Integration of decision-making methods to Decision Support Systems for flight dispatcher during flight planning and operations

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Abstract. Analyzed the necessity of pre-flight preparations and highlighted the necessity of a Decision Support System for flight dispatchers during flight planning and operations. The main goal for the creation of the Decision Support System is the provision of flight dispatchers with informational support about intended flight and receiving the evaluated decision about the possibility of aircraft departure with further issuing of consultation to Pilot-in-Command. Summarized information required for flight planning and operations presented. There are gathering all information from different units meteorological, air traffic control, aeronautical information service which may change several times before departure. Described the mathematical models of binary decision matrices for application in the Base of Knowledge of Decision Support Systems for flight dispatchers for evaluation of factors, which have an influence on departure decisions. Developed the concept of a decision support system for flight dispatchers during flight planning. This system may provide flight dispatchers with pre-flight information and, in addition, can serve as a facility for pre-flight preparation for flight crew with possible consultation of flight operations officer.

1. Introduction

Nowadays air transport is well-known as the most efficient and safe transport in the world. The integration of rapidly-developing technologies allowed minimizing of human intervention during aircraft operation. But the human factor cannot be completely excluded from the aviation industry, since a human is an important link in the functioning of aviation in general (e.g. pilots, air traffic controllers, flight dispatchers, maintenance, etc.). About 70 % of aviation incidents and accidents take place due to situational unawareness and unintentional omission of instructions and factors in flight by pilots [1].

Sometimes pilots intentionally violate national and international aviation rules, manuals, and requirements of pre-flight preparation under the pressure of company management. They are forced to save fuel and do not make required fuel stops, land on the aerodromes with the weather not corresponding to the established minima of the crew, aircraft and airport. Temporary economic benefits are prioritized by management and pilots afraid of losing their job agreeing for non-legal actions and flight safety become under high risk [2]. According to the statistical data, of the 87% of aviation accidents caused by the Human Factor, 33% - conscious violations of flight laws, rules, and regulations by crew members of aircraft, 67%. - true human errors [2], violations in the process of pre-flight training (42%) [3].

Analysis of aviation accidents shows that the decision-maker is significantly influenced by external factors not related to the level of preparedness and technology in the system [2]. The safe operation of flight requires proper pre-flight preparation of flight crew operating the aircraft. For flight routes planning needed detailed analysis of information about the airspace and conditions of its usage, available aerodromes, heliports, navigation aids, meteorological services, communication services, air traffic services and related procedures and regulations.

Therefore, the proper flight planning with evaluation of risks and possible outcomes takes major place to maintain required level of safety of flights [5-7].

2. Purpose of research

Before each flight pilot-in-command and the first officer should analyze a lot of information that frequently has different matters and priorities and take the decision to make a departure and start the flight. The problem is, due to short terms for flight preparation, overestimation of own capabilities often flight crews missing important peculiarities of upcoming flight, which may transform into vital circumstances during flight operation. Mostly, in each airline, the process of flight planning and support of flight crews during flight briefings is executed by flight dispatchers. They are gathering all information from different units – meteorological, air traffic control, aeronautical information service – which may change several times before departure.

The safe flight requires timely access to aeronautical, meteorological, cartographical, and operational information for all aviation staff, involved in flight support [8]. Information required for flight planning and operations represented in Figure 1.

As flight dispatcher has not only one flight under control, arising necessity to integrate decision-making methods to support flight dispatcher in the timely provision of required information beforehand and making evaluated operational activities (e.g. change of alternate aerodrome or fuel stop planning, etc.).

The concept of a Decision Support System for flight dispatchers. Air navigation system operating under continuous influence of different factors. It is referred to as the human-machine system, which consists of humans and equipment continuously interacting. The main component of this system is human, named as human-operator, and effectiveness of functioning and reliability of the system depends on human's decisions [9].

In most cases, decisions are made in difficult conditions, therefore the process of decision-making requires big attention to details and needs a detailed analysis of factors influencing making decisions. The sequence of the human - operator's work consists of exact algorithms, defined by normative documents. For solving the issues of functional variability of human - operator's work sequence due to dynamic changes in the work environment, the models of operator's behavior [10; 11] and the methods of decision-making (neural network models, fuzzy models, the Markov network models, binary decision matrices method) are widely used [12]. The air navigation system is a complex system, therefore a decision couldn't be made with the reference to a single factor, because it influences on system's qualities.

Decision-making in air navigation system based on the evaluation of multiple factors and sub-factors. For analysis of a number of factors and sub-factors in decision-making, the method of binary matrixes will be the most suitable. For each factor and sub-factor selected binary matrices of solutions. Matrices are filled with digits zeros and one, therefore it is called "binary".

