AIRSPACE SIMULATION MODELING

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Abstract. *The main objective of a predictive safety management system (SMS) is to provide a reasonable level and manage flight safety (FS) risks and operational errors. To solve it, it is necessary to identify hazards in a timely manner and assess the severity and frequency (probability) of events that can occur as a result of these factors. The safety assessment (SA) should take into account the human factor, along with technical factors as an important aspect.В статье проведен обзор имитационных моделей воздушного пространства. Рассмотрены функции системы управления воздушным движением.*
Keywords: *flight safety, control system, simulation, airspace, aircraft, model, model parameter.*

INTRODUCTION

The simulation model must simulate the flight of an aircraft in controlled airspace. The advantages of this method are, in fact, the implementation of a predictive approach to flight safety management, as well as obtaining a large amount of data for analysis, obtaining intermediate data (to identify the cause of the situation), accelerating the simulation, the ability to repeatedly “scroll” analyzing the situation and creating new scenarios, taking into account new factors. It should be remembered that the safety of navigation using flight management systems (FMS) is ensured by strict operational discipline (compliance with standard operating procedures - SOPs) and the quality of the database used [1].

MAIN MATERIAL.

Any airspace requires coordination of flights; for this, simulation mathematical models are developed in order to assess flight safety.

The paper sets the task of developing a simulation model of the airspace.

The initial data for the model are:

– airspace structure;
– structure and temporal characteristics of the incoming air stream;
– separation minima (longitudinal, vertical and lateral);
– aircraft performance characteristics.

The simulation mathematical model of the Central Asian region is considered as the most complex system.

General structure of the dynamic air situation model

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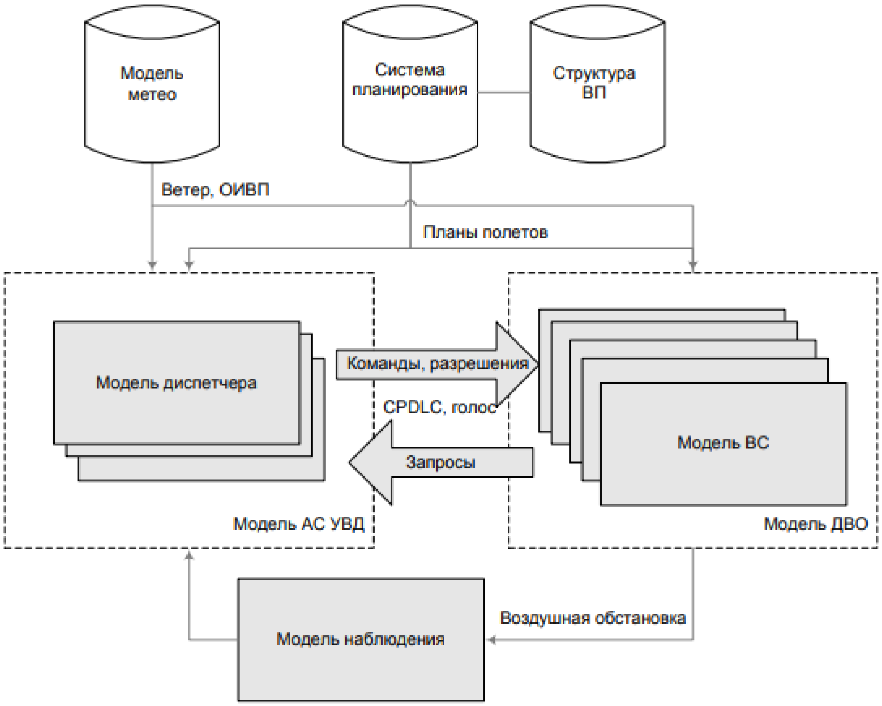

Figure 1 - The structure of the dynamic air situation model [2]

