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COMPLEX MANAGEMENT SYSTEM OF THE AVIATION TRAINING PROCESS

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Abstract

This paper concerns the issue of management and assessment of the aviation training process, which takes into account the elements changing over time: the state of training, its level, quality and mechanisms rationalising the organisational activities and costs. The elements of the complex management system of the aviation training process, which includes probabilistic models for projecting the reliable, safe and effective aviation training, taking into account the requirements imposed by rules, standards and regulations of civil and military aviation, were discussed. In general, its structure, internal modules and exemplary tables of the analysis and assessment of the aviation personnel updates and the validity of permissible breaks during flight by aviation personnel. A schematic diagram of introducing the input data, main parameters, statistical data and expected results in the form of the training schedule, the schedule of the aircraft necessary moving, indicators of the training analysis and assessment, safety and reliability, were mentioned. The mathematical notations of input data and examples of the offered training indicator of aviation personnel were presented. The criterion global function, which exposes the maximisation of the aviation personnel training, as well as the maximisation of the performed flying time of a given type of aircraft, and the minimisation of operating costs of the specific aviation training, was determined. The paper was completed with a conclusion that shows the advantages of the proposed complex management system of the aviation training process.

Keywords: *aviation training system, pilot training, pilot education system*

1. Introduction

The aviation training includes activities on the ground and in the air, which is ended in the acquisition of appropriate licenses and approvals by the aviation personnel and the aviation personnel providing security for the performance of certain tasks on the ground and/or in the air.

The fact that people, who manage the aviation training, have constant transparent access to the current source of information about the aviation training process course, enables a rational approach to the processes of planning, organisation and management of the aviation training at all organisational levels of military aviation. It also increases effectiveness of the action of forces and means of the services responsible for the aviation training, and also supports preventive actions in the flight safety system, the aim of which is to maintain the level of operational readiness (combat) required for the Polish Armed Forces aviation.

In the TURAWA system, which was developed by the Air Force Institute of Technology (ITWL) and implemented for operation in military aviation, the possibility of conducting complex analyses and assessment of the flight safety status, the aviation personnel records and a specific set of information related to the state and course of their training aviation was provided. However, the scope of information, which the services responsible for the course and quality of the aviation training should have, is much larger than the one collected in the TURAWA system so far. There is a lack of information related to, among others, the quality assessment of the performance of aviation tasks, the aviation personnel authorisation to flights, planning of flights by the aviation unit and aviation personnel. There are also different requirements of the personnel implementing and managing the aviation training in terms of presentation and use of the resulting information. An important element in the process of planning the aviation-training course is to provide each member of the aviation personnel with access to the system in order to e.g. construct a schedule of aviation training, taking into account the information from the timing of data beyond the standard range, etc. It will substantially increase the number of the system's users.

Therefore, it is appropriate to construct – especially for the service managing the aviation training – a separate system that will be compatible with the TURAWA system. The consequence of it will be the introduction of changes related to the scope and responsibilities of the Air Base services and aviation training for data recording in both systems, according to the obligations and implemented tasks. Therefore, it is necessary to develop a new module of data processing, which generates resulting information in accordance with the service expectations, for aviation training services. Both systems will use the entire range of the collected information. For these reasons, it is necessary to develop a complex system designed for the personnel managing the aviation training at all organisational levels of military aviation. The system will be supported by planning and assessment of the implementation of aviation tasks performed by the aviation personnel and the aviation unit.

In this system, it is possible to distinguish four data sets related to:

- records, aviation training process and aviation personnel health condition,
- execution of flights and planning the flying time,
- the current recording and operation state of the used aircraft, the knowledge of which is essential for planning the flights,
- designing and issuing the preventive documents and the state of their implementation by individual addressees of recommendations.

The location of this type of the aviation training system in the above mentioned information technology system of the operation support was presented in Fig. 1. It seems the most effective that such a system – globally – constitutes an integral part of the system already used in the Polish Armed Forces, under the code name TURAWA.

