flight", "Actions in case of special cases in flight". Parameters of consumers X_i and their normative values are given in the technical descriptions and instructions for the maintenance of the A/C. The approximate links between the parameters of the consumer X_i and the special flight situations are given in the supplement of Ap 3, [1].

The parameters of the state of the system Y_{ij} and their interconnections with the parameters characterizing the state of the consumer X_i are determined similarly. Using the data, [1], it is necessary to determine the type of the flight situation in which the A/C can enter with the deviation of the parameters of the system Y_{ij} from the normative values specified in the technical descriptions and technical

operation guidelines of the A/C. For example, reduction of the pressure of the working liquid (P_{AOH}) in the hydraulic system, which ensures the retraction (extension) of the landing gear (chassis), leads to an increase in the time of the retraction (extension) of the chassis, and when the pressure drops to a certain critical value, there can be a non-retraction (extension) of the chassis, [1].

ANALYSIS OF THE SYSTEM ELEMENTS FAILURES AND MALFUNCTIONS INFLUENCE UPON THE FLIGHT SITUATIONS RI APPEARING

Based on the analysis of the design of the elements of the system under study, it is recommended to select those units and aggregates, the technical state of which may affect the parameters of the system. For each of the possible types of states of elements it is necessary to assign an index Z_{kj} , in which: k – the ordinal number of the element in the system; j – the ordinal number of the element emerging malfunction. As a result of the analysis, the relationship between the state of the elements and the degree of deviation of the system parameters from the NTD requirements should be determined and the probabilities of the possible types of the system elements failures occurrence at the given failure rates $\lambda_i(t)$ are calculated, [1].

For example, the initial parameters of the hydraulic system (pressure and flow-rate of the working liquid) depend upon the up state of the pressure sources (pumps, pumping stations, hydraulic accumulators), command-regulating (governing) units (electromagnetic valves, safety valves, etc.), upon the tightness (pressurization) of the system, [1].

During the analysis, one should take into account the reservation, which is applied to both separate units and subsystems, [1].

Taking into consideration the given fact that in the process of inter-repair resource (at the stage of normal operation), the failures of A/C elements are random, and the time of their occurrence, as a rule, obeys the exponential distribution law, the probability of failure can be calculated by the formula, [1]:

$$Q(t) = 1 - e^{-\lambda t}, \quad (1)$$

where λ – failure rate of the specified sort, given in accordance with the CP variant completed (Ap 2); t – mean value of the A/C typical flight duration (it is recommended to accept $t = 1$ hour in the CP), [1]

Since A/C elements are highly reliable units, in order to calculate the probabilities $Q(t)$ of the elements failure at the given CP, one may use a simplified formula instead of (1), [1]:

$$Q(t) = \lambda t . \quad (2)$$

The obtained results are used to forming the computation scheme of the model for an estimation of the probability of the system functional failure causing the special flight situation (R_i), [1].

For a **MASTER'S DEGREE** program of the CP performance it is suggested to try implementing some more accurate probabilistic approaches, concepts, doctrines, schemes, and ideas which are going be described and discussed in the **SCIENTIFIC RESEARCH ELEMENTS** Sub-Section; since the **MASTER'S DEGREE** CP is supposed to be a step forward exactly in the field of the top management, scientific research part, and teaching skills development of the students.

COMPOSING THE PROBABILITIES COMPUTATION MODELS OF THE FUNCTIONAL FAILURES CAUSING THE SPECIAL FLIGHT SITUATIONS

In order to calculate the probabilities of the occurrences of the functional failures leading to special flight situations (Q_{R_i}), it is necessary to apply one of the methods for assessing the reliability of complex systems – the method of minimum cross-sections. For each specific situation, the minimum cross-sections are needed to be determined. Under the minimal section, there is a minimal set (list) of elements of the system deemed, the failure of which can lead to a functional failure of the system. The determination of the minimal cross-sections for the system is greatly simplified when using the "trees" of events, [1].

Then, using [1], one distinguishes the failures of the elements and subsystems, capable of causing that given functional failure (the special situation of R_i). The failures of elements and subsystems and the special situation, depending on the logical interconnections, are interconnected with the help of the schemes of conjunction and disjunction (coincidence and association). If the output signal appears only when all input signals arise (arrive), then the logical operator (circuit) "AND" (conjunction, coincidence scheme) is applied. If the output signal appears when the input of any one of the input signals happens (it can be more than just some one signal comes into the input), then the "OR" scheme (disjunction scheme) is implemented, [1].

For r minimum cross sections with the number of elements in each section from 1 to n , the probability of occurrence of the flight situation R_i is based on the generalized formula, [1]:

$$Q_{R_i}(t) = \sum_{j=1}^r \prod_{k=1}^n Q_{ikj}(t), \quad (3)$$

where r – number of minimum cross sections; Π – product of n members; n – the number of elements entering the minimum section; $Q_{ikj}(t)$ – probability of failure of k -th element of j -th section, [1].

Formulae (2, 3) are recommended for the use in the CP, *as an approximation for engineering computations at the specialist's educational BACHELOR'S DEGREE level*, to calculate the probabilities of the functional failures that lead to special flight situations.

For a **MASTER'S DEGREE** level it is recommended to *conduct precise calculations* (the related methodology is going to be discussed below), *compare* their results with the approximate gained by the formula of (6) if there have been made any, and *draw a conclusion about the accepted approximation applicability*.

The estimated computed values of the probabilities of the A/C entering the special situation of R_i , because of the fault of the system under consideration, are compared with the normative values of the probabilities of functional failures, which lead to the special situations of flight; and conclusions about the perfection of the design and M/T systems are drawn. If the actual value of $Q_{R_i}(t)$ exceeds the normalized, then such a system needs to improve the M/T system or a structural improvement, [1].

EXAMPLE OF THE TU-154 AIRCRAFT FUEL SYSTEM FUNCTIONAL RELIABILITY ESTIMATION

The **EXAMPLE**, as well as the nomenclature part (see the above Sub-Sections), is being given after and following the reference [1, Section 4, Sub-Sections 4.1, 4.2, pp. 18-27, Tables 6-9, Figures 3, 4].

Input data: A/C – Tu-154; system – fuel; function of the system – fuel supply from the fuel tank to the engines [1, Section 4, p. 18]. The **EXAMPLE** includes: *DESCRIPTION OF THE TU-154 FUEL SYSTEM OPERATION* [1, Sub-Section 4.1, pp. 18-20, Table 6, Figure 3] and *ANALYSIS OF THE RELATIONSHIPS OF THE SYSTEM UP STATES DISTURBANCES WITH THE ARISES OF SPECIAL FLIGHT SITUATIONS* [1, Sub-Section 4.2, pp. 21-27, Tables 7-9, Figure 4].

The scheme can be included into both the CP EN and GP.

In addition, the proposed modifications to the given functional system of the A/C with the purpose of the M/T process improvement may be indicated in some view.

Moreover, for the precise probabilistic calculations, the student will need the corresponding scheme, the elementary components of which will be described and discussed below in the later Section dedicated to the **SCIENTIFIC RESEARCH** issues.

The mathematical methods relating to that are going to be considered down there too.

When analyzing possible states of the consumers at the selected parameters deviation (deflection) and using the Tu-154 A/C FOG, it can be determined that the emergency situation in flight (R3) occurs in the event of a joint failure of the two engines or the occurrence of a fire, [1].

The difficult situation in flight (R2) will occur if one of the engines fails. Complication of flight conditions (R1) can occur when reducing the thrust of one engine, [1].

DEVELOPMENT OF THE ALGORITHM OF THE FAULTY ELEMENT SEARCH IN THE SYSTEM

The **ALGORITHM**, as well as the **EXAMPLE** and nomenclature part (see above Sub-Sections), is being given after and following the reference [1, Section 5, pp. 17-29, Figure 5].

Using the data about the system and its terminal (final) element, included in the task, it is necessary to compile the optimal plan (algorithm) for finding the defective element in the given system (subsystem) of the A/C, [1].

STRUCTURAL IMPROVEMENT OF THE SYSTEM

The methodical recommendations of this Sub-Section, as well as the previous **ALGORITHM**, **EXAMPLE**, and nomenclature part (see corresponding Sub-Sections), are being given after and following the reference [1, Section 6, pp. 30, 31].

Constructive improvements of the system and its elements need to be developed based on the results of the analysis of the reliability, operational effectiveness, controllability, the impact of failures on the level of safety of flights. In this case, it is necessary to increase the reliability of structural elements, improve controllability, so that it would be possible to transfer these elements into progressive M/T strategies and methods, [1].

In the calculation part of this sub-section of the CP one can provide data on the evaluation of the effectiveness of the technical operation process using M/T advanced strategies and techniques, [1].

