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Directions for improvement of the organisation of air traffic controller training in Ukraine in the conditions of the Russian-Ukrainian War

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■ **Abstract.** . The research relevance is determined by the need to ensure the continuity and quality of training of air traffic controllers in Ukraine following international standards and requirements in the conditions of the closure of Ukrainian airspace for civil aviation due to Russian aggression and the impact of its consequences. The study aimed to substantiate directions for improvement of the organisation of air traffic controller training in Ukraine during the Russian-Ukrainian War. Analytical, comparative, and generalisation methods were used in the research. The study identified the main problems associated with the high-quality organisation of professional training for air traffic controllers in Ukraine under the conditions of the Russian-Ukrainian War, which have both military and systemic reasons. The features of the organisational system for training air traffic controllers in different countries were outlined. A general overview of the regulatory and legal framework for assessing and monitoring the professionally relevant qualities of air traffic controllers was provided based on the requirements of the International Civil Aviation Organisation. An overview of the four levels of readiness of future air traffic controllers for professional activity was summarised, describing low, sufficient, medium, and high levels, based on the specific nature of their duties. An expanded set of criteria for evaluation of the readiness of aspiring air traffic controllers was proposed. Based on the practical experience of the Ukrainian State Flight Academy, a set of measures was suggested to improve the efficiency of automated testing and assessment of the knowledge of future air traffic controllers. The practical significance of the study is determined by recommendations to improve the training system for air traffic controllers in Ukraine in martial law conditions. Their implementation will help overcome the existing challenges in ensuring the organisation of high-quality training for air traffic controllers in Ukraine. Furthermore, it will create the foundation for the rapid recovery and development of the Ukrainian aviation industry after the war

■ **Keywords:** professional training; civil aviation; levels of readiness for professional activity; methods of assessing professional suitability; professionally relevant qualities

■ Introduction

The foundation for ensuring flight safety in civil aviation is primarily the quality of training organisation for future aviation professionals, especially air traffic controllers. This is a key element of the aviation incident prevention system. In Ukraine, the effective organisation of professional training for air traffic controllers, especially

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in conditions of the Russian-Ukrainian conflict, faces numerous significant challenges stemming from both military and systemic issues. Since February 2022, Ukrainian airspace has been closed to civil aviation due to Russian hostility, rendering practical training in real conditions impossible. Simulator training, which is critical for air traffic controllers, is limited due to restricted access to live air traffic data and the inability to practise skills in active airspace. Therefore, cadets are unable to gain comprehensive experience of real air traffic flows, which diminishes the readiness for duty after the end of the war. Training centres for air traffic controllers, such as those at the Ukrainian State Flight Academy, partly mitigate this issue but cannot fully replicate real-world conditions and are equipped with outdated simulators, such as the "Start" system introduced in 1990. Martial law has resulted in reduced state funding for aviation education in Ukraine, as priority shifts to defence needs. The procurement of modern simulators, software updates, and the upkeep of training infrastructure are hampered by limited financial resources. Outdated equipment and restricted access to modern technologies (AI-based simulators) reduce the quality of air traffic controller training compared to international standards.

O. Danylko *et al*. (2023) conducted a comparative analysis of different aspects of professional training in foreign higher education institutions specialising in aviation. The implementation of the concept of collaborative decision-making among air traffic controllers, pilots and airport operators was emphasised in the organisation of training for air traffic controllers. Y. Chen *et al*. (2024) examined methods to optimise aircraft flows. In response to rising workloads for air traffic controllers, the study suggested development of digital twins of airfields to test crisis response scenarios. M. Kaya & S.S. Ateş (2023) investigated the integration of artificial intelligence (AI) into decision-making support systems for controllers in air traffic management. The proposed approach can significantly increase the trust of operators in automated solutions, especially in conditions of high load and uncertainty. M. Jameel *et al*. (2023) presented a virtual pilot for training air traffic controllers, integrating advanced AI tools. This system receives voice commands from student controllers, recognises and interprets them, and then generates a response that imitates the pilot's speech. The proposed system can significantly accelerate the training process of air traffic controllers, reducing dependence on human simulator pilots and reducing overall training costs. The use of open AI tools can facilitate adaptation of the system to different conditions and scenarios (García *et al*., 2023). The use of a digital air traffic controller assistant (digital ATCO), which is integrated into the controller's workplace and performs tasks such as detecting and resolving conflicts, creating commands, and communicating with pilots (Jameel *et al*., 2023), is relevant in the training of controllers. M. Kalashnyk-Rybalko & G. Kalashnyk (2025) and G. Kalashnyk *et al*. (2025) addressed improvement of technological solutions for prevention of psychophysiological causes of language errors of air traffic controllers, developing criteria and indicators for diagnosing leadership competence as a professionally substantial quality of controllers. The organisation of professional training of air traffic controllers in different countries prioritise the integration of modern technologies, psychological training methods and compliance with international standards. At the same time, the processes of organisation of the training of air traffic controllers in the conditions of modern hybrid warfare and its consequences are not sufficiently considered in scientific publications.