Fig. 1. The location of the aviation training system in the information technology system of the aviation operation support of the Polish Armed Forces

2. System Structure

This system can be considered from the point of view of a Commander or a unit, or a tactical level, head of training, specialist, timekeeper, and, the so-called, individual profile, which will be accessible for each pilot after registering and logging to the system. At each of these stages, various subsystems, which are available for browsing, are provided – Fig. 2.

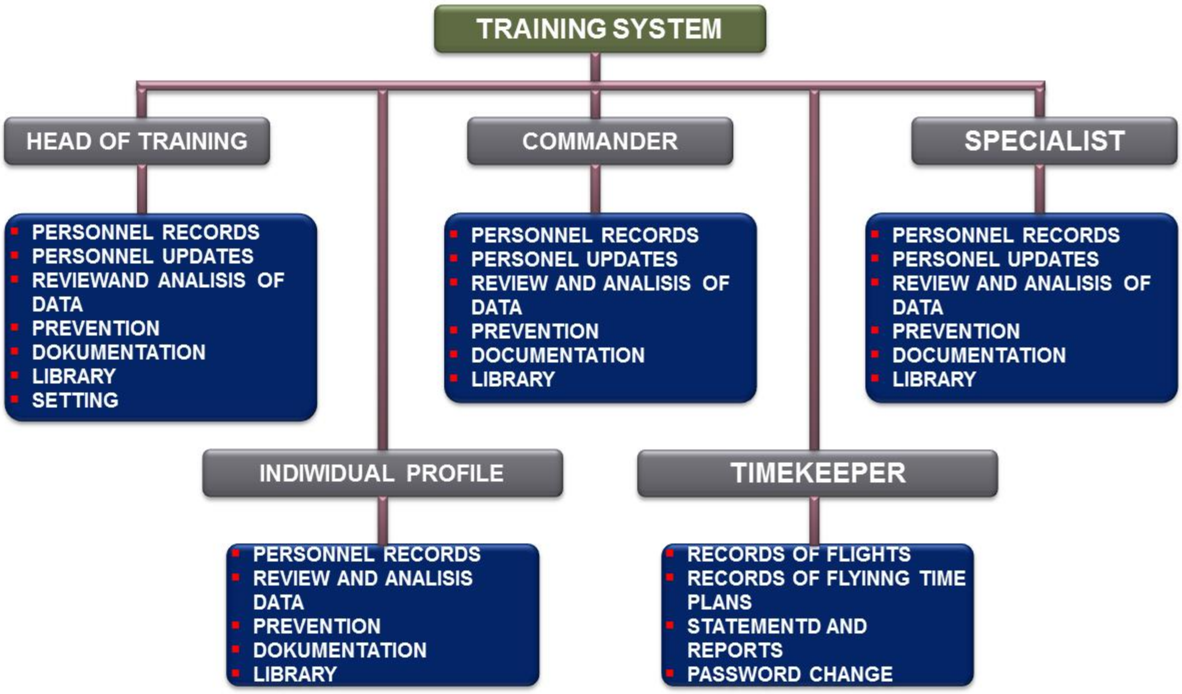

Fig. 2. Major elements of the aviation training system

By exploring the proposed system structure, it is possible to distinguish other subsystems, which will have their own internal structures – an example, see Fig. 3. There will be more subsystems of this kind, currently, eight of them were offered. Among these subsystems, it is possible to identify many elements, which constitute the basis for conducting quite specific analyses and taking necessary decisions.

