Modern Avionics-ATM Ergonomy and Innovation Technologies Implementation Gap Analyses. Latvian and Georgian Case Studies

Nika Tikanashvili[1], Monta Aleksandra Lacane[2]

[1] Georgian Aviation University,
16 Ketevan Dedopali Ave. 0103, Tbilisi, Georgia

[2]Transport and Telecommunication Institute
Riga, Latvia, 1 Lomonosova iela, LV-1019

Abstract: According to EUROCONTROL research, by 2035 year, airports across Europe are expected to be handling 14.4 million flights and 1.4 billion passengers. However, the current air traffic management (ATM) system is not adequately prepared for this volume of air traffic. The system cannot handle such a large number of airplanes in a timely manner, resulting in congested airspace and causing delays for aircraft on the ground and in the air. This situation is economically inefficient and has a significant negative impact on the environment due to carbon emission and noise pollution. For this reason, continuous development and modernization of the air traffic management system is necessary. The Global Air Navigation Plan (GANP) is a flexible engineering-technical methodological document, that allows all International Civil Aviation Organization (ICAO) member states to advance their air navigation capacities based on their specific operational requirements. One of the most problematic parts for successful implementation of the GANP is an innovative air traffic management, and aircraft on-board modern technologies effective interrelationship, taking into account ergonomic factors. System operator-machine-environment main effective functionality is determined by the characteristics of the human operator and depends on a level of process automation and a number of main technical parameters.

Paper is focused on the Latvian and Georgian case studies, as in both counties ATM technologies and automatization level continuously grows and becomes more advanced. Consequently, the development of aircraft on-board systems and new skills of aviation professionals becomes even more critical. As a result of research, methodological approach and general model for effective interconnection of on-board and innovative ATM technologies taking into account human factors is proposed.

Keywords: *air traffic management, avionics, innovative technologies, ergonomics.*

Introduction

ATM significantly contributes to the safety and efficiency of air traffic management. The regulation of air traffic flow further enhances the quality of air navigation service and improves the operational effectiveness of the ATM system. It also has a positive impact on the environment, reducing operational and fuel costs. Ultimately, air traffic flow regulation enables effective airspace organization, maximizing its utilization and providing dynamic and flexible flight routes to customers. Airspace organization involves optimizing the structure of airspace, its classification, air traffic service routes as well as visual and instrument flight procedures. These optimizations are conducted in accordance with standards and recommended set by ICAO GANP [1]. It is becoming clear that the currently existing navigational aids are gradually becoming outdated and, as a result, they cannot meet modern requirements. The next stage of the development of air navigation is closely tied to the utilization of GPS, GLONASS and GNSS for civil purposes. This advancement allows for the reception of signals from space satellites, enabling the determination of object coordinates anywhere around the globe. It become cleat that these systems provide much greater reliability and accuracy. They are also stable against atmospheric conditions, increase airspace capacity, offer economic benefits and reduce the impact of human factors. Additionally, an innovative concept Performance-Based Navigation (PBN), is utilized to enhance aviation security, improve aircraft flight performance, increase airspace capacity and enhance air navigation services [2].

Under these circumstances the development and implementation of innovative on-board technologies becoming critical, and it requires more proactive approach and further enhancement, which might also include new functionalities, new technologies, such are: On-board Automatic Dependent Surveillance – Broadcast/Contract (ADS-B/C), Controller and Pilot Data Link Communication (CPDLC), Electronic Attitude Direction Indicator (EADI), Electronic Flight Instrument System (EFIS), Electronic Horizontal Situation Indicator (EHSI) and others.