Among the factors influencing the external environment on the functioning of the organisational system for training air traffic controllers in Ukraine, it is possible to distinguish significant instability of the labour market and crisis phenomena in the economy of Ukraine in the conditions of the Russian-Ukrainian War; instability of the socio-economic system of Ukraine; acceleration of the rate of knowledge obsolescence; rapid development of intellectual information technologies and AI systems in adaptive simulators for training air traffic controllers; transition from the teaching paradigm (transfer of information) to the learning paradigm (transfer of action potential). In the conditions of a competency-based approach (competence-based education), this specificity imposes requirements on the procedures for solving the relevant tasks of organising education, which determines a relevance of a new scientific and methodological concept based on modern information technologies (Kiryanova, 2024). The improvement of the organisation of training of air traffic controllers, which is based on a competency-based approach to training, was emphasised. The study identified ways to enhance the organisation of air traffic controller training in Ukraine under the conditions of the Russian-Ukrainian War.

Materials and Methods

The methodology of this study was based on a systemic approach, which ensured a comprehensive consideration of directions for improving the organisation of training for air traffic controllers in Ukraine. The study was conducted through systematic processing of various materials and sources that reflect the features of the organisation of the educational process and the specifics of the organisational system for training air traffic controllers. The subject of an analysis was the main issues related to the proper organisation of professional training for air traffic controllers in Ukraine amid the Russian-Ukrainian War, along with potential solutions. A comparative analysis of the organisation of training for air traffic controllers across different countries was

performed. The United States (US), The United Kingdom (UK), EU countries, and Ukraine were selected for comparative analysis. These countries exhibit different characteristics in the technical training of air traffic controllers and variations in educational infrastructure, facilitating a comprehensive study. This analysis emphasised key aspects such as training duration, costs, technical training features, availability and condition of educational infrastructure, training focus, and adherence to international standards. This approach was applied for a detailed study of the professional training systems for air traffic controllers in various countries, as well as to identify key trends, differences, and opportunities for enhancing the Ukrainian training system.

Data were collected from diverse sources, including scientific articles (Zuluaga-Gomez *et al*., 2023; Kaya & Ateş, 2023; Chen *et al*., 2024), regulatory documents of the International Civil Aviation Organisation (ICAO), notably Document 4444 (ICAO, 2016), Annex 1 (ICAO, 2022), Annex 11 (ICAO, 2018), European Aviation Safety Agency (EASA, 2023), Commission Regulation (EU) No. 2015/340 (2015), Eurocontrol Specifications for the ATCO Common Core Content Initial Training (EUROCONTROL, 2015) and Ukraine's Aviation Rules (Order of the State Aviation Service of Ukraine No. 485, 2018). The data was collected to gather extensive information about various aspects of air traffic controller training in the studied countries. The legal framework governing the operation of Ukraine's aviation education system for training air traffic controllers (ATC) was also analysed, which is regulated by several legal acts aligned with international standards, notably those of ICAO and EASA. The analysis utilised regulatory documents from ICAO, EASA, and relevant national legislation such as the Aviation Rules of Ukraine, among others.

In the next phase of the research, the regulatory and legal framework for assessing and monitoring the professionally significant qualities of air traffic controllers was examined in accordance with ICAO regulatory documents (ICAO, 2016; ICAO, 2018; ICAO, 2020; ICAO, 2022a; ICAO, 2022b). This analysis was conducted to summarise the requirements for the organisational system of training air traffic controllers based on ICAO regulations, and to generalise the indicators and criteria for assessing readiness for professional activities. Hence, key criteria, indicators, and methods for evaluating the readiness levels of air traffic controllers were compiled, and the characteristics of four readiness levels for future air traffic controllers – low, sufficient, medium, and high – were established based on the specifics of their professional duties.

In the subsequent stage, sets of criteria and tests used to assess the readiness of air traffic controllers for professional activity were analysed including the ATSA – air traffic skills assessment of the US Federal Aviation Administration (FAA, 2021), and first European air traffic controller selection test (FEAST) (EUROCONTROL, n.d.). During the analysis of scientific literature, a selective search for sources was conducted in the databases of Scopus, Web of Science, Researchgate, Google Scholar, as well as in regulatory document repositories of ICAO, FAA, EASA and EUROCONTROL. The following criteria for source selection were applied: relevance of publications and relevance to the research topic. This provided a comprehensive overview of modern approaches to training air traffic controllers in accordance with international requirements and within the context of current global challenges.