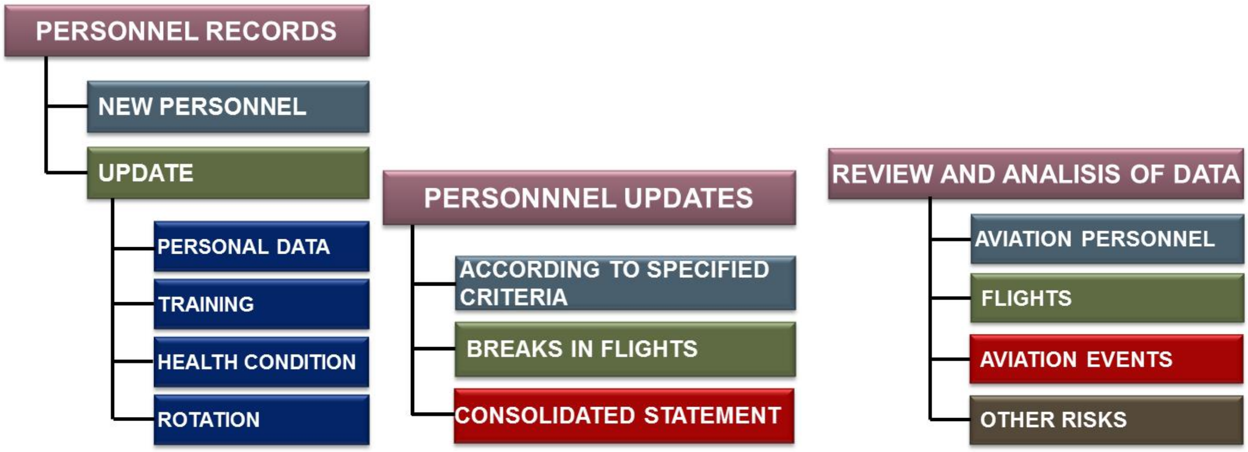

Fig. 3. Options menu – personnel records; personnel updates, review and analysis of data

For example, in the "**CONSOLIDATED STATEMENT**" unit of the "**PERSONNEL UPDATES**" subsystem, the tables with basic personnel data were designed – Fig. 4. This is a table, in which pilots and their updates are included. They were presented in the appropriate colours, depending on the level of updates. The final status of the obtained training and licenses determines the capabilities of a given pilot and the need to carry out additional trainings, workshops, etc.

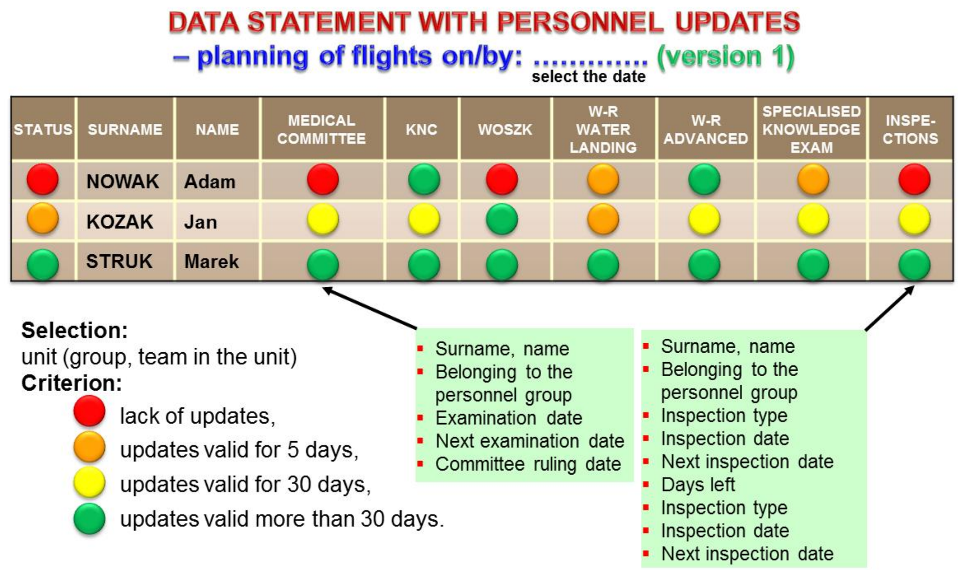

Fig. 4. Review and analysis of data on the aviation personnel updates

Another example constitutes a report indicating the validity of permissible breaks during flights. Such an image clearly presents to the pilots (decision makers), whether their break is too long and requires the resumption.