CHOICE OF THE SYSTEM AGGREGATES MAINTENANCE STRATEGY

The **STRATEGY CHOICE OF THE SYSTEM AGGREGATES MAINTENANCE** considered in this Sub-Section, as well as the previous **STRUCTURAL IMPROVEMENT OF THE SYSTEM, ALGORITHM, EXAMPLE**, and nomenclature part (see above Sub-Sections), is being given after and following the reference [1, Section 7, pp. 31-34, Table 10].

Using the results of the analysis of the given system from the previous sections of the project, it is necessary to substantiate (justify) and make a choice of the M/T strategies for the main aggregates of the system, [1].

In the M/T system of modern A/C there are used the following strategies of M/T of aggregates: M/T according to working hours (M/T-WH) and M/T according to the state (M/T-S). There are two M/T strategies distinguished (discerned) in M/T-S: with the control of parameters (M/T-SCP) and with the control of the level of reliability (M/T-SCLR), [1].

M/T-WH is recommended for implementation to the following components, accessories, [1]:

- the failures of which directly affects the safety and regularity of flights;
- which do not have a sufficient redundancy degree (reserve level);
- which do not have the required level of controllability (control of fitness), availability, and interchangeability;
- the reliability (failure-free operation) of which worsens (is getting worse) (fault of which deteriorates) depending upon the WH;
- for which there are no methods and means of technical diagnostics, and their development is complex, or requires a large amount of (high) expenses, [1].

M/T-SCP (M/T as a condition for monitoring parameters) is recommended for application to the aggregates, [1]:

- having sufficient redundancy (degree of reservation) in the system;
- possessing a sufficient level of controllability (control of usability);

- working up to failure of which has a large dispersion (spread);
- an assessment of the technical condition of which can be made by separate parameters (without a complication of the system);
- for which there are (or can be created) methods and means of technical diagnostics;
- for which it is economically feasible (expedient, rational) to use the M/T-S (service method in the state), [1].

M/T-SCLR (M/T as a state of control of the level of reliability) should be used for aggregates, [1]:

- the failure of which does not directly affect the safety of flights;
- which have a sufficient degree of redundancy (reservation) in the system;
- the reliability (failure-free operation) (failure) of which does not depend upon the WH;
- the failures of which do not remain unnoticed by the crew, or can be detected with the M/T;
- the level of the operational technological effectiveness of which is high, [1].

In practice of the modern A/C operation there is the use of all the listed M/T strategies. Based on the integrated (complex) application of these strategies, A/C M/T programs are developed to increase the cost-effectiveness and safety of the A/C operation, [1].

In order to choose the right (proper, good, correct, appropriate, suitable) strategy, it is necessary to study in detail the essence, features, properties, peculiarities, and specifics of an applicability, implementation of each of them, analyze the potential adaptability of the aggregates to the use of progressive M/T strategies, give proposals (suggestions) on improving the controllability of the system (control of system usability). The algorithm for choosing the M/T strategies of the aggregates is given in [1]. As an example, the distribution of the elements of the system according with the strategies of the M/T is given there. In such case it is necessary to include the main units (items, products) (eight to ten units/items) of the studied system. For an application of the progressive M/T strategies it is necessary to propose appropriate (proper, good, right, correct, appropriate, suitable) structural changes of the units (items, products) and diagnostic parameters (setting of sensors, devices, and so on and so forth), [1].

If on the basis of scientific research, design and operation practices, or for other reasons, it is not possible to apply a progressive strategy to a unit (item, product), then it is worthwhile to keep on the M/T of this unit (item, product) at WH (resource). The choice of a specific M/T strategy for each unit (item, product) should (ought to) be substantiated (justified, proved) in the text of the EN, [1].

It is possible to improve the controllability, for instance, in the example given in [1] this is done, due to the installation of dirtiness (pollution, absence of cleanliness) sensors of the filter elements, signaling their technical state. The lighting up of the signal lamp is adjusted to the reset pre-failure value of the pressure drop, that is, which allows the flight to be completed earlier than the bypass valve to be opened. In addition, the filter in this system has a reservation. The controllability of the return valve is insufficient and it is economically inexpedient to improve its design with a complication. In addition, there is no redundancy of this valve and a creation of the methods and means of diagnostics for such a simple unit is difficult (complicated), therefore, it is recommended that this piece of equipment be serviced on WH (an on-going) basis, [1].

CONTENT OF THE AIRCRAFT CREW PRELIMINARY AND PRE-FLIGHT PREPARATIONS AND THE CREW ACTIONS IN THE SPECIAL FLIGHT SITUATIONS

The content covered in this Sub-Section, as well as the previous **STRATEGY CHOICE, STRUCTURAL IMPROVEMENT, ALGORITHM, EXAMPLE**, and nomenclature part (see above Sub-Sections), is being given after and following the reference [1, Section 8, p. 34].

Before each flight, regardless of its duration, the crew of the A/C must perform preliminary and pre-flight preparations for the flight, [1].

Preliminary and pre-flight preparations are carried out in accordance with the requirements of the documents regulating the flight work [7, 9, 10].

In case of certain special situations occurrence in flight, the crew of the A/C is obliged to act in accordance with the requirements [5, 7].

The study of the issues of the A/C preparations for a flight, as well as the crew's actions in case of special situations in flight, will allow the student to get acquainted with the flight operation process in detail, [1].

In the CP, the student must specify the sequence of the performance of the preliminary and pre-flight preparations of each member of the A/C crew, as well as the specific procedure of the crew actions in case

of occurrence in flight of one of the special conditions and one of the special cases that are considered in that student's CP, [1].

SCIENTIFIC RESEARCH ELEMENTS

As that has been mentioned and emphasized above in the **GENERAL GUIDELINES** Section, as well as in the Sub-Sections of the **METHODICAL INSTRUCTIONS TO THE PROJECT SECTIONS**, especially in the Sub-Sections titled as **ANALYSIS OF THE SYSTEM ELEMENTS FAILURES AND MALFUNCTIONS INFLUENCE UPON THE FLIGHT SITUATIONS RI APPEARING** and **COMPOSING THE PROBABILITIES COMPUTATION MODELS OF THE FUNCTIONAL FAILURES CAUSING THE SPECIAL FLIGHT SITUATIONS** correspondingly, some certain **SCIENTIFIC RESEARCH ELEMENTS** part is an essential (absolutely necessary, vital, indispensable, important, crucial, critical, fundamental) portion of the **MASTER'S DEGREE** candidate CP.

The presented Sub-Section contains several following suggestions to the students; but it is not limited just only to those next items that are being mentioned below.

AIRCRAFT GIVEN FUNCTIONAL SYSTEM MAINTENANCE PROCESS IMPROVEMENTS CRITERIA (INDICES, MEASURES) CHOICES

In order to prove the justifiability (strength, sustainability) of the developed in the CP the A/C given functional system M/T process improvements a student is and has to (should) give some good reasons in favor of either for the student's arguments substantiating the advantages of the proposed things.

Therefore, it is unavoidable to introduce certain both qualitative and quantitative values, regularly (generally) accepted as the measures (criteria or indices/indexes), helping construct, describe, and develop mathematical research models [1-3, 8, 12, 13, 16, 20, 21, 23-27, 36-38]. The choice of these criteria or measures does not have to be solely based upon the having been well known or standard values or approaches [1-3, 8, 36]. The students' creativity work must be manifested here. Heuristic, challenging task and problem settings are welcome to be developed.

Moreover, the continuation of such developments in future might result in Ph.D. studies, dissertations, theses works. The first stages of those concepts, theories, hypotheses, or just initial ideas are the investigations, perhaps, possibly originating in the current CP developments.

A good selection (proposition, development) of the appropriate measures ensures a fruitfulness of the whole CP study part.

The comprehensive references are obligatory throughout the whole CP work, especially at the **SCIENTIFIC RESEARCH ELEMENTS** Sections in order to distinguish the students' achievements in the conducted research.

However, generally known ideas, things, provisions etc. usually do not require any references due to the common use of such pieces of knowledge or information.

For example, as a result of the **IMPROVEMENT OF THE AIRCRAFT GIVEN FUNCTIONAL SYSTEM MAINTENANCE PROCESS** some reliability, dependability probabilistic characteristics might be increased, so the corresponding measures might be chosen to demonstrate, prove, substantiate the advantages of the proposed modifications. These are, let us say, for instance, might be the basic probabilistic values (measures) of Reliability, Failure-Free Operation, Durability, Longevity, Maintainability, Storability or any of these measures combinations [1-3, 8, 13, 16, 20, 21, 23-27, 36].

MAINTENANCE PROCESS IMPROVEMENTS MEASURES DESCRIPTIONS

The measures (criteria) having been chosen (selected, proposed, developed) in compliance (agreement, accordance) with the CP study purposes (reasons) in the previous Sub-Section, in their turn, have to be properly described. This is the first stage for the proposed measures, relating with the scientific core of the CP, correct (acceptable) substantiation.