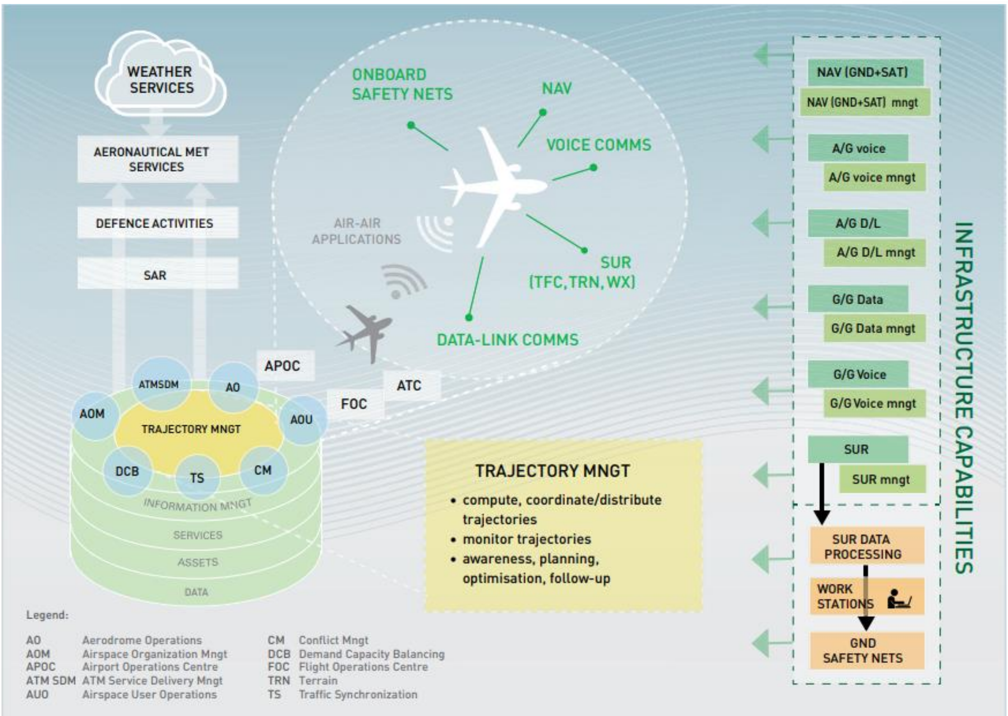

Figure 1. ATM logical architecture

Ground based satellite navigation and innovative technologies are in active phase of implementation global, regional and national levels proposed by the GANP activities, in order to achieve increase capacity, efficiency, and accuracy level of ATM system. Every ICAO member state is requested to fulfill GANP requirements and implement the best international practices on national level in their Air Navigation Service Providers (ANSP's) operation [3].

Figure 2. Multilayer Structure of the GANP on National Level

With other priorities, human performance-related considerations in the following areas should be taken into account for effective modernization of ATM on regional and national level:

- Quality of initial training;
- Adaptation developed procedures for new staff;
- Requalification smooth and effective process for active professionals;

- Implementation of new knowledge, skills and attitudes;
- New roles, autonomy, and responsibilities;
- Social factors and management of the cultural changes linked to increased automation [5].

Main problem in the more active implementation of the GANP is that, there are currently no unified requirements for all categories of ATM personnel, and also, the development of ATM technologies is faster, than training of personnel with appropriate qualifications. This problem is more visible in countries which, just have started an active modernization of ATM infrastructure. In particular, Latvia and Georgia are among these countries. The figure below shows the progress made so far, per Single European Sky ATM Research (SESAR) Essential Operational Changes, in the implementation of the SESAR phases based on the official statistics of the European Organization for the Safety of Air Navigation (EUROCONTROL, LSSIP 2022 – Local Single Sky Implementation, Latvia, Georgia) [4].

Table 1. SESAR Essential Operational Changes (Latvia, Georgia)

Latvia	**Georgia**	**Essential Operational Changes in ATM system**
100%	100 %	Interconnected ATM Networks
91%	84 %	Traffic Management System (TMA) and Airport Performance
87 %	82 %	Infrastructure and Services of Communication and Navigation Systems (CNS)
100 %	100 %	Digital Aeronautical Information Management (AIM) and Meteorological (MET) Services
100 %	90 %	Fully Dynamic and Optimised Airspace
100%	100 %	Trajectory Based Operations

Additional problem in this situation is that, as investigation reports and statistics of aviation accidents and incidents proves, there are still exist several facts, which have the straight connection with the human incomplete competencies in ATM maintenance [9].

Research Methodology

To fulfill the objectives, the research based on the following methodology: literature analysis, in particular, the theoretical works of scientists in aviation field common area of the research. Also the synthesis of information from reports, plans, broadcasts, analytical documents, and useful data from international aviation organizations (ICAO, EUROCONTROL, SESAR), the processing official investigation reports on aviation accidents and incidents. Basically in order to achieved aim of the research used analysis, synthesis, qualitative, statistical, deductive and comparison methods.