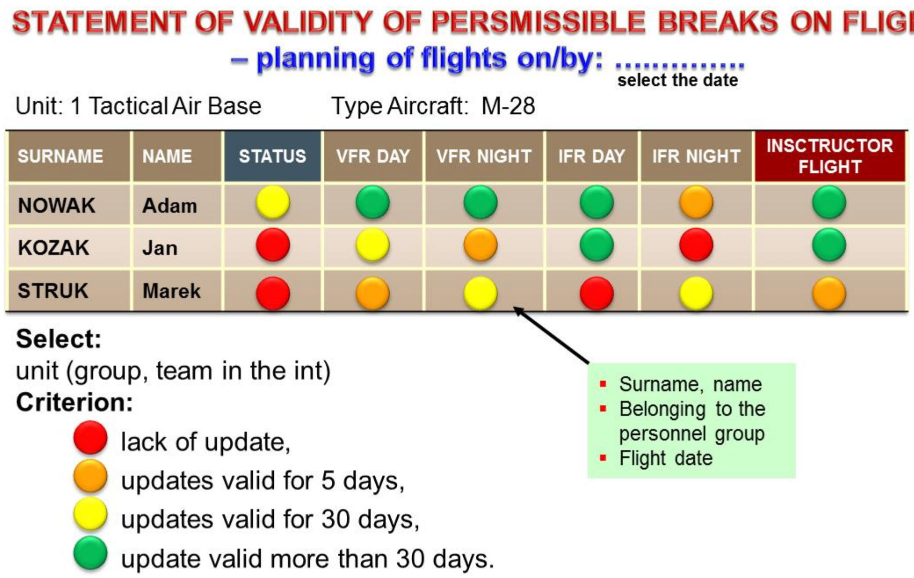

Fig. 5. The review and analysis of data on the updates of the aviation personnel permissible breaks

A very important element of the proposed aviation training system is the organisation of the data processing in the system. It requires the development of the algorithms showing general rules, the paths of data entry, calculation, presentation, assessment, etc. The main menu of the system will consist of three modules, i.e. allowing to: enter data, as well as to review and analyse the documentation and auxiliary materials. In further subsystems, there will be many other modules, other subsystems, etc. Of course, it is not a closed system, and at any time, it is possible to extend it by other important subsystems.

Such a system of training will be accompanied by the aviation personnel from the very beginning, i.e. from the date of the beginning of the records in the aviation school to the end of the service in the air Fig. 6.