Here we have (ought) to (should, must) underline, emphasize, put a stress once again upon the fact, that a correct referring is absolutely necessary (obligatory, mandatory) thing to be performed in conjunction with the perfect description of the proposed measures. For the scientific research work is always so scrupulous (meticulous, conscientious, thorough, careful, rigorous, painstaking, fastidious, particularly accurate with the, attentive) to/with other authors (scientists) results (achievements). The reference must be as detailed as possible, pointing in square brackets [the *Reference Number* according with list presented in the corresponding section of the CP submitted to the **EXAMINATION BOARD** to be defended, *Volume* (preferably if there are any in the referred publication or piece of work), the reference *Section, Sub-Section*, rubricating *Part, Sub-Part, Chapter, Sub-Chapter, §* or *§§*, and

so on, *p.* or *pp.* ranges, (*Formulas Numbers*), as well as *Figures* and *Tables* etc.].

If in the text part of the CP, which is usually the EN, there are no references, this means (implies) that the author of the CP expresses the author's own ideas; develops her/his own theories, hypotheses etc.; derives her/his own mathematical formulas, equations, expressions and so on; creates models, proofs; introduces axioms, postulates; states definitions, verbal formulations; develops methods, approaches, and ways; proves her/his own theorems; formulates problems; discovers, reveals, makes known, discloses, divulges, exposes, makes public, tells something new herself of himself; and so on and so forth.

In case, when no mentioned above deeds or achievements are of the CP author's, nevertheless the references to the origins or information sources are absent (omitted deliberately or not), then, it is plagiarism.

Plagiarism is an awful violation (breach, infringement, abuse, desecration, destruction, copying, stealing) of other individuals' author rights and it is banned lifetime, accompanied with the cancellation of all awarded in preceding scientific degrees, ranks, and sometimes even positions. From time to time, we may see the reports in the press and hear information spread and widened by mass media about such kind of crimes and the power officials accused and sentenced to be guilty of the crimes leaving their cabinets.

So, the references as much detailed as possible are helpful for the researcher be easy oriented in the wealth of information on the studied subjects, and, at the same time, on the other hand, such style references are protective (advocates), likewise immunities obtained in results of the injections (inoculations, vaccinations) against viruses, infections or diseases.

Following the developed example the descriptions might be e.g. for the Reliability, Failure-Free Operation measures, i.e. probabilistic values of the Reliability Functions, Survival Functions, or on the contrary for Failure measures, that is probabilities of Faults and Failures, Failure Rates, Failure Intensities, or their complex combined measures such as (Instantaneous) Availability Functions, Operational Availability Functions etc., [1-3, 8, 13, 16, 20, 21, 23-27, 36].

MAINTENANCE PROCESS IMPROVEMENTS MEASURES EXPLANATIONS

The measures (criteria) having been chosen and described in the previous Sub-Sections, in their turn, have to be properly explained. That part of the CP work is close to, follows the descriptions, and precedes scientific substantiations.

In **EXPLANATIONS** Sections it is generally given the deeper analyses and more detailed interrelationships of the models previously described above in order to give a representation of the research gap at which the attention is concentrated. Having centered the explained study objectives a student may go on with **SUBSTANTIATIONS** Sections.

In the framework of the considered examples, it might be a traditional **PROBABILITY THEORY** [36-38] and **RELIABILITY THEORY** [1-3, 8, 13, 16, 36] interpretations in accordance to the elementary schemes shown in multiple books.

For the sequential connections of elements of a system (sub-system), the reliability function of their system (sub-system) (survival function, probability of that during the predetermined operating time the failure of the system (sub-system) will not happen) is expressed with [36, Part II, Chapter 10, § 1, p. 137, (2)]:

$$R(t) = \prod_{i=1}^n R_i(t), \quad (4)$$

where $R_i(t)$ – reliability function of the i^{th} element.

In case of parallel connections of the systems' (sub-systems') elements, the failure function (probability of that during the predetermined operating time the failure of the system (sub-system) will happen) is expressed with [36, Part II, Chapter 10, § 1, p. 137, (8)]:

$$Q(t) = \prod_{i=1}^n Q_i(t), \quad (5)$$

where $Q_i(t)$ – failure function of the i^{th} element.

The reliability or failure function of the entire system consisting of the systems and sub-systems explained above is being found based on Eq. (4) and (5), as well as the theorems for the complete group of non-conjoint, independent events [38].

It is useful to compare the precise results with the approximate ones obtained through the considered above methods and come to a

conclusion about the approximate methods applicability and accessibility in the specified problem setting.

*MAINTENANCE PROCESS IMPROVEMENTS MEASURES
SUBSTANTIATIONS*

The measures (criteria) having been chosen, described, and explained in the previous Sub-Sections, in their turn, have to be properly (scientifically) substantiated. The first four Sub-Sections, ## 11.1-11.4, of the given **SCIENTIFIC RESEARCH ELEMENTS** Section # 9, dedicated to the selection, description, explanation, and substantiation of the search criteria form the basement (foundation) for the further research.

Those parts might be united into one specified Section of the CP work, EN. It might be as well one more **INTRODUCTION** Section of the CP EN organized exclusively for the purposes of the **SCIENTIFIC RESEARCH ELEMENTS** Section # 11 to make the students' that type work be in more relief against the rest material.

SUBSTANTIATIONS Sections regularly have to include (encompass, cover) the logical proofs, deliver contemplations, speculations, mathematical derivations. As well as everywhere described above, the individual developments are very precious and prized in here.

In the discussed example, it can be different methods of the reliability and failure functions derivations.

For instance, it can be with the use of the binomial distribution formula.

In another case, it may be for different laws of distributions.

Elements of the Markovian processes and mass service theory [37] are also can be applied to the reliability problems solving.

For example, considering a Markovian random process with discrete states and continuous time, for a general case with three states we have a graph shown in Fig. 1 [37].

Here, in Fig. 1 "0" designates the up state of the system; "1" – damage; "2" – failure. The corresponding values of the failure rates λ_{ij} and restoration rates μ_{ji} will determine the process going on in the system. For the substantiated reasons, for the state of "2" to be a state without an "exit", it has to be satisfied the conditions of $\mu_{20} = \mu_{21} = 0$. Then, it, the state of "2", will be a real failure.

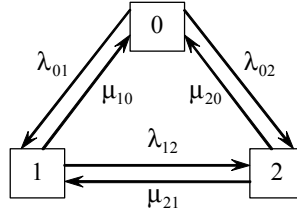


Fig. 1. Graph of three states of an aircraft functional system

The corresponding, to the graph of Fig. 1, system of ordinary linear differential equations of the first order by Erlang will have the view of [37]:

$$\left. \begin{aligned} \frac{dP_0}{dt} &= -(\lambda_{01} + \lambda_{02})P_0 + \mu_{10}P_1 + \mu_{20}P_2; \\ \frac{dP_1}{dt} &= \lambda_{01}P_0 - (\lambda_{12} + \mu_{10})P_1 + \mu_{21}P_2; \\ \frac{dP_2}{dt} &= \lambda_{02}P_0 + \lambda_{12}P_1 - (\mu_{20} + \mu_{21})P_2. \end{aligned} \right\} \quad (6)$$

Here, in the system of equations (6), P_0 , P_1 , and P_2 – probabilities of the corresponding states (see Fig. 1); t – time. In accordance with [38, Chapter XIII, § 30, pp. 108-113], the characteristic equation for system (6) will be similarly (likewise) [38, Chapter XIII, § 30, p. 109, (5)]:

$$\begin{vmatrix} -(\lambda_{01} + \lambda_{02}) - k & \mu_{10} & \mu_{20} \\ \lambda_{01} & -(\lambda_{12} + \mu_{10}) - k & \mu_{21} \\ \lambda_{02} & \lambda_{12} & -(\mu_{20} + \mu_{21}) - k \end{vmatrix} = 0. \quad (7)$$

Determinant (7) yields

$$\begin{aligned} & [-(\lambda_{01} + \lambda_{02}) - k][-(\lambda_{12} + \mu_{10}) - k][-(\mu_{20} + \mu_{21}) - k] + \lambda_{01}\lambda_{12}\mu_{20} + \\ & + \lambda_{02}\mu_{10}\mu_{21} - \{\lambda_{02}[-(\lambda_{12} + \mu_{10}) - k]\mu_{20}\} - \{\lambda_{01}\mu_{10}[-(\mu_{20} + \mu_{21}) - k]\} - \\ & - \{[-(\lambda_{01} + \lambda_{02}) - k]\lambda_{12}\mu_{21}\} = 0. \end{aligned} \quad (8)$$

From (8) it can be found the roots of $k_{1,2,3}$. For each root k_i of Eq. (7), (8), namely k_1 , k_2 , k_3 we will write down the system of linear uniform (homogenous) algebraic equations with respect to their

coefficients $\alpha_1^{(i)}$, $\alpha_2^{(i)}$, $\alpha_3^{(i)}$, [38, Chapter XIII, § 30, p. 108, (3)]. The system derives from an assumption of a partial solution existence in the view of [38, Chapter XIII, § 30, p. 108, (2)] for the system of Eq. (6). Since having three roots in the stated problem setting, we obtain, [38, Chapter XIII, § 30, p. 109], the solution of the system of Eq. (6).