The aim of the research is to develop a methodological approach based on gap analyzes and modeling, that automatically determines the air traffic management system and on-board innovative technologies logical relationship and also will be connected through implementation to the learning outcomes of the proper educational programs of the educational institutions for human performance development.[7]

The main objectives of the research are as follows:

1. To create taxonomy of ATM innovative technologies, on-board modern systems and human performance;

2. To propose a methodology for assessment of gap between the implementation of ATM and avionics innovative technologies taking into account human factors;

3. To design, implement and evaluate an algorithm for educational courses syllabus and modules development of ATM and avionics technicians educational programs.

The main five research questions and the objectives of this work are the following:

1. Which main parameters are enhanced by implementation of innovative technologies in avionics and ATM systems operation?

2. How affects the technologies development on the reliability and safety level of flights assurance?

3. What theoretical and practical part should utilized in educational courses and syllabus in parallel of technological environment changes in this area of aviation?

4. What technical characteristics should be developed in cockpit systems to catch up ATM technologies development in order to achieve more effective interrelationship?

5. What type ergonomic factors are activated after active modernization of technologies on-board and ATM systems?

The main contribution of this work is, that by putting of developed models into practice together with enhanced ergonomic factors in new technological environment of ATM and on-board systems, it is possible to harmonize them effectively, which represents the scientific value of the research results and provides an increased level of flights safety, better throughput and enhanced efficiency of the air traffic.

Early Results

At the first stage of research presented methodology for assessing the accuracy and reliability of the radio navigation and radar systems widely used for today, in particular, Very High Frequency Omni directional radio range (VOR), Distance Measuring Equipment (DME), the Instrument and Microwave Landing Systems (ILS-MLS) and their proper on-board systems. Mathematical calculations, as well as methods of analysis and synthesis were used to determine compliance with modern technical requirements and norms of international aviation organizations, and a taxonomy of the main problematic issues were classified.[13]

A methodology for partially solving the above-mentioned problematic issues is proposed, including ways to increase the accuracy of the VOR radio beacon.

The formula for the dependence of phase on azimuth is given:

$$U = U_m[1 + m\,cos(\Omega t - \alpha)]\,cos\,\omega\,t \qquad (1)$$

Where m is the modulation coefficient; Ω - rotation frequency of the moving antenna; α - azimuth of the aircraft; ω - angular frequency of high frequency oscillations.

Several modifications to improve the accuracy of a VOR radio beacon using the formula are given in Table 2.

Table 2. VOR radio beacon modifications

Radio Beacon	Azimuth measurement error (degrees)	Note
VOR	2,5	P-Precision
DVOR	1,5	D- Doppler
PDVOR	0,8	H- High
PDVOR(H)	0,5	M-Medium
PDVOR(M)	0,3	

Mathematical calculations have established practical approaches to extend the DME and bring it into line with ICAO requirements:

$$D^2{}_d = R^2 + (R+H)^2 - 2R(R+H)$$
$$\cos\eta = 2(1-\cos\eta)(R^2+RH) + H^2 \quad (2)$$

$$D^2{}_d = 4\sin^2\frac{\eta}{2}(R^2+RH) + H^2 \rightarrow \sin^2\frac{\eta}{2} = \frac{D^2{}_d - H^2}{4(R^2+RH)} \quad (3)$$

Arc of spherical length at distances of no more than 600-700 km $\eta = \frac{D_s}{R}$

So $$\sin^2\frac{\eta}{2} = \sin^2\frac{D_s}{2R} = \frac{D^2{}_d}{4R^2} \text{ than } \frac{D^2{}_s}{4R^2} = \frac{D^2{}_d - H^2}{4(R^2+RH)}; \rightarrow D_s = \frac{\sqrt{D^2{}_d - H^2}}{\sqrt{1+\frac{H}{R}}} \quad (4)$$

Based on the research as well compared to the metric range ILS and MLS systems with following main advantages: increased accuracy and protection from obstacles; great reliability; providing wider airspace coverage, take-off management; runway and ground traffic management. The MLS device operates in the 5 GHz band. Compared to the ILS system, the MLS system provides an azimuth overlap in the forward sector up to ±60^0, with an elevation angle of 10-200.

Different methods of increasing the effectiveness of ground radar and on-board systems has been also investigated during the research, however, the implementation of the mentioned techniques in practice, based on the data of international aviation organizations, is insufficient to meet the airspace requirements expected by GANP 2016-2030.[11]

That is why the research work focused on analysis of the implementation of alternative innovative technologies necessary to meet the increased requirements caused by the growth intensity of flights, in order to successfully solve the given problems: lower material costs, provide easy technical service, increase accuracy, reliability and meet the safety requirements imposed on the system. In particular, the ways of automatic solution of navigation tasks are classified below, which should ensure the quality of adjustment of flight modes, especially the quality of transition processes.