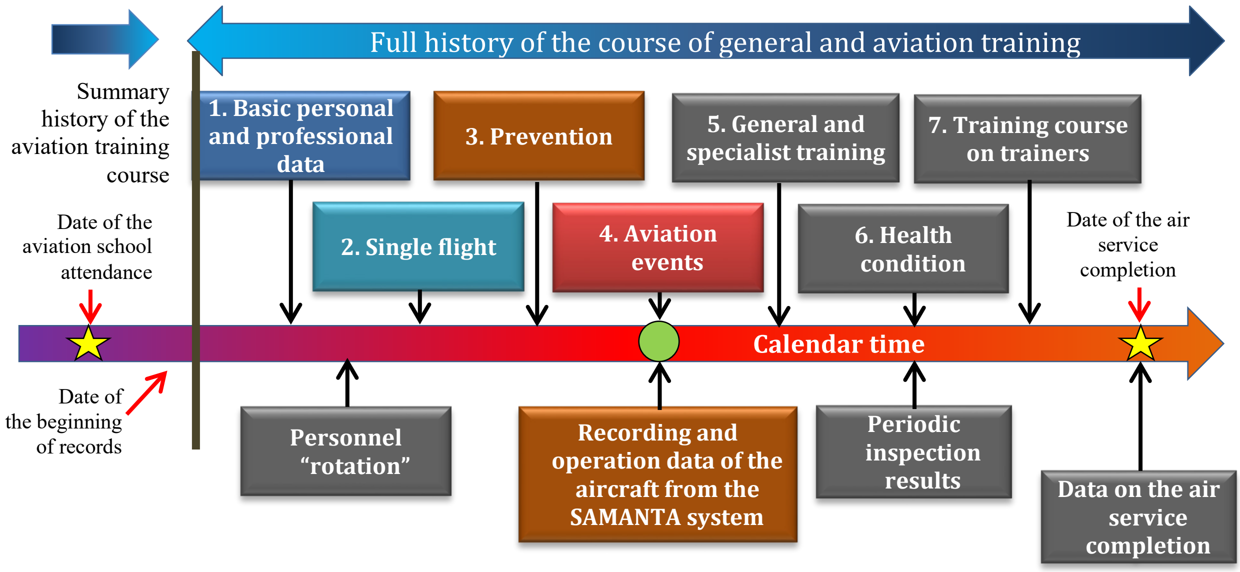

Fig. 6. Aviation training system of the aviation personnel

The general diagram of the aviation training model includes **Input conditions** which define the assumed training plan in given aircraft, **Parameters** which constitute data on the aviation personnel and aircraft fleet, and **Initial conditions:** statistical historical data on aviation training, statistical data on the failure frequency of aircraft and their simulators, and additionally, **Disruptions** which include: additional tasks, occurring failures of aircraft and simulators, random events of aviation personnel (diseases, accidents, etc.). The model will allow obtaining results in the form of the training schedule, the schedule of the aircraft necessary moving, indicators of the training analysis and assessment, safety and reliability – Fig. 7.