The other method of the system of Eq. (6) solution is represented with the *Laplace transformations* in the *operational calculus* [38, Chapter XIX, pp. 400-432].

The system of Eq. (6) is transformed with [38, Chapter XIX, § 1, p. 401, (4)]:

$$F(p) = \int_0^{+\infty} e^{-pt} f(t) dt, \quad (9)$$

where p – complex parameter (variable) of the Laplace transformation.

The function $F(p)$ is called the *Laplace transformant (image)* of the function $f(t)$, which is called the *initial function*, or *original*. The indication is [38, Chapter XIX, § 1, pp. 401, 402, (7)]:

$$L\{f(t)\} = F(p). \quad (10)$$

In accordance with the theorem for transformants of derivatives [38, Chapter XIX, § 8, P. 409, (27)], the system of Eq. (6), taking into account the initial conditions of the problem, that is for the probabilities of the system's possible states: $P_0|_{t=t_0} = 1$, $P_1|_{t=t_0} = P_2|_{t=t_0} = 0$, $t_0 = 0$, will have the corresponding algebraic system

$$\left. \begin{aligned} & \left(pF_0(p) - [P_0|_{t_0=0} = 1] = L\left\{ \frac{dP_0}{dt} \right\} \right) = -(\lambda_{01} + \lambda_{02})[F_0(p) = L\{P_0\}] + \\ & + \mu_{10}[F_1(p) = L\{P_1\}] + \mu_{20}[F_2(p) = L\{P_2\}]; \\ & \left(pF_1(p) - [P_1|_{t_0=0} = 0] = L\left\{ \frac{dP_1}{dt} \right\} \right) = \lambda_{01}[F_0(p) = L\{P_0\}] - \\ & - (\lambda_{12} + \mu_{10})[F_1(p) = L\{P_1\}] + \mu_{21}[F_2(p) = L\{P_2\}]; \\ & \left(pF_2(p) - [P_2|_{t_0=0} = 0] = L\left\{ \frac{dP_2}{dt} \right\} \right) = \lambda_{02}[F_0(p) = L\{P_0\}] + \\ & + \lambda_{12}[F_1(p) = L\{P_1\}] - (\mu_{20} + \mu_{21})[F_2(p) = L\{P_2\}]. \end{aligned} \right\} \quad (11)$$

$$\left. \begin{aligned} pF_0(p)-1 &= -(\lambda_{01} + \lambda_{02})F_0(p) + \mu_{10}F_1(p) + \mu_{20}F_2(p); \\ pF_1(p)-0 &= \lambda_{01}F_0(p) - (\lambda_{12} + \mu_{10})F_1(p) + \mu_{21}F_2(p); \\ pF_2(p)-0 &= \lambda_{02}F_0(p) + \lambda_{12}F_1(p) - (\mu_{20} + \mu_{21})F_2(p). \end{aligned} \right\} \quad (12)$$

The obtained algebraic equations system, Eq. (12), solving is possible in different ways. One of them is a matrix-vector.

Let us rewrite the system of Eq. (12) in the following style

$$\left. \begin{aligned} [p + (\lambda_{01} + \lambda_{02})]F_0 & - \mu_{10}F_1 & - \mu_{20}F_2 & = 1; \\ -\lambda_{01}F_0 & + [p + (\lambda_{12} + \mu_{10})]F_1 & - \mu_{21}F_2 & = 0; \\ -\lambda_{02}F_0 & - \lambda_{12}F_1 & + [p + (\mu_{20} + \mu_{21})]F_2 & = 0. \end{aligned} \right\} \quad (13)$$

The matrix for the transformation of the system of Eq. (13) will be [38, Chapter XXI, § 1, p. 510, (5)]:

$$\mathbf{M} = \begin{vmatrix} p + (\lambda_{01} + \lambda_{02}) & -\mu_{10} & -\mu_{20} \\ -\lambda_{01} & p + (\lambda_{12} + \mu_{10}) & -\mu_{21} \\ -\lambda_{02} & -\lambda_{12} & p + (\mu_{20} + \mu_{21}) \end{vmatrix}. \quad (14)$$

The needed (unknown/wanted/sought) vector-column of transformants is

$$\mathbf{F} = \begin{vmatrix} F_0 \\ F_1 \\ F_2 \end{vmatrix}. \quad (15)$$

Then the transformation of the system of Eq. (13) is [38, Chapter XXI, § 8, p. 522, (5)]:

$$\begin{vmatrix} p + (\lambda_{01} + \lambda_{02}) & -\mu_{10} & -\mu_{20} \\ -\lambda_{01} & p + (\lambda_{12} + \mu_{10}) & -\mu_{21} \\ -\lambda_{02} & -\lambda_{12} & p + (\mu_{20} + \mu_{21}) \end{vmatrix} \cdot \begin{vmatrix} F_0 \\ F_1 \\ F_2 \end{vmatrix} = \begin{vmatrix} 1 \\ 0 \\ 0 \end{vmatrix}. \quad (16)$$

Or, to make it shorter it is [38, Chapter XXI, § 8, p. 523, (6)]:

$$\mathbf{M} \cdot \mathbf{F} = \mathbf{B}, \quad (17)$$

where \mathbf{B} – vector-column of free members of the system of Eq. (13):

$$\mathbf{B} = \begin{vmatrix} 1 \\ 0 \\ 0 \end{vmatrix}. \quad (18)$$

The required solution of Eq. (15) will be [38, Chapter XXI, § 9, p. 523, (2)] found with the use of the inverse matrix \mathbf{M}^{-1} :

$$\mathbf{F} = \mathbf{M}^{-1} \cdot \mathbf{B}. \quad (19)$$

The last equation (19) with taking into account [38, Chapter XXI, § 7, p. 521, (5)]:

$$\mathbf{M}^{-1} = \frac{1}{\Delta(\mathbf{M})} \cdot \tilde{\mathbf{M}}, \quad (20)$$

where, $\Delta(\mathbf{M})$ – determinant of matrix \mathbf{M} , Eq. (14), [38, Chapter XXI, § 7, p. 520, (2)], compare the determinants of the matrix \mathbf{M} , Eq. (14) with the one of the Eq. (7); $\tilde{\mathbf{M}}$ – adjacent matrix to matrix \mathbf{M} , [38, Chapter XXI, § 7, p. 521, (4)]; can be written as [38, Chapter XXI, § 9, p. 523, (3)]:

$$\mathbf{F} = \frac{1}{\Delta(\mathbf{M})} \cdot \tilde{\mathbf{M}} \cdot \mathbf{B}, \quad (21)$$

or, in the developed view [38, Chapter XXI, § 9, p. 523, (4)]:

$$\begin{pmatrix} F_0 \\ F_1 \\ F_2 \end{pmatrix} = \frac{1}{\Delta(\mathbf{M})} \cdot \begin{pmatrix} M_{11} & M_{21} & M_{31} \\ M_{12} & M_{22} & M_{32} \\ M_{13} & M_{23} & M_{33} \end{pmatrix} \cdot \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad (22)$$

where M_{ij} – algebraic addition of the element of m_{ij} , [38, Chapter XXI, § 2, p. 512], of the initial matrix Eq. (14).

Fulfilling multiplying the matrixes in the right hand part of Eq. (22) we will obtain [38, Chapter XXI, § 9, p. 523, (5)]:

$$\begin{pmatrix} F_0 \\ F_1 \\ F_2 \end{pmatrix} = \frac{1}{\Delta(\mathbf{M})} \cdot \begin{pmatrix} M_{11} \cdot 1 + M_{21} \cdot 0 + M_{31} \cdot 0 \\ M_{12} \cdot 1 + M_{22} \cdot 0 + M_{32} \cdot 0 \\ M_{13} \cdot 1 + M_{23} \cdot 0 + M_{33} \cdot 0 \end{pmatrix} = \frac{1}{\Delta(\mathbf{M})} \cdot \begin{pmatrix} M_{11} \\ M_{12} \\ M_{13} \end{pmatrix}. \quad (23)$$