- Frequency (aperiodicity);
- Shortness (short time constant);
- Astatism (absence of systematic error after the end of transient processes);
- Sustainability.

In order to fulfill these tasks, it is necessary to implement the following innovative technologies in the air traffic management system, on ground and in the cockpit. Alternative radio broadcasting technology of aircraft navigation service ADS-B, ADS-C and Multilateration (MLAT) system, in the work mathematically developed, algorithm of operation of each system and classified their advantages in relation to existing analogues.

The closed form of the lateralization algorithm allows to establish linear relationships between the parameters as a result of mathematical transformations, and does not require prior knowledge of any information about any aircraft. For these reasons, the closed form of the lateralization algorithm is adopted in practice. Determine how aircraft coordinates are obtained using the hybrid time of Time Difference Of Arrival (TDOA) lateralization algorithm. Let's assume that the first stage has already been completed and time readings have been received from the antennas.[12]

If τ_i is TDOA measurement performed by the principle, which is defined by the i number of antennas whose coordinates are: (x_i, y_i , z_i). Then, the equation that defines X = (x, y, z) from the transmitter to the antennas TDOA measurement of received signals will have the following form

$$\tau_i = \sqrt{\frac{(x-x_i)^2+(y-y_i)^2+(z-z_i)^2}{c}} \tag{5}$$

Where c = 3 x 10^5 km.

Eq. (5) describes the non-linear relationship between aircraft location *(x)* and TDOA measurement *(τ)*. If we square both sides of the equation, then equation (*1)* will take the form:

$$(\tau_i \times c)^2 = (x-x_i)^2+(y-y_i)^2+(z-z_i)^2 \tag{6}$$

By further simplifying formula (6), will have:

$$(\tau_i \times c)^2 = (x^2+y^2+z^2)-(2xx_i+2yy_i+2zz_i)+\left(x_i^2+y_i^2+z_i^2\right) \tag{7}$$

Designation:

$$\tau_i \times c = R_i,\ R = (x^2+y^2+z^2),\ K_i = \left(x_i^2+y_i^2+z_i^2\right) \tag{8}$$

If enter the formula (8) into (7), then will get:

$$R_i^2 = R-(2xx_i+2yy_i+2zz_i)+K_i \tag{9}$$

In the case of 4 receiving antennas, will have:

$$R_1^2 = R-(2xx_1+2yy_1+2zz_1)+K_1 \tag{10a}$$
$$R_2^2 = R-(2xx_2+2yy_2+2zz_2)+K_2 \tag{10b}$$
$$R_3^2 = R-(2xx_3+2yy_3+2zz_3)+K_3 \tag{10c}$$
$$R_4^2 = R-(2xx_4+2yy_4+2zz_4)+K_4 \tag{10d}$$

Large-scale use of the MLAT and ADS-B, ADS-C and other innovative ATM technologies system compared to primary and secondary radars significantly reduces material costs, facilitates maintenance work required for system operation, and increases the level of reliability and efficiency of the air traffic control system. The advantages of the these systems are expressed by meeting the requirements of

EUROCONTROL [6] and ICAO, technical testing showed that mentioned systems significantly exceeded the previous systems in detecting defects, this number reached a percentage of 98%, and the accuracy and quality of work were also improved.