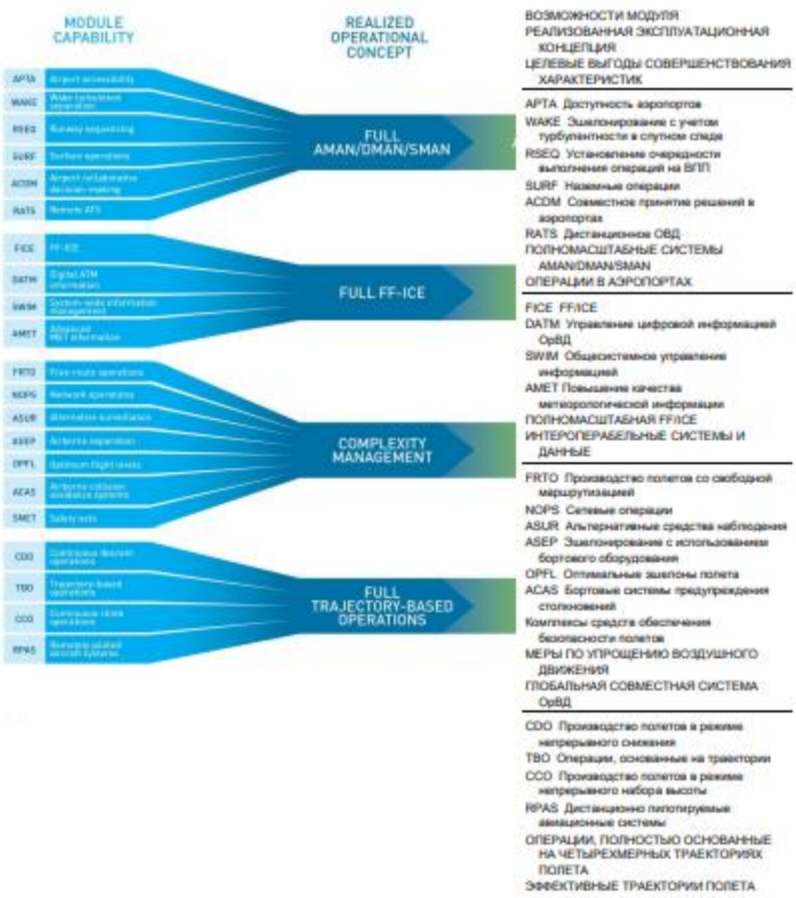

Figure 2 - Implementation of models ASBU

The most effective method for analyzing a complex model of a dynamic air situation, which allows taking into account the whole variety of factors affecting it with various technical means, is statistical modeling.

We have proposed the introduction of the ASBU model, in the general structure of the model of the dynamic air situation in the Central Asian region (fig. 3).

The implementation of ASBU models is intended to improve coordination between air traffic services through the use of a data exchange system between ATS units.

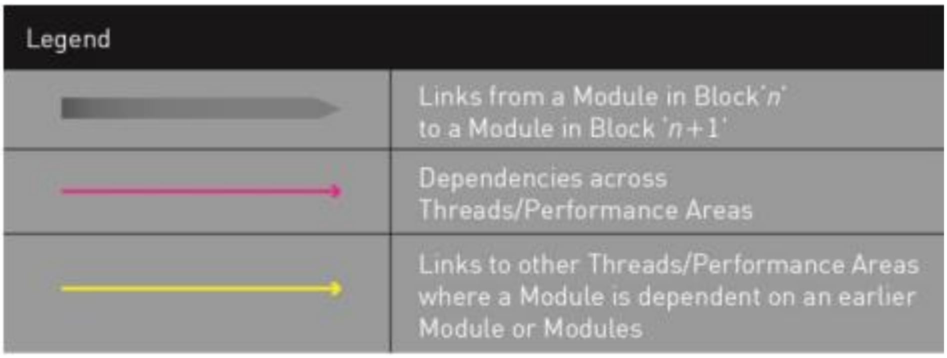

Figure 3 – Basic designations

This figure suggests an interconnection with other mission chains/performance improvement areas where one module is dependent on a previous module or modules.