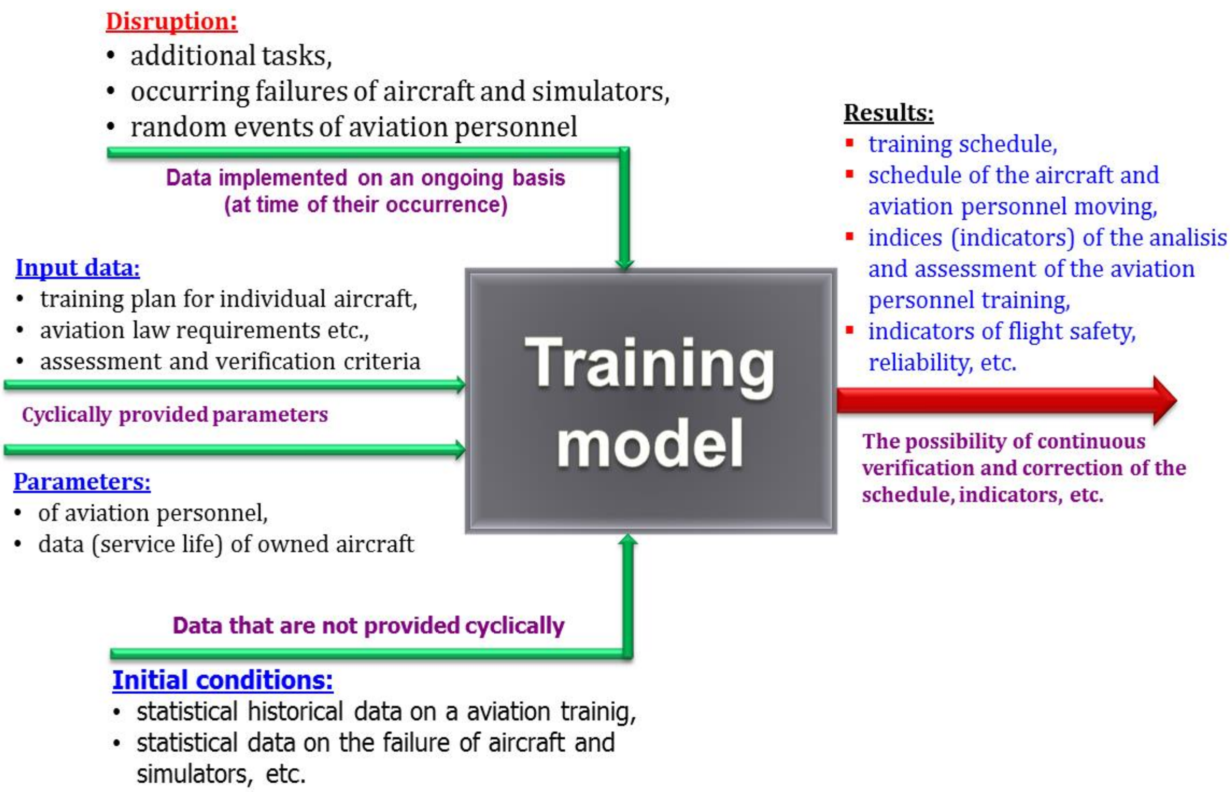

Fig. 7. General diagram of the aviation training system operation

3. Mathematical Modelling

In order to achieve the right and optimal functionality of such a system, it was necessary to develop mathematical models securing the requirements in terms of quality, methodology for calculating basic statistical safety and reliability indicators. In addition, new indicators of training and aviation personnel assessment were offered.

The input data in the aviation training process constitutes sets of elements of the training system, which include:

- a set of types of aircraft:

$$SP = \{sp_i \; : i = 1, 2, ..., n\}, \tag{1}$$

where:
i – another type of aircraft,
n – the number of all types of aircraft;

- a set of aircraft of the i type:

$$\forall sp_i \in SP, \;\; L(sp_i) = \{l_i^m \; : m = 1, 2, ..., M\}, \tag{2}$$

where:
m – a consecutive number of aircraft of the i type,
M – the number of all aircraft of the i type;

- a set of pilots with licenses for a given type of aircraft sp_i:

$$\forall sp_i \in SP \quad P(sp_i) = \{p_i^k \; : k = 1, 2, ..., K\}, \tag{3}$$

where:
k – a consecutive number of the pilot with licenses for a given type of aircraft sp_i,
K – the number of all pilots with licenses for a given type of aircraft sp_i.

Within the framework of the created aviation training system, it is very crucial to determine a set of types of the aviation training required for a given type of aircraft sp_i. In the mathematical context, this set can be written as:

$$\forall sp_i \in SP \quad S(sp_i) = \{s_i^j \; : j = 1, 2, ..., J\} \tag{4}$$

where:
j – a consecutive number of the task for a given type of aircraft sp_i,
J – the number of all tasks for a given type of aircraft sp_i.

It is also necessary to define the matrix (binary) of allocation of a type of training (exercises) s_i^j for a given pilot p_i^k with licenses for a given type of aircraft sp_i:

$$\Omega(sp_i) = \begin{bmatrix} \omega_{p_i^1}^{s_i^1} & \omega_{p_i^1}^{s_i^2} & \cdots & \omega_{p_i^1}^{s_i^J} \\ \omega_{p_i^2}^{s_i^1} & \omega_{p_i^2}^{s_i^2} & \cdots & \omega_{p_i^2}^{s_i^J} \\ \cdots & \cdots & \cdots & \cdots \\ \omega_{p_i^K}^{s_i^1} & \omega_{p_i^K}^{s_i^2} & \cdots & \omega_{p_i^K}^{s_i^J} \end{bmatrix} = \left[\omega_{p_i^k}^{s_i^J} \; : p_i^k \in P(sp_i), s_i^j \in S(sp_i), \omega_{p_i^k}^{s_i^j} \in \{0,1\}\right]. \tag{5}$$

It is also important to determine the matrix of time T (positive actual data) needed to perform a given type of aviation training (exercises) s_i^j for a given type of aircraft sp_i by a given pilot p_i^k:

$$T(sp_i) = \begin{bmatrix} t_{p_i^1}^{s_i^1} & t_{p_i^1}^{s_i^2} & \dots & t_{p_i^1}^{s_i^J} \\ t_{p_i^2}^{s_i^1} & t_{p_i^2}^{s_i^2} & \dots & t_{p_i^2}^{s_i^J} \\ \dots & \dots & \dots & \dots \\ t_{p_i^K}^{s_i^1} & t_{p_i^K}^{s_i^2} & \dots & t_{p_i^K}^{s_i^J} \end{bmatrix} = \left[t_{p_i^k}^{s_i^J} : p_i^k \in P(sp_i), s_i^j \in S(sp_i), t_{p_i^k}^{s_i^j} \in \Re^+ \right], \tag{6}$$

where: $t_{p_i^k}^{s_i^j}$ – cycle time covered on a given training (exercise) s_i^j for a given type of aircraft sp_i by a given pilot p_i^k.