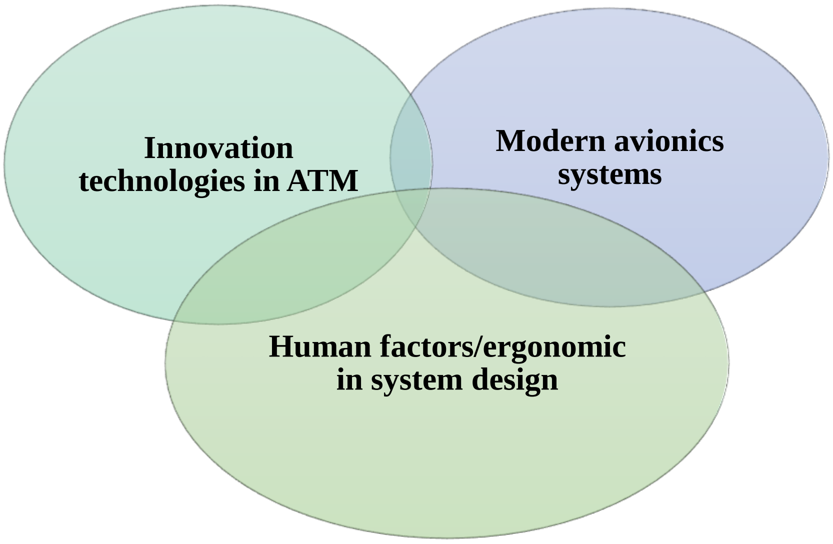

Figure 3. Vienne diagram for graphic representation main aim of research

Table 3. Gap analyses and taxonomy of ATM system complex operation

Taxonomy of avionics modern technologies for better integration in system design	**Taxonomy ATM innovation technologies implementation in system design**	**Principles for a better integration of human factors/ergonomic (HF/E) in system design**
On-board Automatic Dependent Surveillance – Broadcast (ADS-B)	Optimization of approach procedures including vertical guidance, by using of performance-based navigation (PBN) and ground-based augmentation system (GBAS)	Build joint design teams and don't treat HF/E as a mandatory add-on
Control and Pilot Data Link Communication (CPDLC)	Increased runway throughput through optimized wake turbulence separation Improve traffic flow through sequencing (AMAN/DMAN)	Make a coherent user centred design logical HF/E product
Electronic Attitude Direction Indicator (EADI)	Safety and efficiency of surface operations and enhanced vision systems (EVS)	Trying for a short, iterative user-centred design process
Electronic Flight Instrument System (EFIS)	Improved airport operations through. Increased interoperability, efficiency and	Develop objective HF/E criteria instead of follow on user opinions

	capacity through ground-ground integration	
Electronic Horizontal Situation Indicator (EHSI)	Service improvement through digital aeronautical information management	Assess as early as possible with the help of different prototypes
On-board Automatic Dependent Surveillance – Contract (ADS-C)	Meteorological information supporting enhanced operational efficiency and safety	Select convenient conditions for assessment: Evaluate daily operations as well as critical decisions and solutions
	Improved operations through enhanced en-route trajectories. Improved flow performance through planning based on a network-wide view	Help to be organized the problem-solving process during implementation by facilitating trade offs
	Initial capability for ground surveillance. Air traffic situational awareness (ATSA)	Do a proper problem design in the first place when it's possible to understand real problem and the find mechanisms and necessities
		Be part in strategic decisions and provide a purpose focused view of technology

Conclusions - Innovation technologies: new opportunities and risks

A case studies have been handled in order to identify possible gaps in training of aviation personnel involved- air traffic controllers, pilots and ATM engineers/technicians. The case studies have identified and have considered examples of recently developed and introduced new technologies which either are already used or might be used in the nearest future in Latvia and Georgia.

The technologies considered are summarized in a table:

Table 4. Methodological approach and general model for effective interconnection of on-board and ATM systems taking into account human factors

Change: new system or technology	**Impact on ATC's**	**Impact on pilots**	**Impact on ATM engineers/technicians**	**Risks**
Cockpit layout - A liquid-crystal displays (LCD)	No impact	Better quality picture	Different principle of operations	Incompatibility with other systems
New functionality-CPDLC	Additional tool to use when air traffic intensity is low	Additional tool to use when air traffic intensity is low	Complicated programming of the system, necessity to	Missed information due to inappropriate programming of

	New operational procedures New functional window to pay attention to	One more system to pay attention to New operational procedures	understand key issues, functions required by ATC and pilots (layout, message types, formats of messages, response times etc.)	messages Inability by technical personnel to fix issue due to lack of knowledge in pilotage or ATC
New flight parameters displayed or available – angle of attack	No impact	Additional parameter available which might influence safety of a flight	New parameter to distinguish, calculate and fix if necessary	Inappropriately shown parameter
New software tool for air traffic controllers- AMAN	New ATC tool which helps in approach phase to organize air traffic. But needs additional training to start using it and training when system becomes operational so that controllers are able to control traffic in case of failure of this system	Possibly shorter approach trajectories	New software functionality which can become inoperative	Air traffic controllers unable to work normally without this system. Engineers unable to understand problem of system's functionality which is vital for controllers because of lack of knowledge in air traffic control
Circle around radar blip to indicate which aircraft calls Air Traffic Controllers (ATCO)	Faster response time to a call from a pilot Easier to determine which aircraft calls	Possible faster reaction from ATCO	New item on list which should be checked New item on the list which can malfunction	ATCOs get used to the indication, unable to keep time of response within normal limits when the function is not available
New navigation aids available - Ground Based Augmentation System (GBAS) Landing System (GLS) - Performance Based Navigation (PBN) approaches	New approach trajectories, which are more flexible to environment and layout of an aerodrome	New flight trajectories	Use of additional systems (Global Positioning System GPS + GBAS), system compatibility	Systems incompatible