In accordance with the initial matrix Eq. (14)

$$\begin{aligned} M_{11} &= (-1)^{1+1} \cdot \{[p + (\lambda_{12} + \mu_{10})][p + (\mu_{20} + \mu_{21})] - \lambda_{12}\mu_{21}\} = \\ &= p^2 + p(\mu_{20} + \mu_{21}) + (\lambda_{12} + \mu_{10})p + (\lambda_{12} + \mu_{10})(\mu_{20} + \mu_{21}) - \lambda_{12}\mu_{21} = \\ &= p^2 + p(\mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10}) + \lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}. \quad (24) \\ M_{12} &= (-1)^{1+2} \cdot \{-\lambda_{01}[p + (\mu_{20} + \mu_{21})] - \lambda_{02}\mu_{21}\} = \end{aligned}$$

$$= p\lambda_{01} + \lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}. \quad (25)$$

$$\begin{aligned} M_{13} &= (-1)^{1+3} \cdot \{\lambda_{01}\lambda_{12} + \lambda_{02}[p + (\lambda_{12} + \mu_{10})]\} = \\ &= p\lambda_{02} + \lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10}. \end{aligned} \quad (26)$$

$$\begin{aligned} \Delta = \Delta(\mathbf{M}) &= [p + (\lambda_{01} + \lambda_{02})][p + (\lambda_{12} + \mu_{10})][p + (\mu_{20} + \mu_{21})] + \\ &+ (-\lambda_{01})(-\lambda_{12})(-\mu_{20}) + (-\lambda_{02})(-\mu_{10})(-\mu_{21}) - \\ &- (-\lambda_{02})(-\mu_{20})[p + (\lambda_{12} + \mu_{10})] - (-\lambda_{12})(-\mu_{21})[p + (\lambda_{01} + \lambda_{02})] - \\ &- (-\lambda_{01})(-\mu_{10})[p + (\mu_{20} + \mu_{21})]. \end{aligned} \quad (27)$$

$$\begin{aligned} \Delta &= p\{p^2 + p(\mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10} + \lambda_{01} + \lambda_{02}) + \\ &+ [(\lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}) + (\lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}) + \\ &+ (\lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10})]\}. \end{aligned} \quad (28)$$

Compare the last determinants of the Eq. (27) and (28) with the determinants of the Eq. (8).

Now, applying the matrix-vector approach of Eq. (13)-(28), in accordance with Eq. (19)-(23), it yields for the transformant of F_0 the following expression:

$$\begin{aligned} F_0 &= \frac{M_{11}}{\Delta(\mathbf{M})} = \\ &= \frac{p^2 + p(\mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10}) + \lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}}{\left(\begin{aligned} &p\{p^2 + p(\mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10} + \lambda_{01} + \lambda_{02}) + \\ &+ [(\lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}) + (\lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}) + \\ &+ (\lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10})]\} \end{aligned} \right)}. \end{aligned} \quad (29)$$

Let us designate for members in Eq. (24)-(26) and Eq. (27)-(29)

$$a_1 = \mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10}, \quad b_1 = \lambda_{12}\mu_{20} + \mu_{10}\mu_{20} + \mu_{10}\mu_{21}. \quad (30)$$

$$c_1 = \lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}. \quad (31)$$

$$d_1 = \lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10}. \quad (32)$$

$$e_1 = \mu_{20} + \mu_{21} + \lambda_{12} + \mu_{10} + \lambda_{01} + \lambda_{02}. \quad (33)$$

Then Eq. (29) will get the view of

$$F_0 = \frac{M_{11}}{\Delta(\mathbf{M})} = \frac{p^2 + pa_1 + b_1}{p(p^2 + pe_1 + b_1 + c_1 + d_1)}. \quad (34)$$

The other two transformants of F_1 and F_2 will be, correspondingly with the expressions of Eq. (19)-(23) and Eq. (25)-(28) and notations of Eq. (30)-(33), written down as follows:

$$F_1 = \frac{M_{12}}{\Delta(\mathbf{M})} = \frac{p\lambda_{01} + \lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}}{p(p^2 + pe_1 + b_1 + c_1 + d_1)}. \quad (35)$$

$$F_2 = \frac{M_{13}}{\Delta(\mathbf{M})} = \frac{p\lambda_{02} + \lambda_{01}\lambda_{12} + \lambda_{02}\lambda_{12} + \lambda_{02}\mu_{10}}{p(p^2 + pe_1 + b_1 + c_1 + d_1)}. \quad (36)$$

Applying the same designations as of the expressions of (30)-(33) to the nominators of the fractions of Eq. (35) and (36) we obtain

$$F_1 = \frac{p\lambda_{01} + c_1}{p(p^2 + pe_1 + b_1 + c_1 + d_1)}. \quad (37)$$

$$F_2 = \frac{p\lambda_{02} + d_1}{p(p^2 + pe_1 + b_1 + c_1 + d_1)}. \quad (38)$$

Finally, the ratios for the transformants of the expressions of (34)-(38) represented in the view of the simplest fractions (elementary ratios) will be found with taking into account the k_1 , k_2 , and k_3 :

$$k_3 = 0, \quad (39)$$

$$k_1 = \frac{-e_1 + \sqrt{e_1^2 - 4f_1g_1}}{2f_1}, \quad k_2 = \frac{-e_1 - \sqrt{e_1^2 - 4f_1g_1}}{2f_1}, \quad (40)$$

where $f_1 = 1$ and $g_1 = b_1 + c_1 + d_1$ correspondingly with the denominators of Eq. (29)-(38), i.e. of the determinant Eq. (27) or Eq. (28); – corresponding roots, here; and with corresponding coefficients of the decomposition.

At last for the image (transformant)

$$F_0 = \frac{b_1}{k_1k_2} + \frac{1 - \frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1} - \frac{b_1}{k_1k_2}}{(p - k_1)} + \frac{k_2 + a_1 + \frac{b_1}{k_2}}{(p - k_2)}. \quad (41)$$

And for the probability (original) of Eq. (6)

$$P_0(t) = \frac{b_1}{k_1 k_2} + \left(1 - \frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1} - \frac{b_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{k_2 + a_1 + \frac{b_1}{k_2}}{k_2 - k_1} \right) e^{k_2 t}. \quad (42)$$

Or on the other hand

$$P_0(t) = \frac{k_1 e^{k_1 t} - k_2 e^{k_2 t}}{k_1 - k_2} + a_1 \frac{e^{k_1 t} - e^{k_2 t}}{k_1 - k_2} + \frac{b_1}{k_1 k_2} + \left(-\frac{b_1}{k_2(k_2 - k_1)} - \frac{b_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{b_1}{k_2(k_2 - k_1)} \right) e^{k_2 t}. \quad (43)$$

$$P_1(t) = P_1^{(1)}(t) + P_1^{(2)}(t) = \lambda_{01} \frac{e^{k_1 t} - e^{k_2 t}}{k_1 - k_2} + \frac{c_1}{k_1 k_2} + \left(-\frac{c_1}{k_2(k_2 - k_1)} - \frac{c_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{c_1}{k_2(k_2 - k_1)} \right) e^{k_2 t}. \quad (44)$$

$$P_2(t) = P_2^{(1)}(t) + P_2^{(2)}(t) = \lambda_{02} \frac{e^{k_1 t} - e^{k_2 t}}{k_1 - k_2} + \frac{d_1}{k_1 k_2} + \left(-\frac{d_1}{k_2(k_2 - k_1)} - \frac{d_1}{k_1 k_2} \right) e^{k_1 t} + \left(\frac{d_1}{k_2(k_2 - k_1)} \right) e^{k_2 t}. \quad (45)$$

STATISTICAL INVESTIGATIONS (OBSERVATIONS, DATA COLLECTIONS, DATA PROCESSING ETC.)

In the framework of this Sub-Section it is suggested to use not only given in Ap data, but also to try to retrieve and analyze some original statistical information on the studied A/C functional system concerning the system's elements reliability parameters and find the parameters' statistical estimations needed in regards with the following probabilistic (stochastic) computations. These corresponding approaches can easily be found in, let us say, [1-17, 28-33].

Such student's individual observations are to be processed (treated) with the appropriate statistical and mathematical methods described, for example, in the vast majority of the traditional study-books, such as [15].

HYPOTHESES (STATEMENTS, PROBLEMS)

Herein it is suggested to formulate the own concept (idea, problem, hypotheses).

In accordance with the graph (see Fig. 1) one may state that the A/C given functional system maintenance improvement, developed in one's CP, influences the corresponding values of the failure rates λ_{ij} and restoration rates μ_{ji} determining the process going on in the system.

The problem might be, for instance, to choose an optimal maintenance periodicity for the A/C given functional system. In its turn, it might be done likewise in example described in reference [2].

On condition that probability of the failure state "2": P_2 does not exceed (go beyond) the accepted limit (level), whereas (while) the up (normal operation conditions) state of the system designated as "0" probability: P_0 is not lower than the accepted level (limit), the corresponding maximum of the damage state P_1 can be considered as an optimum for the A/C given functional system maintenance periodicity; that has been considered, discussed, and disputed in references [2, 20, 21, 23-27].

PROOFS (DERIVATION, SOLUTIONS, TESTING)

Within this Sub-Section material, a student is supposed to give some kind of a proof to the student's speculation s, contemplation s, studies, thoughts, considerations, assumptions, theories, guesswork, suppositions etc.