Results and Discussion

Air traffic controllers are a substantial component of air traffic safety. Civil aviation has a developed network of industry-specific higher educational institutions, colleges and training centers. Air traffic controllers are required to undergo a certification and attestation procedure with the issuance of an appropriate document. The isolation of Ukrainian civil aviation from international airspace has hindered integration with EUROCONTROL and ICAO programmes. Limited access to international training centres and exchange schemes diminishes opportunities for updating to modern standards. Regressed European training standards, such as Commission Regulation (EU) No. 2015/340 (2015), may hinder the recognition of Ukrainian air traffic controller certificates after the war. Therefore, improvemenet of the organisation of air traffic controllers' training in Ukraine during the Russian-Ukrainian War is crucial for the swift recovery of civil aviation once the war concludes.

Features of the organisational system for training air traffic controllers include increased responsibility for the results of professional activities, as controllers are responsible for air transport safety. This determines strict requirements for the quality of professional training and for decision-making processes, as each decision carries high stakes and the risk of catastrophic consequences in case of errors. Air traffic controllers must be able to make the right decisions under strict time constraints, while operating within an environment where the safety criterion imposes stringent demands on all aspects of their professional activities. At the same time, the peculiarities of their training are shaped by the impossibility of practicing skills for actions in extraordinary in-flight situations, the incompleteness or contradictions of information received during aircraft control, and the unpredictability of when and where special situations may arise. These conditions complicate training of controllers regarding emergencies, thus necessitating the development of creative thinking to assess situations, devise and implement optimal solutions under conditions of stress and time pressure. Covering these aspects, the study analysed the organisation of training for air traffic controllers in different countries (Table 1).

Table 1. *Features of the organisation of training for air traffic controllers in different countries*

Country/ Region	Duration of training	Cost of training	Features of technical training	Availability and condition of educational infrastructure	Main focus of training
US	2-5 years (depending on the program: initial training, ~3-5 months at the FAA Academy, further on-the-job training 1-3 years)	Free for candidates accepted to the FAA Academy (government-funded); private programs cost 10,000-30,000 USD per course	Use of simulators (TRACON, En Route), radar and non-critical systems training, emphasis on FAA standards	Highly developed infrastructure: FAA Academy (Oklahoma), simulation centers, partnership with universities (CTI programs)	Flight safety, strict adherence to FAA procedures, and rapid response in high-traffic conditions
UK	1-2 years (initial training, ~12-18 months at NATS or colleges, plus up to 6 months of practical training at the facility	20,000-50,000 GBP (depending on the program; NATS partially subsidises for selected candidates)	Modern simulators (3D airport models), training in management according to EUROCONTROL standards, and emphasis on automated systems	Well-developed infrastructure: NATS College, simulation centers at airports (Heathrow, Gatwick), cooperation with EUROCONTROL	Coordination with European standards, efficiency at busy airports, and stress resistance
EU countries	1-3 years (depending on the country: initial training ~6-12 months, practical training 1-2 years)	10,000-40,000 EUR (in some countries subsidised by the state or EUROCONTROL)	Use of SESAR simulators, training in European standards (EASA), emphasis on intercultural interaction	Diverse infrastructure: national centers (e.g. DFS in Germany, DSNA in France), coordination through EUROCONTROL	Diverse infrastructure: national centers (e.g. DFS in Germany, DSNA in France), coordination through EUROCONTROL
Ukraine	4 years years (full-time) for a bachelor's degree, an additional 1 year 5 months for a master's degree, and practical training at the facility for up to 6 months	The approximate cost of a bachelor's program is 60,000-120,000 UAH per year (depending on the full-time or part-time form of study)	Using automated systems such as "Start", with emphasis on air traffic safety, at a high level of proficiency in aviation phraseology according to ICAO standards	The Ukrainian State Flight Academy is the main institution for training air traffic controllers. Equipped with an air traffic control training center for practical training	Flight safety, training meets international ICAO standards, harmonisation with European standards

Note: *Collegiate Training Initiative (CTI) – USA Federal Aviation Administration (FAA) program, which collaborates with colleges and universities to train future air traffic controllers; SESAR – Single European Sky ATM Research; NATS – National Air Traffic Services; DFS – Deutsche Flugsicherung GmbH; DSNA – Direction des Services de la Navigation Aérienne*

Source: *compiled by the authors based on NATS (n.d.), Order of the State Aviation Service of Ukraine No. 485 (2018), EASA (2023), OFR & NARA (2025)*

In EU countries, ATC training programs are long but provide in-depth theoretical training. The US prioritises practical training and a fast transition to work, which is suitable for a quick introduction of controllers into the profession, but may limit the theoretical basis. European ATC training programs are more universal for international careers, while the US is adapted to local conditions, which may limit the mobility of graduates.