In the research six different technologies have been analysed and the conclusions have been made:

- New software technologies or tools are designed to make operational processes more flexible, to make air traffic controllers more reliable by introducing more automation, where automation analyse parameters and give solutions. Risk: air traffic controller step by step gets used to automation and loses skills in manual operation, consequently- unable to complete tasks without automation, not enough skills for manual operations;
- New radio navigation tools introduced to increase accuracy of systems and reliability of service. Risk: GLS is based on GPS, PBN is based on GPS. Might experience some difficulties of GPS is lost;

- New specific functionalities for air traffic controllers and pilots require more detailed understanding of operational procedures of air traffic control or pilotage of aircraft to keep systems operational. Risk - technicians unable to fix problems due to lack of knowledge in pilotage of aircraft or air traffic control procedures.

As a result, this research shows that on the one hand every new system, tool or function introduces more reliable parameters of characteristics, but on the other hand - more attention should be focused on personal training and maintenance procedures. More harmonized interconnection of main three research tasks provides increased safety, capacity and efficient level of ATM operation for the future growth requirements of air transportation in Latvia, Georgia and globally. With the fast-growing and high-density global air traffic, ensuring efficiency and air transportation safety becomes a critical challenge. Innovative technologies and automatization is already revolutionizing the way air traffic management systems are manufactured and hence is believed to play a key role in optimizing air traffic flow [13].

In the gained recommendations of the research obtained international experience and is possible to be provided, for both, as for aviation training institutions as well, for the air navigation service providers, and have a positive impact for the further development of aviation industry.

ACKNOWLEDEMENTS

This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [YS-21-483].

References

[1] Doc 9750-AN/963, 2016–2030 Global Air Navigation Plan. ICAO.

[2] ASBU Implementation Monitoring Report ICAO EUR States (2020) ICAO.

[3] European Air Navigation Plan (2022), ICAO EUR States, Volume III.

[4] EUROCONTROL (2022) Local Single European Sky Implementation (LLSIP) Latvia, Georgia.

[5] SESAR. *The Roadmap for Delivering High Performing Aviation for Europe.* Executive View European ATM Master Plan.

[6] EUROCONTROL *Forecast Update 2023-2029 years* https://www.eurocontrol.int/publication/eurocontrol-forecast-update-2023-2029

[7] *„Ontology based approach for human competency gap analysis in Air Traffic Management"* Autors: Igor Kabaskin, Nika Tikanashvili. Publication of paper in Transport and Telecommunication Journal, 2019, volume 20, no. 3 (ISSN 1407-6179, indexed in Scopus, Web of Science and others scientific data bases)

[8] Human Factors Digest No.6 ERGONOMICS, ICAO Circular 238-AN/143.

[9] Official Web-Page of Causes of Fatal Accidents by Decade. http://www.planecrashinfo.com/cause.htm

[10] Protégé - a free, open-source ontology editor and framework for building intelligent systems. https://protege.stanford.edu/

[11] International Standards and Recommended Practices, *ICAO Annex 19 to the Convention on International Civil Aviation.*

[12] Szabó, P., Ferencová, M. and Železník, V.: *Cloud Computing in Free Route Airspace Research*, 2022, Algorithms, MDPI.

[13] Nika Tikanashvili doctoral thesis *"Implementation of innovative technologies in the air traffic management system taking into account human factors in order to ensure the safety of flights"* scientific supervisors: DScTech, Professor Sergo Tepnadze., and Dr.habil.sc.ing., Professor Igor Kabashkin., Tbilisi 2019.