In order to prove the statements formulated in the previous Sub-Section, let us consider the first derivative of the probability of the damaged but not failure (ruined, crash, break, fracture, split, crack, rupture) state P_1 , Eq. (44), with respect to time t :

$$\begin{aligned} \frac{dP_1(t)}{dt} &= \frac{\lambda_{01}}{k_1 - k_2} (k_1 e^{k_1 t} - k_2 e^{k_2 t}) + k_1 \left(-\frac{c_1}{k_2(k_2 - k_1)} - \frac{c_1}{k_1 k_2} \right) e^{k_1 t} + \\ &\quad + k_2 \left(\frac{c_1}{k_2(k_2 - k_1)} \right) e^{k_2 t}. \end{aligned} \quad (46)$$
$$\frac{dP_1(t)}{dt} = \frac{-k_1 k_2 \lambda_{01}}{k_1 k_2 (k_2 - k_1)} (k_1 e^{k_1 t} - k_2 e^{k_2 t}) +$$

$$+ \left(-\frac{k_1 k_1 c_1}{k_1 k_2 (k_2 - k_1)} - \frac{k_1 c_1 (k_2 - k_1)}{k_1 k_2 (k_2 - k_1)} \right) e^{k_1 t} + \left(\frac{k_1 k_2 c_1}{k_1 k_2 (k_2 - k_1)} \right) e^{k_2 t}. \quad (47)$$

Equalizing Eq. (47) to zero yields

$$\frac{dP_1(t)}{dt} = \frac{-k_1 k_2 \lambda_{01} (k_1 e^{k_1 t} - k_2 e^{k_2 t}) - k_1 k_1 c_1 e^{k_1 t} - k_1 c_1 (k_2 - k_1) e^{k_1 t} + k_1 k_2 c_1 e^{k_2 t}}{k_1 k_2 (k_1 - k_2)} = 0. \quad (48)$$

$$-k_1 k_2 \lambda_{01} (k_1 e^{k_1 t} - k_2 e^{k_2 t}) - k_1 k_1 c_1 e^{k_1 t} - k_1 c_1 (k_2 - k_1) e^{k_1 t} + k_1 k_2 c_1 e^{k_2 t} = 0. \quad (49)$$

$$-(\lambda_{01} k_2 k_1 e^{k_1 t} - \lambda_{01} k_2 k_2 e^{k_2 t}) - k_1 c_1 e^{k_1 t} - c_1 k_2 e^{k_1 t} + c_1 k_1 e^{k_1 t} + k_2 c_1 e^{k_2 t} = 0. \quad (50)$$

$$-\lambda_{01} k_2 k_1 e^{k_1 t} + \lambda_{01} k_2 k_2 e^{k_2 t} - c_1 k_2 e^{k_1 t} + k_2 c_1 e^{k_2 t} = 0. \quad (51)$$

$$-\lambda_{01} k_1 e^{k_1 t} + \lambda_{01} k_2 e^{k_2 t} - c_1 e^{k_1 t} + c_1 e^{k_2 t} = 0,$$

$$(\lambda_{01} k_2 + c_1) e^{k_2 t} = (\lambda_{01} k_1 + c_1) e^{k_1 t}. \quad (52)$$

$$e^{(k_2 - k_1)t} = \frac{\lambda_{01} k_1 + c_1}{\lambda_{01} k_2 + c_1}, \quad (k_2 - k_1)t = \ln \frac{\lambda_{01} k_1 + c_1}{\lambda_{01} k_2 + c_1}. \quad (53)$$

Thus, we have come to the optimal solution, maintenance periodicity, expressed with

$$t_p^* = \frac{\ln(\lambda_{01} k_1 + c_1) - \ln(\lambda_{01} k_2 + c_1)}{k_2 - k_1}. \quad (54)$$

EXPERIMENTATIONS (TRIALS ETC.)

Now, it is suggested to conduct experimentations (tests, trials, mathematical modeling, computer simulation, numerical or calculation experiments [15] etc.) with the obtained above theoretical studies, mathematical derivations, and statistical search results.

In order to illustrate this point for the example considered (see Fig. 1), the mathematical modeling has been realized for such initial data for the probabilities: $P_0|_{t=t_0} = 1$, $P_1|_{t=t_0} = P_2|_{t=t_0} = 0$, $t_0 = 0$, and other values: $\lambda_{01} = 5 \cdot 10^{-3} \text{ h}^{-1}$; $\lambda_{02} = 2 \cdot 10^{-4} \text{ h}^{-1}$; $\lambda_{12} = 1 \cdot 10^{-3} \text{ h}^{-1}$; $\mu_{10} = 1 \cdot 10^{-4} \text{ h}^{-1}$; $\mu_{20} = 3 \cdot 10^{-5} \text{ h}^{-1}$; $\mu_{21} = 5 \cdot 10^{-5} \text{ h}^{-1}$; $t = 0 \dots 1.5 \cdot 10^3 \text{ h}$. $t_{\text{opt}} \approx 393 \text{ h}$ is found with the expression of Eq. (54).

GRAPHICAL REPRESENTATIONS

The material developed in this Sub-Section is needed (required, useful, helpful, wanted, requested, necessary) in order to represent the achieved results in the best possible way. It is an appropriate (good, suitable, proper, right, correct, fitting) idea to represent such material in both EN and GP of the submitted to the **EXAMINATION BOARD** to be defended CP.

In the developed problem setting, the diagrams plotted by the numerical simulation with the formulae of Eq. (6)-(54) are shown in Fig. 2.

The demonstrated in Fig. 2 designations of a_1 , a_0 , and a_2 (Fig. 2) are for the probabilities of $P_1(t)$, $P_0(t)$, and $P_2(t)$ obtained with the computer simulation for the differential equations system (6) related to the corresponding graph shown in Fig. 1. Also, $P_1(t)$, $P_0(t)$, and $P_2(t)$ are for $P_1(t)$, $P_0(t)$, and $P_2(t)$ respectively, and $P_{00}(t)$ is for $P_0(t)$ as well, being plotted after the calculation with the use of Eq. (43) instead of Eq. (42) used for gaining $P_0(t)$ result. Both curves $P_{00}(t)$ and $P_0(t)$ coincide.

The corresponding value of the optimal periodicity $t_{opt} = 393.267$, determined with the expression of Eq. (54), delivering the maximum to the probability of $P_1(t)$, the damage “1”, however, being not the failure state “2”, on the condition that the probability of the latter state “2” $P_2(t)$ does not go beyond (exceed) the accepted level (limit), whereas (while) the up (normal operation conditions) state of the system designated as “0” probability: $P_0(t)$ is not lower than the accepted level (limit), is portrayed in Fig. 2; as well as $P_1|_{t=t_{opt}} = 0.64339$ and $P_2|_{t=t_{opt}} < 0.3$, $P_0|_{t=t_{opt}} > 0.1$ are visible in Fig. 2.

EXTRAPOLATIONS

Here, within the developments made in the framework of this Sub-Section it is advisable to produce some sort of the achieved results generalization (spreading out, broadening, expanding, extrapolating etc.).

Prognostic (predictive, analytical, prophetic, projecting, foretelling, and so on and so forth) evolutions are welcome here too.

SIMILAR SCIENTIFIC RESEARCH STUFF

Apparently, some of the students are sometimes so smart (intelligent, knowledgeable, gifted etc.), they can even be the cleverer than their professors, that they are encouraged (inspired, motivated) to generate their own theoretical and practically applicable approaches to the **SCIENTIFIC RESEARCH ELEMENTS**.

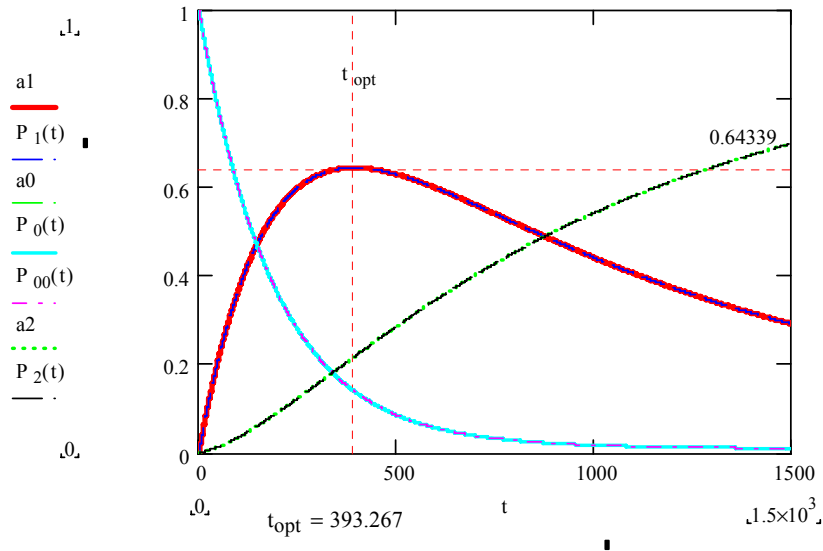


Fig. 2. Results of the computer calculation experiments conducted with the help of the MathCad standard platform

In such respect [1-38], the considered example may be given an attention to in regards with the **MULTI-OPTIONAL HYBRID-EFFECTIVENESS FUNCTIONS UNCERTAINTY MEASURE CONDITIONAL OPTIMIZATION DOCTRINE** (method, approach, concept) applicable (used, implemented) to the aeronautical engineering optimal maintenance periodicities determination [20, 21, 23-27].