The legal framework for the functioning of the aviation education system of Ukraine for the training of air traffic controllers is regulated by regulatory legal acts that comply with international standards, in particular the requirements of the ICAO and the EASA. These documents establish requirements for the organisation of training, licensing, certification and maintenance of professional qualifications of ATC controllers. The Aviation Rules of Ukraine (Order of the State Aviation Service of Ukraine No. 485, 2018) are a key document in regulating the professional training of ATC controllers. It is based on ICAO standards (Commission Regulation (EU) No. 2015/340, 2015; ICAO, 2016; ICAO, 2022a). Aviation Rules of Ukraine (Order of the State Aviation Service of Ukraine No. 485, 2018) establish requirements for: qualification standards (education, medical certification, English language proficiency at ICAO Level 4 or higher); training programs that include theoretical training, practical training on simulators and internships; procedures for issuing ATCO Licenses and ratings; determines the mandatory accreditation of educational institutions that provide training and their compliance with EUROCONTROL standards. ICAO has established standards and recommended practices for the training, licensing and maintenance of professional competence of controllers. These requirements are aimed at ensuring flight safety by assessing the professionally relevant qualities of air traffic controllers (Table 2).

The analysis of research data by Y. Chen *et al.* (2024), M. Kaya & S.S. Ateş (2023) supported the need to improve assessment methods, as well as the criteria and indicators of professional readiness. Based on the review of modern approaches to evaluation of information systems and the specifics of air traffic controller training, improved indicators and criteria for assessing readiness were proposed, encompassing psychophysiological, intellectual, theoretical, and practical aspects. Selection of candidates with suitable psychophysiological traits was prioritised due to flight safety heavily relying

on quick decision-making under stress. Assessing the readiness of future air traffic controllers for professional activity is a key element of their training in the context of the high responsibility and specificity of their professional duties (Table 3).

The research summarised the characteristics of four levels of readiness of future air traffic controllers for professional activity – low, sufficient, medium and high – considering the specifics of their professional activity (Table 4).

Table 2. *Regulatory and legal support for the assessment and monitoring of professionally relevant qualities of air traffic controllers*

ICAO document	Criteria for professionally relevant qualities	Methods of assessment and monitoring	Application of the requirements of the document during preparation
Annex 1 – Personnel Licensing	Cognitive: memory, attention, spatial thinking. Psycho-emotional: stress tolerance, emotional stability. Communicative: English (ICAO Level 4)	Medical certification (Class 3), psychological tests (attention, memory, stress tolerance tests), periodic competency exams (knowledge of procedures, communication)	Psychological selection before training, regular medical examinations, and language tests
Doc 4444 – PANS-ATM	Spatial awareness, quick decision-making, and communication skills	Simulation assessments, On-the-job training (OJT) observations, and radio communication assessment	Simulation training for developing air traffic control skills
Doc 9868 – Training	Cognitive: information processing, memory. Psycho-emotional: stress tolerance, decision-making. Communicative: ICAO phraseology	Psychological tests, simulation exercises, periodic refresher courses	Stress management training, team interaction, simulation training, and language courses
Doc 10056	Cognitive and psychological qualities, teamwork, and situational awareness	Competency-based assessment, automated systems for monitoring performance, observation and assessment by trainers during practical sessions	Integration of human factors into training
Annex 11 (Air Traffic Services)	Professional competence, communication skills, and operational efficiency	Practical exams, monitoring procedures, certification	Practical exams, monitoring procedures, certification

Source: *compiled by the authors based on ICAO (2016), ICAO (2018), ICAO (2020), ICAO (2022a), ICAO (2022b)*

Table 3. *Generalised criteria, indicators and methods for assessing the levels of readiness of air traffic controllers for professional activity*