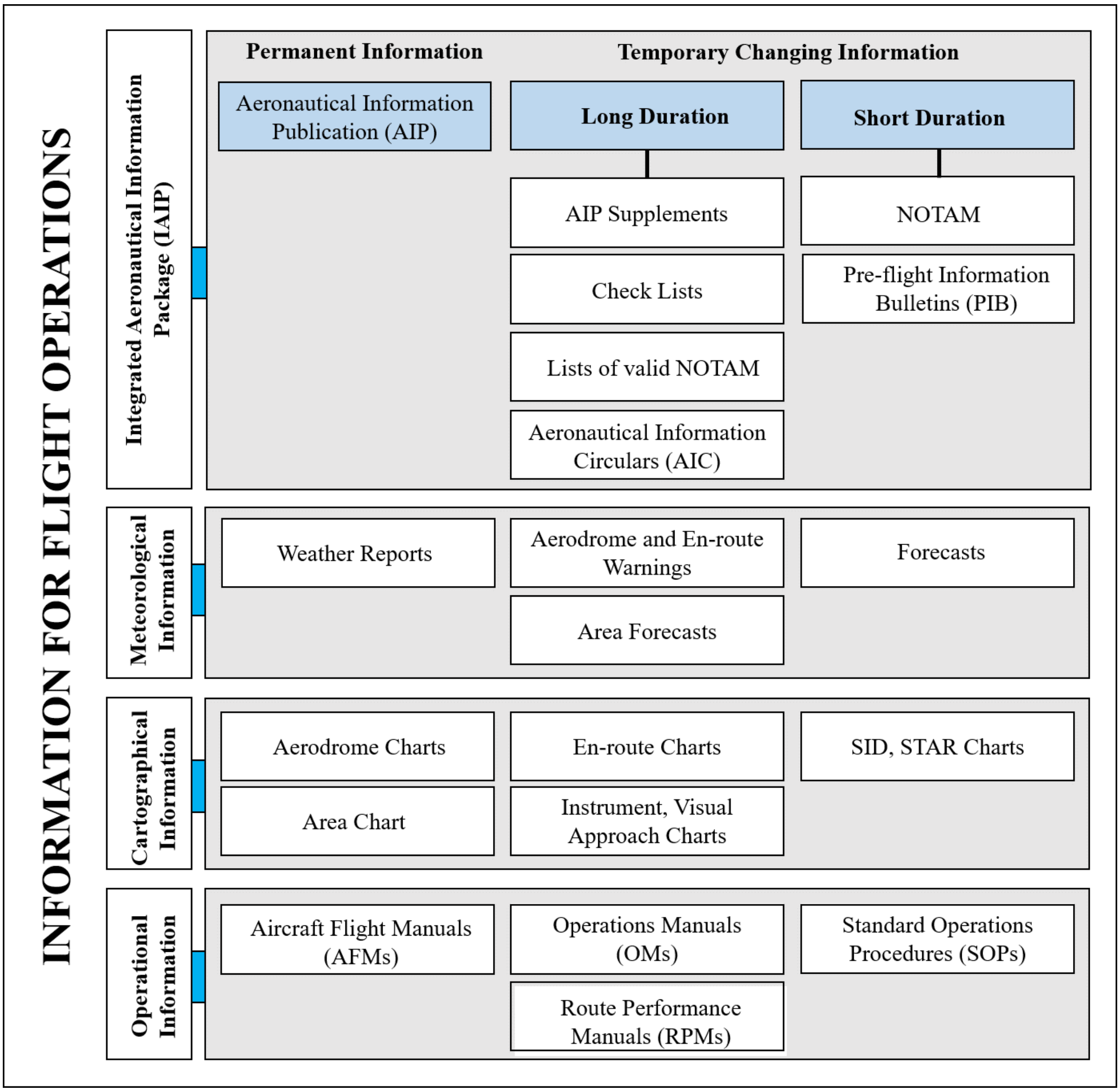

Figure 1. Information required for flight planning and operations.

Zero states that given factor and sub-factor are not taking in consideration, digit one – given factor and sub-factor taken into consideration at given conditions. The objective function is to find the maximum sum of binary criteria.

$$D_j = \sum a_{i,j} \rightarrow max \,,$$

where
i is sub-factor of evaluation;
j is factor of evaluation;
a_{ij} is binary criteria.

Then, all binary criteria collected into decision matrix A.

$$A = \begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,j} & \cdots & a_{1,m} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,j} & \cdots & a_{2,m} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i,1} & a_{i,2} & \cdots & a_{i,j} & \cdots & a_{i,m} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{k,1} & a_{k,2} & \cdots & a_{k,j} & \cdots & a_{k,m} \end{pmatrix}; i = \overline{1,k}, j = \overline{1,m}$$

where

k - is number of evaluated sub-factors;

m - is number of alternative factors [9].