The optimal values of aeronautical engineering maintenance periodicities illustrated in Fig. 2 can be obtained not only in the entire probabilistic way, but also in a hybrid partially probabilistic partially optional way [20, 21, 23-27].

The essence of the doctrine (method, idea, approach, concept) is to consider the process developing in the system from the position of some hybrid optional functions distribution optimality.

Consider the options essential to the system.

Objective functional, like proposed in references [20, 21, 23-27], is as follows:

$$\Phi_h = - \sum_{i=1}^3 [xF_1^{(i)}] \ln [xF_1^{(i)}] - \frac{t_p^*}{\lambda_{01}} \sum_{i=1}^3 [xF_1^{(i)}] (M_{12}^{(i)}) + \gamma \left[\sum_{i=1}^3 [xF_1^{(i)}] - 1 \right],$$

$$F_1^{(i)} = \frac{M_{12}^{(i)}}{\Delta(\mathbf{M})} = \frac{k_i \lambda_{01} + c_1}{p(p^2 + pe_1 + b_1 + c_1 + d_1)},$$

$$M_{12}^{(i)} = k_i \lambda_{01} + c_1, \quad \Delta(\mathbf{M}) = p(p^2 + pe_1 + b_1 + c_1 + d_1), \quad (55)$$

where x is an unknown parameter; $h_i = xF_1^{(i)}$ is the multi-optional hybrid functions depending upon the options effectiveness functions of $F_1^{(i)}$; t_p^*/λ_{01} is the intrinsic parameter of the system and the process, which is the ratio of the optimal (delivering the sought maximal value to the probability) time t_p^* of the maintenance periodicity, it is unknown yet for such problem formulation and the time of t_p^* is going to be determined as a solution, i.e. it is not the Eq. (54) so far, however it will be, that is why the indication is the same, to the flow intensity λ_{01} ; $M_{12}^{(i)}$, Eq. (25), is the algebraic addition of the initial elementary intensities matrix \mathbf{M} , Eq. (14), formed in the style likewise from the Erlang's system, Eq. (6), element of m_{12} ; γ is the parameter, coefficient, function (uncertain Lagrange multiplier, weight coefficient) for the normalizing condition.

Consider an extremum existence necessary conditions for the objective functional of (55), [23, p. 91, (14, 15)]:

$$\frac{\partial \Phi_h}{\partial h_i} = \frac{\partial \Phi_h}{\partial [xF_1^{(i)}]} = 0, \quad \forall i \in \overline{1,3}. \quad (56)$$

$$\ln [xF_1^{(1)}] + \frac{t_p^*}{\lambda_{01}} (\lambda_{01} k_1 + c_1) = \gamma - 1 = \ln [xF_1^{(2)}] + \frac{t_p^*}{\lambda_{01}} (\lambda_{01} k_2 + c_1). \quad (57)$$

From where

$$\ln[xF_1^{(1)}] + \frac{t_p^*}{\lambda_{01}}(\lambda_{01}k_1 + c_1) = \ln[xF_1^{(2)}] + \frac{t_p^*}{\lambda_{01}}(\lambda_{01}k_2 + c_1). \quad (58)$$

After that, we have got the *law of subjective conservatism* on one hand and on the other hand the similar to Eq. (53) expression:

$$\ln[xF_1^{(1)}] - \ln[xF_1^{(2)}] = \frac{t_p^*}{\lambda_{01}} [(\lambda_{01}k_2 + c_1) - (\lambda_{01}k_1 + c_1)]. \quad (59)$$

At last, we obtain

$$\ln[xF_1^{(1)}] - \ln[xF_1^{(2)}] = t_p^* \left[\left(k_2 + \frac{c_1}{\lambda_{01}} \right) - \left(k_1 + \frac{c_1}{\lambda_{01}} \right) \right]. \quad (60)$$

After that likewise Eq. (53), (54)

$$t_p^* = \frac{\ln[F_1^{(1)}(\cdot)] - \ln[F_1^{(2)}(\cdot)]}{k_2(\cdot) - k_1(\cdot)}. \quad (61)$$

And finally equivalent with Eq. (54) with taking into account Eq. (35), (37) for the roots, i.e. the second, third, and fourth expressions of the Eq. (55), [23, p. 91, (16)]

$$t_p^* = \frac{\ln \frac{k_1 \lambda_{01} + c_1}{p(p^2 + pe_1 + b_1 + c_1 + d_1)} - \ln \frac{k_2 \lambda_{01} + c_1}{p(p^2 + pe_1 + b_1 + c_1 + d_1)}}{k_2(\cdot) - k_1(\cdot)}. \quad (62)$$

$$t_p^* = \frac{\ln(k_1 \lambda_{01} + c_1) - \ln(k_2 \lambda_{01} + c_1)}{k_2(\cdot) - k_1(\cdot)}. \quad (63)$$

Thus, the result of Eq. (54) is obtained in absolutely not probabilistic rather in the **MULTI-OPTIONAL HYBRID-EFFECTIVENESS FUNCTIONS UNCERTAINTY MEASURE CONDITIONAL OPTIMIZATION DOCTRINE** way [20, 21, 23-27].

The same approach is applicable to $F_2^{(i)}$ with yielding the parallel to the Eq. (54) and (63) results.

Now we ought to say that for the situation when the probability of $P_2(t)$ undergoes the extremum instead of the probability of $P_1(t)$, the problem, **due to the symmetry**, has a symmetrical solution, [23, p. 91, (17)]:

$$t_p^* = \frac{\ln(\lambda_{02}k_1 + d_1) - \ln(\lambda_{02}k_2 + d_1)}{k_2 - k_1}. \quad (64)$$

That is the system according to the developing stationary Poisson flow process has the possible states optimal options related with either the system of parameters $\{k_i, \lambda_{02}, d_1\}$ or $\{k_i, \lambda_{01}, c_1\}$ values for the initial moment probability of the state “0” being equaled to “1”.

These theoretical speculations and hypotheses can be represented with the diagrammatic graph illustrating the flows shown in Fig. 3.

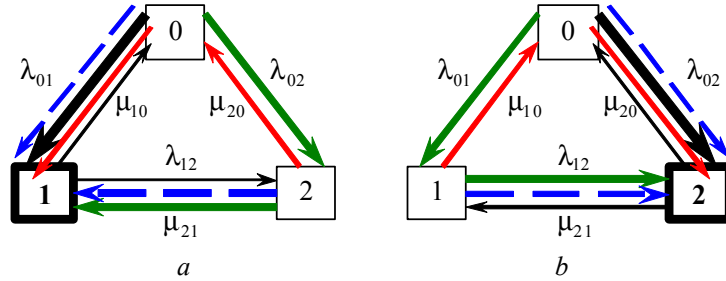


Fig. 3. Diagrammatic graph of the three states of an aircraft functional system illustrating the prevailing flows with the maximum of the probability at the state of:
a) – “1”; b) – “2”

In Fig. 3 for the system of parameters $\{k_i, \lambda_{01}, c_1\}$, as well as Eq. (25), values it is shown the prevailing flows that dominate the developing process:

$$M_{12} = p\lambda_{01} + c_1, \quad c_1 = \lambda_{01}\mu_{20} + \lambda_{01}\mu_{21} + \lambda_{02}\mu_{21}. \quad (65)$$

It is visible that intensities of λ_{12} and μ_{10} do not calibrate the optimal options’ dispositions. In that particular case, none of the flows from the state “1” is taken into account.

The solutions in the view of either Eq. (54) and (63) or its symmetrical reflection solution as Eq. (64) are the general ones. That is, the partial cases are obtained from them.