Assessment criterion	Criterion description	Indicators	Assessment methods	Relationship to professional duties
Cognitive competence	Ability to process information quickly, think spatially, multitask, and predict	Reaction time to tasks. Accuracy of test scenarios; Number of errors in simulations; Ability to predict trajectories	Psychometric tests (e.g., ATSA); Simulation exercises on simulators; Spatial imagination tests	Need for rapid analysis of complex scenarios, real-time coordination of aircraft movements, and avoidance of airspace conflicts
Psycho-emotional resilience	Ability to remain calm, efficient and self-controlled under stressful conditions	Anxiety level; HRV; Recovery time after stressful tasks	Psychometric tests (e.g. ATSA, MMPI); Physiological measurements (HRV, EEG); High-stress simulations; TOVA attention and concentration tests	Working under high pressure, need to make decisions in critical situations
Professional knowledge and skills	Mastery of ICAO standards, ATC procedures and the ability to apply them in practice	Accuracy of procedures; Knowledge of the regulatory framework (assessment through tests); Efficiency in simulation tasks	Written tests on knowledge of standards; Simulation exercises on simulators; Assessment of the implementation of standard procedures	Ensuring the safety and efficiency of air traffic through compliance with international standards
Communicative competence	Clarity, conciseness and correctness of communication, particularly in an English-speaking environment	Quality of communication (clarity, compliance with ICAO standards); Use of standard phraseology; ICAO language proficiency level 4+	Analysis of communication recordings during simulations; English language proficiency tests (ICAO Language Proficiency)	Clear transmission of instructions to pilots, coordination with other controllers in an international environment
Team interaction	Ability to cooperate, lead and adapt to teamwork	Level of cooperation in group tasks; Leadership qualities (assessment through behaviour); Adaptability to a multicultural environment	Observation of behaviour in team simulations; Assessment of intercultural competence	Coordination with other controllers and participants in the aviation system to ensure safety

Note: *MMPI – Minnesota Multiphasic Personality Inventory; HRV – Heart rate variability; EEG – ElectroEncephaloGram*
Source: *compiled by the authors based on ICAO (2016), FAA (2021), ICAO (2022a), ICAO (2022b), J. Zhang et al. (2023), D. Ziakkas et al. (2024), V. Polishchuk et al. (2024)*

Table 4. *Characteristics of the levels of readiness of air traffic controllers for professional activity*

Level	Characteristics of readiness levels
Low	▪ Slow response to pilot requests: delays in issue of instructions; ▪ Low coordination accuracy: frequent errors in traffic management; ▪ Poor multitasking: difficulty handling multiple tasks simultaneously; ▪ Low stress tolerance: loss of concentration under pressure; ▪ Limited interaction with pilots: unclear or contradictory instructions.
Sufficient	▪ Adequate response speed to requests, but possible delays in peak conditions; ▪ Moderate coordination accuracy: rare errors in traffic management; ▪ Basic multitasking: ability to handle several tasks under standard conditions; ▪ Moderate stress tolerance: maintaining concentration in non-critical situations; ▪ Clear instructions, but with limited adaptability.
Medium	▪ Prompt response to pilot requests in most situations; ▪ High coordination accuracy: minimal errors in air traffic control; ▪ Efficient multitasking: managing multiple tasks in complex conditions; ▪ Good stress resilience: maintaining focus during peak situations; ▪ Adaptive instructions: adjusting to changes in air traffic.
High	▪ Instant response to pilot requests, even in crisis conditions; ▪ Flawless coordination: no errors in complex traffic scenarios; ▪ Exceptional multitasking: effectively managing multiple tasks simultaneously; ▪ Strong stress resistance: maintaining stable performance under peak loads; ▪ Adaptive instructions: predicting changes and optimising traffic; ▪ Capable of handling with new technologies.

Source: *developed by the authors based on ICAO (2016), ICAO (2022a), ICAO (2022b)*

The characteristics of the readiness levels (low, sufficient, medium, high) are based on the ability of candidates to perform professional duties in conditions of multitasking, stress and automation. The professional duties of air traffic controllers include multitasking, rapid response to changes in the airspace, coordination with crews and adaptation to automated systems. Different countries use different sets of criteria and tests to assess the readiness of air traffic controllers for professional activities: ATSA (FAA, 2021), FEAST (EUROCONTROL, n.d.) of the European Air Traffic Management Program (EATMP), which complicates unification. Despite progress, according to researchers by Z. Chen *et al*. (2021), modern simulators do not always reproduce the emotional pressure of real-life working conditions for an air traffic controller. It requires improving assessment methods, as well as improving the criteria and indicators of readiness for professional activity.

An examination of methods used for organising air traffic controller training (Zuluaga-Gomez *et al*., 2023; Chen *et al*., 2021) identified common organisational shortcomings, including issues related to the effectiveness of automated testing and the assessment of air traffic knowledge of controllers. To improve the efficiency of automated testing and assessment of air traffic controller knowledge, a set of measures was proposed by expanding the range of simulator scenarios using AI and developing adaptive test systems that use machine learning for the dynamic selection of tasks based on the controller's level of knowledge and responses to reduce testing duration; using cloud technologies to deploy test and simulation systems.