[14] AN-Conf/13-WP/232 ICAO 2018 "*Potential of Artificial Intelligence (AI) in Air Traffic Management (ATM)".*

[15] SESARJU, 2022 *MAHALO – Modern ATM via Human/Automation Learning Optimisation*

თანამედროვე ავიონიკის - საჰაერო მოძრაობის მართვის სისტემის ერგონომიკა და ინოვაციური ტექნოლოგიების დანერგვის შედარებითი ანალიზი. ლატვიისა და საქართველოს შემთხვევების შესწავლა

ნიკა თიკანაშვილი[1], მონტა ალექსანდრა ლაჩანე[2]
[1]საქართველოს საავიაციო უნივერსიტეტი, ქეთევან დედოფლის გამზირი
№ 16, 0103, თბილისი, საქართველო
[2]ტრანსპორტისა და ტელეკომუნიკაციის ინსტიტუტი
რიგა, ლატვია, ლომონოსოვას ქუჩა №1, LV-1019

რეზიუმე

ევროპის საჰაერო ნავიგაციის უსაფრთხოების ორგანიზაციის (EUROCONTROL)-ის კვლევის მიხედვით, 2035 წლისთვის ევროპის აეროპორტები მოემსახურება 14.4 მილიონ ფრენას და 1.4 მილიარდ მგზავრს. საჰაერო მოძრაობის მართვის ამჟამინდელი სისტემა (ATM) არ არის სრულ მზადყოფნაში საჰაერო მიმოსვლის მსგავსი მოცულობისათვის. სისტემა ვერ გაუმკლავდება თვითმფრინავების ასეთ დიდ რაოდენობას დროულად, რაც გამოიწვევს საჰაერო სივრცის გადატვირთულობას და მოძრაობის შეფერხებას მიწაზე და ჰაერში. ეს მდგომარეობა ეკონომიკურად არაეფექტურია და მნიშვნელოვან უარყოფით გავლენას ახდენს გარემოზე ნახშირბადის გამოყოფისა და ხმაურით დაბინძურების გამო. ამ მიზეზით აუცილებელია საჰაერო მოძრაობის მართვის სისტემის უწყვეტი განვითარება და მოდერნიზაცია. გლობალური საჰაერო ნავიგაციის გეგმა (GANP) არის მოქნილი საინჟინრო-ტექნიკური მეთოდოლოგიური დოკუმენტი, რომელიც საშუალებას აძლევს ყველა სამოქალაქო ავიაციის საერთაშორისო ორგანიზაციის (ICAO) წევრ სახელმწიფოს განავითაროს საჰაერო ნავიგაციის შესაძლებლობები მათი სპეციფიკური ოპერატიული მოთხოვნების საფუძველზე. GANP-ის წარმატებული განხორციელების ერთ-ერთი ყველაზე პრობლემური ნაწილია საჰაერო მოძრაობის მართვის სისტემის ინოვაციური და საჰაერო ხომალდის თანამედროვე ტექნოლოგიების ეფექტური ურთიერთკავშირი ერგონომიკური ფაქტორების გათვალისწინებით. სისტემის „ოპერატორი-მანქანა-გარემოს" ძირითადი ეფექტური ფუნქციონირება განისაზღვრება ადამიანური ფაქტორით და მნიშვნელოვნადაა დამოკიდებულია პროცესის ავტომატიზაციის დონესა და უამრავ ძირითად ტექნიკურ პარამეტრზე.

ნაშრომი ორიენტირებულია ლატვიისა და საქართველოს შემთხვევების შესწავლაზე. წარმოდგენილია დამოკიდებულება, ორივე ქვეყნის საჰაერო მოძრაობის მართვის სისტემაში ინოვაციური ტექნოლოგიების სწრაფ დანერგვას, თვითმფრინავების საბორტო სისტემების განვითარებასა და ავია სპეციალისტების შესაბამისი ახალი ცოდნითა და უნარებით მომზადების დონეს შორის. კვლევის შედეგად შემოთავაზებულია მეთოდოლოგიური მიდგომა და ეფექტური ურთიერთ დამოკიდებულების მოდელი საჰაერო მოძრაობის მართვის თანამედროვე სისტემების დანერგვასა და საბორტო ინოვაციური ტექნოლოგიების განვითარებას შორის, ადამიანური ფაქტორების გათვალისწინებით.

საკვანძო სიტყვები: *საჰაერო მოძრაობის მართვა, ავიონიკა, ინოვაციური ტექნოლოგიები, ერგონომიკა.*