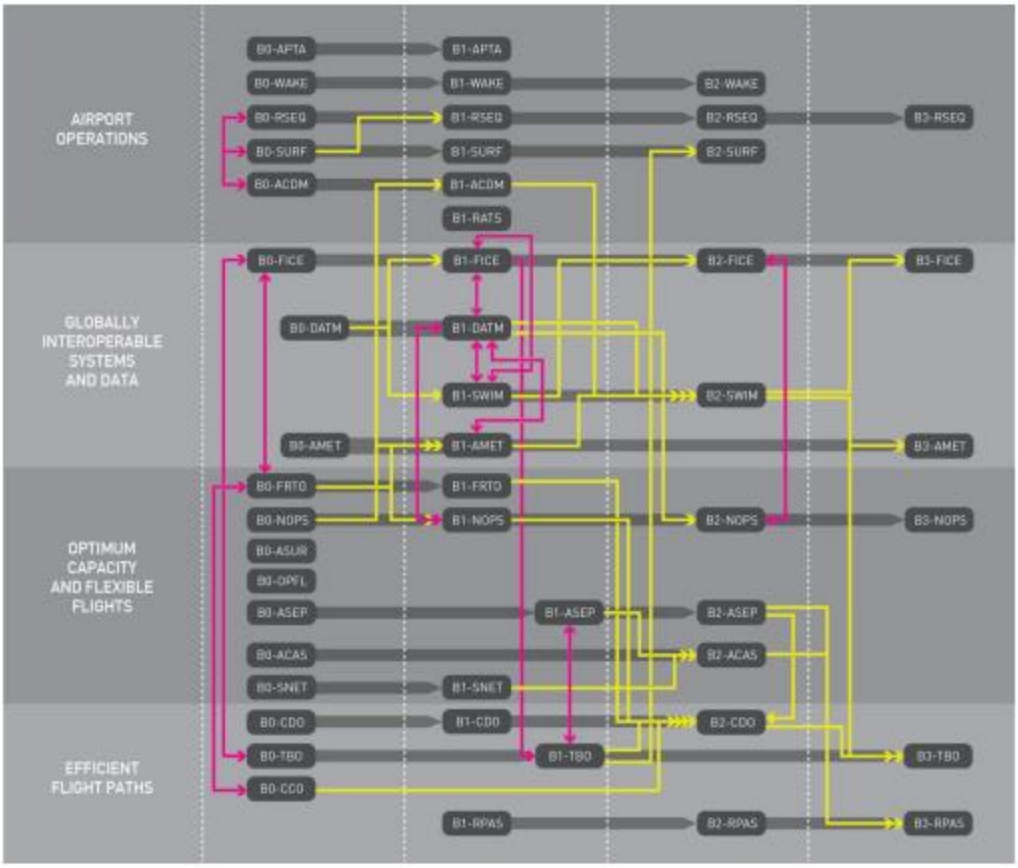

Figure 4 - Relationship with other mission chains/areas of performance improvement

Empirical testing of the model assumptions was performed with a statistical analysis of the original data. Homogeneity testing was carried out in the STATISTICA package using the Wilcoxon rank statistics.

The various block upgrade modules define expected operational improvements and drive the development of what is needed for implementation, while technical roadmaps define the lifespan of specific hardware required to deliver those improvements. Most importantly, they also encourage global interoperability.

ASBU modules help to improve the performance of the air navigation system in the Central Asian region. The starting point for the Central Asian region will be to conduct an assessment of the actual performance of the system in order to identify problems that need to be addressed now or in the future, in key areas for improvement. In our model, 2 key indicators are selected such as: efficiency, flight safety.

When implementing the ASBU modules shown in fig. 3 we get the following results (Table 1):

Table 1 – The results of the model on the basis of which the correlation is built

	B0-WAKE Improved runway capacity through optimized wake turbulence separation	B0-RSEQ Runway traffic flow optimization based on queuing (AMAN/DMAN)	B0-APTA Optimization of approach procedures, including vertical plane	B0-SURF Safety and efficiency of ground operations (use of A-SMGCS systems of levels 1-2) and technical vision system with advanced visualization capabilities (EVS)	B0-ACDM Optimization of operations at airports based on the application of CDM collaborative decision-making principles at airports
Flight efficiency	0,00214	0,0369	0,0023661	0,0024412	0,0120707
Flight safety	0,00147	0,0417	0,03864	0,398667	0,1971253