The indicators used to assess the professional suitability of a future air traffic controller include both objective and subjective indicators. Objective indicators include the results of cognitive ability tests (for example, attention and memory tests), simulator assessments, and error statistics. Subjective indicators include instructor assessments, candidate self-assessment, and psychological stress resistance tests. A comprehensive approach to assessing the professional suitability of air traffic controllers is relevant, with an emphasis on cognitive (attention, memory, spatial orientation, analytical thinking) (de Freitas *et al*., 2022; Ceken, 2025), psychomotor (reaction speed, coordination, accuracy of task performance), and personal (stress resistance, responsibility, initiative, self-criticism) components. It is necessary to improve automated systems for testing and monitoring of knowledge, skills, and abilities among candidates. The indicators and criteria for evaluation should be comprehensive, covering technical, pedagogical, economic and psychophysiological aspects, and also comply with the principles of systematicity and practical applicability. Based on the analysis of modern approaches to the evaluation of information systems and the specifics of the training of air traffic controllers, the following indicators and criteria were proposed (Table 5).

Table 5. *Criteria and indicators of readiness of the air traffic controller for professional activity*

Criterion	Indicator	Description
Psychophysiological stability	Level of stress tolerance, reaction speed	Assessment of the dispatcher's ability to work under conditions of high psycho-emotional stress
Intellectual abilities	Accuracy of decision-making, analytical thinking	Ability to analyse complex situations and make quick and accurate decisions

Table 5. Continued

Criterion	Indicator	Description
Theoretical knowledge	Knowledge of regulations, ATC procedures, and radio telephony	Mastery of special disciplines, necessary for air traffic control
Practical skills	Performing management procedures, interacting with crews	Ability to apply knowledge in practice, including use of automated systems
Flight safety	Probability of avoiding emergencies	Assessment of the controller's ability to prevent emergencies and ensure safety
Workstation throughput	Number of aircraft handled per unit of time	Controller efficiency in heavy air traffic conditions
Use of automated systems	Accuracy of work with information systems	Ability to effectively interact with automated control points
Level of professional training	Results of automated and traditional diagnostics	Assessment of readiness for independent work based on testing and simulations
Adaptability to change	Flexibility in responding to non-standard situations	Ability to adapt to changes in airspace or regulations
Level of professional communication	Quality of communication (clarity, compliance with ICAO standards); Use of standard phraseology; ICAO language proficiency level 4+	Clear transmission of instructions to pilots, coordination with other controllers in an international environment

Source: *compiled by the authors based on Order of the State Aviation Service of Ukraine No. 485 (2018), EASA (2023)*

The study substantiated an expanded set of criteria for evaluating the readiness of future air traffic controllers for professional activity, encompassing psychophysiological, intellectual, theoretical, and practical aspects (Table 5). Particular emphasis was placed on selecting candidates with suitable psychophysiological traits, as flight safety largely relies on their ability to make quick decisions under stressful conditions. Under normal flight conditions, operations of air traffic controller are strictly governed by regulatory documents, which facilitate the algorithmic organisation of their tasks. Modern methods of organising training for air traffic controllers do not fully meet modern standards for development of their knowledge, skills, and abilities, nor do they ensure the reliability and promptness of decisions in critical situations. The most notable shortcomings in the organisation of training for air traffic controllers include (Kaya & Ateş, 2023): inadequate consideration of individual training characteristics, insufficient effectiveness of knowledge acquisition, limited success of independent training, ineffective control and ongoing assessment of trainees' knowledge, skills, and abilities, limited capabilities of specialised technical tools, low efficiency of simulator training, which does not account for individual differences, limited visibility, accessibility, and duration of knowledge acquisition. Additionally, in conditions of martial law, aviation educational institutions in Ukraine are compelled to adapt to distance learning formats, which are not always effective for the practical training of air traffic controllers.

Problem-based learning is a vital method in training air traffic controllers, as it encourages the development of critical thinking, independence, and the ability to solve complex professional tasks under conditions of uncertainty. This approach fosters crucial qualities, such as attention, memory, observation, initiative, caution, and determination; it also aids in developing skills for analysing complex situations that occur during air traffic control; and it stimulates the cognitive activity of cadets through the modelling of real work scenarios. During theoretical training, problem-type tasks are utilised to simulate real air traffic control situations to educate on how to make quick decisions under stress and while multitasking. Since air traffic controllers operate under high psychological pressure, the training process emphasises fostering psychological resilience and cognitive capabilities. The psychological foundations of problem-based learning consider the factors of task complexity that influence the development of swift response and decision-making skills. Qualities such as criticality, self-criticism, unconventional thinking, and responsibility are cultivated, which are essential for the role of a air traffic controller.