In the proposed innovative aviation training system, several new indicators for the aviation personnel training assessment were introduced. An example is the indicator of the pilot training in a given type of aircraft. This type of indicator will allow to quickly assess the state of aviation personnel training (each of them separately) in a given type of aircraft sp_i by comparing the time actually spent in this type sp_i or its simulator during trainings and workshops in relation to the total time, including the flying time in this type sp_i. Such a comparison will indicate who has too few hours completed at workshops and trainings, and who has too many of them. It will facilitate the training process control by the aviation management personnel, and allow implementing some corrections in the training schedule.

$$W_w(p_i^k) = \frac{1}{T_i} \sum_{j=1}^{J} \sum_{z=1}^{Z} t_z(s_i^j), \tag{7}$$

where:

- Z – the number of times, when a given exercise s_i^j was performed in a given type of aircraft sp_i by a given pilot p_i^k,
- $t_z(s_i^j)$ – the time spent by a given pilot p_i^k on performing a given exercise s_i^j in a given type of aircraft sp_i,
- T_i – the total time spent by a pilot p_i^k in a given type sp_i, determined in accordance with the relationship:

$$T_i = \sum_{i=1}^{n} \sum_{k=1}^{K} t_{p_i^k}^{sp_i} + \sum_{i=1}^{n} \sum_{k=1}^{K} t_{p_i^k}^{ssp_i}, \tag{7a}$$

where:

- $t_{p_i^k}^{sp_i}$ – flying time in a given type of aircraft sp_i by a given pilot p_i^k,
- $t_{p_i^k}^{ssp_i}$ – working time on the simulator of a given type of aircraft ssp_i by a given pilot p_i^k.

The quality of the aviation training complex system solution will be assessed with the use of three externalised functions, i.e. exposing the maximisation of the aviation personnel training, the maximisation of the performed flying time in a given type of aircraft, and the minimisation of operating costs of a given aircraft. The global function of the criterion of the purpose includes:

$$F(X) = [f_1(X), f_2(X), f_3(X)], \tag{8}$$

where:

- $f_1(X) \rightarrow max$ – function defining the maximisation of the aviation personnel training (including flying time in simulators),

$f_2(X) \rightarrow max$ – function defining the maximisation of the performed flying time in aircraft,
$f_3(X) \rightarrow min$ – function defining the minimisation of operating costs of the pilot training.

4. Conclusions

The proposed innovative aviation training system seems to be very complex and requiring the current update of input data. This involves a large time input by the personnel operating the system, as well as continuous verification of input data and the analysis of obtained parameters and indicators, especially by the aviation managing personnel, which manages the aviation training.

The modular structure of the aviation training system seems to be very vulnerable to changes and adjusting to new requirements, criteria, etc. Therefore, it is appropriate to popularise and implement it for operation. In addition, the proposal that the system will accompany the aviation personnel during the entire active period of its occupational service gives a lot of information to decision makers. It allows modifying the existing training plans, including aviation universities, which determine the basic habits of young students of aviation, sometimes very difficult in terms of changes in subsequent periods of military service.

In addition, the possibility of using the system for the proper training of the technical personnel (ground) should be specified. The aircraft operation system provides detection of the occurred damage during pre-flight preparation. In order to ensure the system's correct operation, all its elements (including – a human) should work properly. It means that the engineering and technical personnel (ground) should be properly trained and prepared to effectively detect and remove the aircraft failures, which has a direct impact on the level of flight safety.

The training process is usually carried out in two stages. The first stage is a theoretical training, after which the practical one is performed. It is carried out based on the approved training programme, which specifies the ranges of necessary skills for the trained personnel. In case of the above training, it is very useful to have a proper system of analysing and assessment of the aviation training process and training equipment, which includes – apart from aircraft – flight simulators.

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