Table 1 continuation

	B1-APTA Airport Access Optimization	B1-WAKE Improving Runway Capacity through dynamic separation including wake turbulence	B1-RSEQ Optimization of operations at airports based on the organization of departures, ground movement and arrivals	B1-SURF Improving the safety and efficiency of ground movement (SURF)	B1-ACDM Optimization of operations at airports based on the application of CDM principles to the overall organization of airport operations	B1-RATS Remote controlled airfield control towers
Flight efficiency	0,0018853	0,0024036	0,0017652	0,2272554	0,018	1,1267

Flight safety	0,0307893	0,0392533	0,0288267	1,15	0,013	1,8

Let's graphically present the results of the correlation between the improvement in efficiency and flight safety (fig. 5)

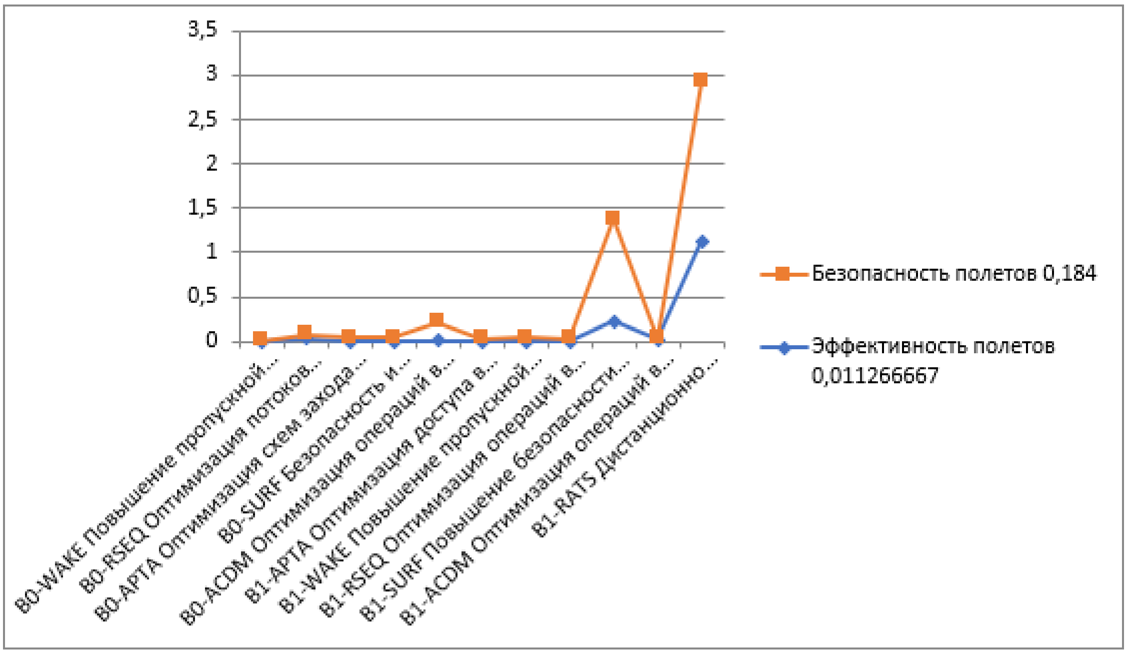

Figure 5 – Correlation Results for Efficiency and Safety Improvements

Thus, enabling the use of airspace that would otherwise be divided (i.e. the use of airspace for special purposes), as well as providing a flexible route that takes into account specific air traffic patterns, can improve both flights safety and efficiency. Improved performance will enhance routing capabilities, reduce the likelihood of congestion on main routes and busy intersections, as well as reduce route length and fuel consumption.

CONCLUSION

The use of performance-based navigation (PBN) and landing systems (GLS) based on the use of ground-based augmentation systems (GBAS) improves the reliability and predictability of landings on the runway, and this is facilitated by the use of basic global navigation satellite systems (GNSS), barometric vertical navigation (VNAV), satellite-based augmentation systems (SBAS) and GLS. The flexibility inherent in the PBN approach pattern can be used to increase runway capacity.

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