If all elements of matrix A equal 1 - decision can be made, if any of the elements of matrix A equals zero, the decision cannot be made.

The advantage of the binary decision matrices method, that decisions taken by the evaluation of multiple factors and may be easily used in the programming of Decision Support Systems, laid in the concept of Decision Support System for flight dispatcher [9].

One of the advanced ways to support flight dispatcher actions during flight planning and operations is the development of a Decision Support System.

Decision Support Systems are significant opportunities for supporting various types of operator activities during the decision making, forecasting, and timely issuance of recommendations to the operator of a complex system as an air navigation system, especially in extreme situations. The Decision Support Systems may be defined as interactive computer systems designed to support various activities during the decision making in relation to weakly structured and unstructured problems as of providing aeronautical and meteorological information before, in, and after the flight [9-11].

To reach each source of pre-flight information needs a lot of time. For example, before choosing an alternate aerodrome, analysis of aeronautical and meteorological information should be done at least.

Therefore, the Decision Support System for flight dispatchers should be a single source of information with a simple interface and allow access to all required information.

According to ICAO recommended practices for flight planning [5; 13], automated pre-flight information systems should be able to:

a) provide for the continuous and timely updating of the system database and monitoring of the validity and integrity of pre-flight information stored;

b) permit access to the system by operators and flight crew members and also by other aeronautical users concerned through suitable telecommunications means;

c) use access and interrogation procedures based on abbreviated plain language based on a menu-driven user interface, or other appropriate mechanisms;

d) provide for rapid response to a user request for information.

The main purpose of Decision Support System for flight dispatcher is provide informational support of flight dispatcher actions and increase the effectiveness of pre-flight preparation. The conceptual model of Decision Support System for flight dispatcher is presented at Figure 2.

The decision making on departure, which is solved as a result of pre-flight training, is a multi-step process that can be decomposed both "vertically" and "horizontally". Many decision-making steps in this situation can be formally represented in the form of a Cartesian product:

$$\Theta^{в} \times \Theta^{г}_{\theta^{в}} \to \{\theta\},$$

where

$\Theta^{В} = \{\theta^{В}\}$ is many levels of decision-making "vertical" decomposition;

$\Theta^{Г} = \{\theta^{Г}\}$ is many levels of decision-making "horizontal" level decomposition $\theta^{в} \in \Theta^{в}$.