The multiplier of x in such a case is expressed with

$$\sum_{i=1}^3 [xF_1^{(i)}] = 1. \quad (66)$$

With respect to the Eq. (55) second condition

$$\begin{aligned}
& x \frac{k_1 \lambda_{01} + c_1}{p(p^2 + p e_1 + b_1 + c_1 + d_1)} + x \frac{k_2 \lambda_{01} + c_1}{p(p^2 + p e_1 + b_1 + c_1 + d_1)} + \\
& \quad + x \frac{k_3 \lambda_{01} + c_1}{p(p^2 + p e_1 + b_1 + c_1 + d_1)} = 1. \\
& \frac{x[(k_1 \lambda_{01} + c_1) + (k_2 \lambda_{01} + c_1) + (k_3 \lambda_{01} + c_1)]}{p(p^2 + p e_1 + b_1 + c_1 + d_1)} = 1. \\
& x = \frac{p(p^2 + p e_1 + b_1 + c_1 + d_1)}{\lambda_{01}(k_1 + k_2) + 3c_1}. \tag{67}
\end{aligned}$$

The optimal optional-hybrid functions are found from the extremum existence conditions of Eq. (56), [23, p. 91, (14)], like in [28-32]:

$$\frac{\partial \Phi_h}{\partial h_i[\cdot]} = 0, \quad \forall i \in \overline{1,3}, \tag{68}$$

since in functional Eq. (55)

$$h_i[x, F_1^{(i)}(\cdot)] = x F_1^{(i)}, \quad \forall i \in \overline{1,3}. \tag{69}$$

Therefore

$$\begin{aligned}
& -\ln h_i[\cdot] - 1 - \frac{t_p^*}{\lambda_{01}} [M_{12}^{(i)}(\cdot)] + \gamma = 0, \\
& \ln h_i[\cdot] = -\frac{t_p^*}{\lambda_{01}} [M_{12}^{(i)}(\cdot)] + \gamma - 1. \tag{70}
\end{aligned}$$

Hence,

$$h_i[\cdot] = \exp \left\{ -\frac{t_p^*}{\lambda_{01}} [M_{12}^{(i)}(\cdot)] + \gamma - 1 \right\}, \quad \forall i \in \overline{1,3}. \tag{71}$$

From normalizing condition for functional Eq. (55)

$$\sum_{j=1}^3 h_j[\cdot] = 1 = \sum_{j=1}^3 \exp \left\{ -\frac{t_p^*}{\lambda_{01}} [M_{12}^{(j)}(\cdot)] + \gamma - 1 \right\} = e^{\gamma-1} \sum_{j=1}^3 e^{-\frac{t_p^*}{\lambda_{01}} [M_{12}^{(j)}(\cdot)]}. \tag{72}$$

From where

$$e^{\gamma-1} = \frac{1}{\sum_{j=1}^3 e^{-\frac{t_p^*}{\lambda_{01}} [M_{12}^{(j)}(\cdot)]}}. \quad (73)$$

Finally, we obtain the analogous expressions [23, p. 91, (18)] to the known in Subjective Analysis the canonical distribution of preferences, [31, 32] developed mathematically similar to the Jaynes' entropy principle [28-30]:

$$h_i[\cdot] = \frac{e^{-\frac{t_p^*}{\lambda_{01}} [M_{12}^{(i)}(\cdot)]}}{\sum_{j=1}^3 e^{-\frac{t_p^*}{\lambda_{01}} [M_{12}^{(j)}(\cdot)]}}. \quad (74)$$

However in this work we interpret it, Eq. (74), as the optional hybrid functions distribution since we do not consider any active elements or subjects (persons, individuals, or human beings) in the system. Instead we deal with the objectively existing optimal quality of the system, corresponding with the system intrinsic nature, rather than subjectively preferred (although might be also essential, indispensable) matter.

Partial cases and their generalizations are also suitable in such Sub-Section.

In addition, the problem of the aircraft flight situations dynamics might be considered. One of possible approaches is presented with the graph shown in Fig. 4.

In the situations illustrated in Fig. 4, there are the four special flight situations: R1, R2, R3, R4, as well as R0 – normal flight conditions taken into account.

The students might consider the case, construct, and solve the corresponding system of the ordinary linear differential equations of the first order by Erlang (similarly with the Eq. (6)-(54) methods). Also, investigations in the style of Eq. (55)-(74), as well as Eq. (4)-(5), are welcome.

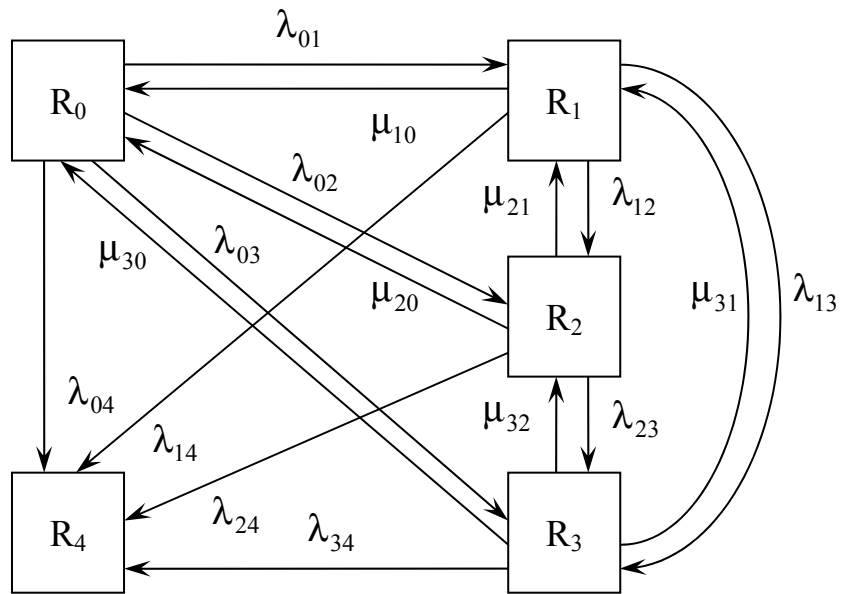


Fig. 4. Graph of the aircraft flight situations dynamics

SCIENTIFIC RESEARCH CONCLUSIONS

There must be sound reasons and reliable grounds for the self-sureness in the CP deeds and validity, valuable abilities of the achieved results of the **SCIENTIFIC RESEARCH**.

Here, there has to (should) be included a statement (or a few/several statements) about the expediency (practicality, usefulness, rationality etc.) of the study, phenomena stipulated (predetermined) by the revealed causes, plausible explanations, partial cases consideration, and their generalizations, as well as prospects of further investigations in the specified scientific fields (areas, spheres) and so on.

REPEATED COMPUTATIONS AFTER THE PROPOSED IMPROVEMENTS WOULD BE IMPLEMENTED AND SCIENTIFIC RESEARCH HAVE BEEN CONDUCTED

Recurrent calculations are required in order to demonstrate the predicted effectiveness (expediency) of the proposed improvements.

It has to take into account the having been conducted scientific research results, expected (anticipated) advantages of the improvements applications (use) for both the system structural design and A/C M/T system technique (technology), as well as organizational means and methods implementations.

THE ACHIEVED OR FORESEEN RESULTS COMPARISON WITH THE INITIAL MAINTENANCE SYSTEM PROVISIONS

Critically analyze the achieved and foreseen results of your entire CP work.

COURSE PROJECT CONCLUSIONS

In conclusions, it is necessary to briefly summarize the results of the analysis and calculations of all CP sections and give comments on the conformity (conventionality, traditionalism, compliance, accordance, agreement, correspondence) of the system and its units to the modern level of and requirements to the M/T system program.

Emphasize the benefits of the conducted scientific research results implementations. Evaluate the findings and discoveries made.

There must be sound reasons and reliable grounds for your self-confidence in the CP deeds and validity, valuable abilities of the results you got.

METHOD GUIDE ON THE GRAPHICAL PART

The GP is a representative part of the CP. It should reflect the principal (main, major) developments done in the CP and achieved results. It is suggested to present the proposed design improvements comparatively with the initial aeronautical engineering structures and systems units in the CP GP. This kind of drawings must be done in accordance with the SSU as well as USDD requirements.

Also, the results of the **SCIENTIFIC RESEARCH ELEMENTS**, likewise final formulas derived, statistical data individually retrieved, and diagrams plotted, found personally by the student and proving (substantiating, showing, demonstrating, justifying, confirming, verifying) the expediency of the proposed and developed in the CP improvement of the M/T process of the aircraft given functional system are indispensable in the GP.

THE PROJECT DEFENSE PROCEDURE

The CP defense procedure is organized in the following regular order (much coinciding with the **PROJECTING WORK ORGANIZATION; CONTENT, SCOPE, AND STRUCTURE OF THE TERM PAPER; METHOD GUIDES ON THE EXPLANATORY NOTES and GRAPHICAL PART**). In actual fact this process of the CP defense procedure is organized in those stages' steps:

- Get the task on the CP.
- Apply with the specified individual Assignment form.
- Sign and Date the Assignment.
- Complete the nomenclature sections of the CP.
- Develop the required **SCIENTIFIC RESEARCH ELEMENTS**.
- Propose your own ideas, concepts, approaches etc.
- Perform the necessary parts of the CP EN.
- Carry out the essentials of the best performance of the CP results in the representative GP.
- Train your CP defense report with the co-students.
- Consult the lecturer or needed specialists.
- Check everything in the CP once again.
- Sign and Date the final version of the CP.

And you are warmly welcome to submitting the CP materials to defend in the **EXAMINATION BOARD**.

The student is supposed to tell about her/his CP in a short (brief, concise, abridged) (up to 5 minutes) report showing and demonstrating the work performed in the EN and GP. It is very important to highlight the results obtained, any kinds of proofs, developed methods, especially individually by the student who is the author of the project.

After the report, it ought to be discussions between the student and **EXAMINATION BOARD** members. In case of questions arise; the student should generate answers grounded on her/his knowledge and back them up with CP achievements represented in both EN and GP.

Sometimes it looks like giving extra explanations and substantiations of the proposed in the CP M/T process improvement expediency.

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