In EU countries, problem-based learning is used in training air traffic controllers, fostering critical thinking and decision-making skills in stressful situations, along with intensive use of simulators that imitate real scenarios, such as conflict and emergencies (Efthymiou, 2023). The USA prioritises practical training through simulators and OJT (On-the-Job Training). Theoretical training in the USA is kept to a minimum for earlier progression to practical skills. Case methods are commonly employed to analyse real air traffic incidents. Despite advancements in training air traffic controllers, certain issues remain. These include the insufficient adaptation of problem-based learning methods to the specific requirements of training controllers as operators of complex system, the need for continuous updates to training programmes correlating with the latest technologies and standards of the ICAO, and limited access to modern training facilities at some aviation educational institutions. To enhance the effectiveness of air traffic controller training, it was essential to address the challenges of adapting methods, updating training programmes, and providing modern training facilities. Training of air traffic controllers as a problem area, which includes pedagogical and psychological knowledge, is poorly formalised. To solve this problem, it is necessary to use modern information technologies and AI methods (Degas *et al*., 2022; Abu Talib *et al*., 2025).

In the process of planning air traffic controller training, three typical elements can be distinguished: theoretical training, practical training, and control. Theoretical (pre-training) education includes studying the basics of air navigation systems, concepts of air traffic organisation, air traffic service procedures, and principles of capacity management. Professional disciplines that form the foundational knowledge for a dispatcher are prioritised. The greatest opportunities for adaptation to professional activity are offered by practical training. It is designed to determine and reinforce the educational material in declarative systems, to develop professionally relevant skills and abilities, and to foster intuition in procedural systems (simulators). During simulator training, four main steps are identified presenting the trainee with exercises on a specific training element or a set of elements that the cadet has become familiar with during the initial review of the theory, executing these exercises by the trainee, computer evaluation of each exercise's results, providing the necessary assistance throughout each exercise.

Simulation systems and simulators are employed to assess practical skills in simulated conditions, such as air traffic control or emergency response, for example, using a Full-Flight Simulator (FFS) or ATC simulators (Ziakkas *et al*., 2024). The Ukrainian State Flight Academy operates a certified air traffic control training centre. Advantages of simulation systems and simulators for training air traffic controllers include realistic reproduction of the working environment, assessment of reactions to stressful situations and multitasking, and collection of real-time data on decision-making. Disadvantages of these systems for training include high development and operational costs, limited scenario variety compared to real-life conditions and difficulty in assessing "soft" skills such as communication and leadership.

Systems such as EUROCONTROL FEAST (EUROCONTROL, n.d.) are adapted for use in aviation training centres. The Ukrainian State Flight Academy hosts a certified training centre for administering the EUROCONTROL FEAST. CBT systems are used to evaluate theoretical knowledge, covering air traffic rules, phraseology, meteorology, and more through multiple-choice questions, matching tasks, or direct answers. These systems offer several advantages: rapid result processing, the ability to generate large question databases with random selection, and objective assessment (free from subjective influence by instructors). However, limitations include restricted evaluation of practical skills, the potential for rote memorisation of answers, and the absence of assessment of the cadet's psychophysiological state. A substantial element in assessing the readiness for professional activity of future air traffic controllers are systems of analysis of behaviour and psychophysiological state. They use biometric data (heart rate, stress level, reaction speed) (Lambay *et al*., 2024) to assess the readiness for high load conditions. Among their advantages are the ability to evaluate psychophysiological stability and identify overload risks (Zhang *et al*., 2023). However, they also have disadvantages, such as limited integration with other assessment systems and the high cost of equipment (for instance, sensors for monitoring). Automated adaptive testing systems dynamically adjust the complexity of questions or scenarios based on the controller's level of training. They can be used for personalised assessment and reduce testing time by removing tasks that are too easy or too difficult. Among the challenges are the complexity of developing adaptation algorithms and the need for a large task database.