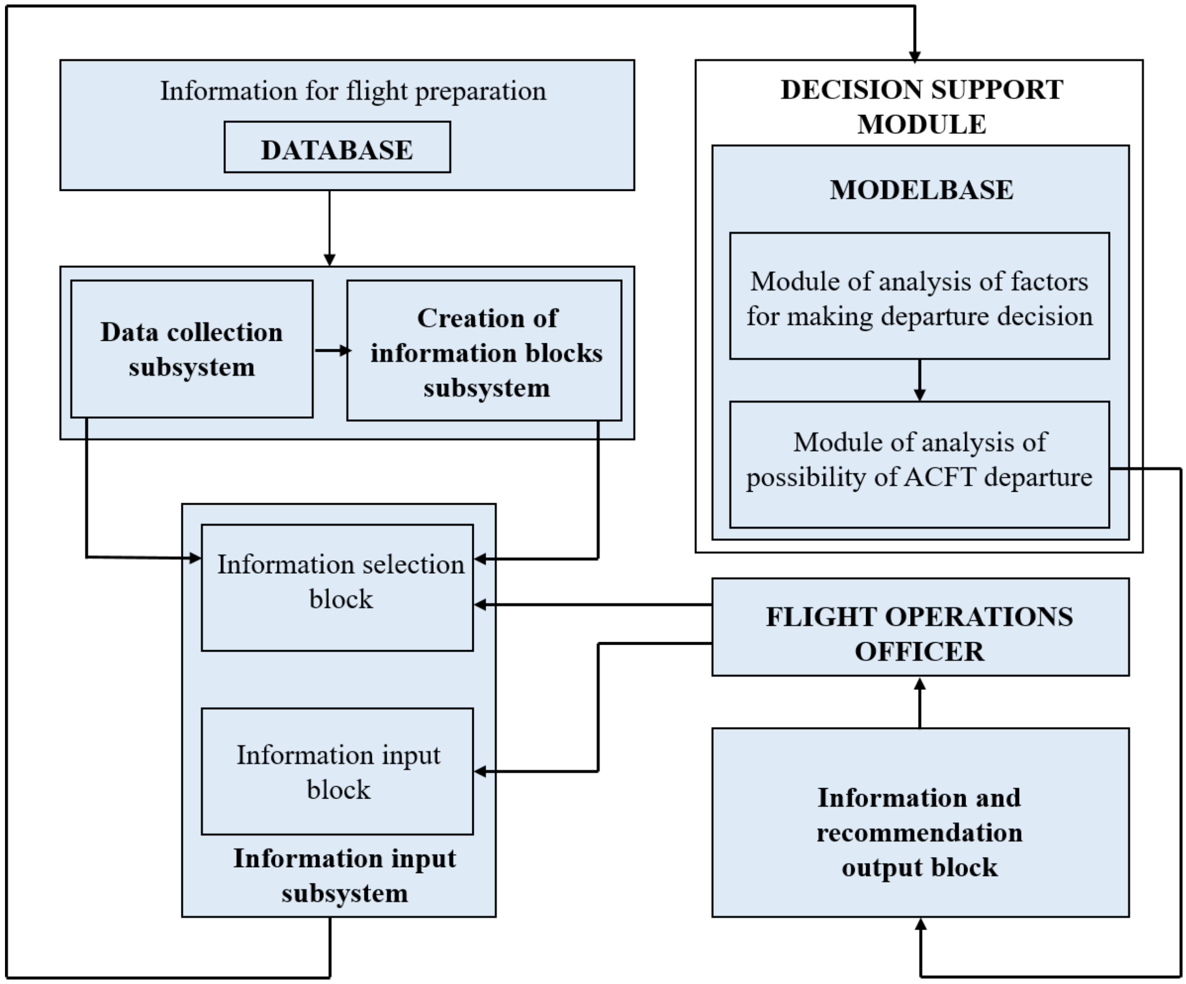

Figure 2. The conceptual model of decision-support system for flight dispatcher.

Let's consider the structure of each stage separately. Stages of Decision Support System operation for flight dispatcher are the following:

Step 1 - Preparation of pre-flight information. At this stage, the Data collection subsystem requests from Database all required information, transfers and sorts it to the Information blocks subsystem by types (aeronautical, meteorological, etc.). Then, the flight dispatcher through the Information input subsystem sets parameters of flight and selects necessary information from the Information selection block, connected with the Data collection subsystem, and Creation of information blocks subsystem.

Step 2 - Analysis of the possibility to perform the flight. At this stage, the Information input subsystem transfers data to the Decision support module, where the Decision Support System performs an analysis of the factors, influencing on the flight, and analyze the possibility to depart and perform the flight.

Step 3 - Issuing of recommendations. At this stage, the decision-support system issues recommendations regarding the possibility of aircraft departure.

The described conceptual model of the Decision Support System for flight dispatchers can be used as a base for further development of decision-support system software to increase the effectiveness of pre-flight briefing.

Although it is often necessary to provide advice, information and assistance to the aircraft crew in preparation for the flight, it is often necessary to provide it with information during the flight to ensure its safe completion. The daily receipt of a large amount of information of different structure, which must be quickly processed and provided to users in a timely manner, necessitates the prompt work of flight services. But because the authorities of aeronautical information and meteorology differ in nature and composition, in most cases the procedure for obtaining pre-flight information is associated with high labor costs and often does not provide timely selective information on a particular flight.

Nowadays the Global Operating Concept for Air Traffic Management [15] for improving the effectiveness of performance of flights assumes provision Collaborative Decision Making between all operational partners – pilots, flight dispatchers, air traffic control services, airports, airlines, and ground operators – on the basis of shared information on the flight process and ground handling of aircraft at an airport [16].

The Flight & Flow Information for a Collaborative (FF-ICE) concept is limited to the exchange of flight information between members of the air traffic management community. The exchange of flight information starts with the advance submission of flight information by airspace users to the air traffic management system and ends with the archiving of the relevant information after the flight. This concept focuses on the global needs for the exchange of flight information but also takes into account regional and local needs. The Decision Support System performs a timely analysis and support of flight information.

Conclusion

The proposed concept of a Decision Support System for flight dispatchers can be used for the future development of decision-support software. It will allow automating the routine actions of flight dispatcher during flight planning and flight operations and will make the possibility for the dispatcher to issue all pre-flight information for pilots via a unified source of pre-flight information.

The system will help flight dispatchers to make a quick analysis of all factors influencing the possibility of flight and in such a dynamic environment, where each factor can change anytime, easily support operational decisions. The effectiveness of flight performance depends on the timely information provided. Efficiency addresses the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective. In all phases of flight, airspace users want to depart and arrive at the times they select and fly the trajectory they determine to be optimum [17; 18].

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