Automating the system for assessing a future air traffic controller's readiness significantly reduces subjectivity in evaluation. Simulation systems cane be used for practical skills assessment in conditions close to real life, while adaptive systems enhance engagement and training effectiveness. However, their use during training faces challenges such as high development and implementation costs, and a limited number of scenarios in simulators, which do not always reflect real air traffic controller conditions. Based on the results of the research, the following set of measures was proposed to increase the efficiency of automated testing and assessment of knowledge of air traffic controllers: a comprehensive evaluation covering knowledge, skills, and stress tolerance, expantion of the scenario database using AI to generate dynamic situations that emulate rare or extreme events (e.g., equipment failures, adverse weather), developing adaptive testing systems that employ machine learning to tailor tasks based on the controller's knowledge and reactions, thereby reducing test duration and increasing accuracy; utilising cloud technologies to deploy testing and simulation systems, which lowers hardware costs. Collaboration with organisations such as EUROCONTROL and ICAO is essential to standardise new methods of automated testing and ATC controller assessment. However, the ongoing Russian-Ukrainian War has limited cooperation with EUROCONTROL, EASA. Restricted access to global training centres and exchange programmes hampers adaptation to contemporary standards.

The approach to optimisation of the activities of air traffic controllers from the perspective of training is based on the concept that the effectiveness of their work is dependent on their level of competence. From this standpoint, practical tasks related to professional selection and training are addressed, forming the organisational system of air traffic controller training. This system encompasses two types of logically interconnected tasks: design and development of internal work tools, which include creating training programmes, developing the ontology of educational disciplines, and establishing optimal (rational) schedule, planning and predicting the results of air traffic controller training,

which include evaluating the preparedness of each air traffic controller at a specific training period, forecasting the duration of training, developing a model for an air traffic controller, selecting effective means and methods for training air traffic controllers and enhancing the, establishing quantitative criteria to assess the level of readiness of air traffic controllers, determining suitable periods for training (including re-training) and verifying the level of competence of air traffic controllers.

The main institution for training air traffic controllers in Ukraine is the Ukrainian State Flight Academy (Kropyvnytskyi). It is accredited to train air traffic controllers based on ICAO and EASA standards. The academy's training programmes for air traffic controllers include basic training to acquire initial knowledge, simulator training, rating training for specific sectors such as aerodrome, area, or approach control, and OJT. The Ukrainian State Flight Academy employs a simulator that replicates real working conditions for air traffic controllers. However, the simulator and many training tools at the academy are outdated, which hampers training for modern automated air traffic control systems. Martial law, in effect since 2022, restricts access to equipment upgrades due to financial constraints. The closure of airspace during the war further complicates practical training and internships for future air traffic controllers. Modernising air traffic controller training simulators and introducing simulators supporting systems such as SESAR (n.d.) will help align with European standards, which is vital for Ukraine's future integration into the single European aviation space. Candidates applying to the Ukrainian State Flight Academy must undergo a strict medical examination following ICAO Class 3 standards. Regular medical checks are mandatory throughout cadet training and for maintaining an air traffic controller certificate. Proficiency in English at ICAO Level 4+ is compulsory for all air traffic controllers operating in international airspace. The training programmes include specialised aviation English courses designed for air traffic controllers.

Military operations restrict access to training centres, especially near combat zones. Online training maintains the continuity of theoretical education, reducing risks for cadets and instructors. Meanwhile, practical classes can be held in secure locations or in collaboration with training centres in EU countries, where Ukrainian cadets can participate in simulator training for air traffic controllers. The Ukrainian State Flight Academy organises such training for future pilots at centres in the Czech Republic, Slovakia, and Latvia. However, training for air traffic controllers in EU training centres is absent. Establishment of such programmes will help retain Ukraine's human resource potential and decrease cadet outflow abroad. Therefore, improving air traffic controller training can be achieved through such interconnected approaches as refining methods to optimise training processes and develop the necessary knowledge, skills, and abilities in air traffic management, enhancing criteria for evaluating the competence of air traffic controllers, upgrading automated testing and assessment systems and further improving simulator training through advanced information technologies.

Recommendations for enhancing Ukrainian air traffic controller training system amid martial law include several measures. The outdated training infrastructure for air traffic controllers in Ukraine should be modernised through international cooperation and technical assistance from organisations such as ICAO, EASA, or EUROCONTROL to upgrade training equipment and implement simulators that support modern air traffic management systems such as SESAR (SESAR, n.d.). This could be achieved via the ICAO (n.d.) initiative, which provides capacity-building support for modernising ATM infrastructure in war-affected regions, and through technical assistance grants or donations, such as those offered by the EUCONTROL European ATM Voluntary Solidarity Fund for Ukrainian aviation sector (EUROCONTROL, 2024), Fund IFATCA "Support Ukrainian Controllers" (IFATCA, n.d.). The introduction of high-fidelity simulators compatible with the SESAR (n.d.) programme, which emphasises digitalisation, automation, and performance-based navigation (PBN), could involve the purchase or lease of SESAR-compatible tools through EASA technical cooperation programmes. These simulators should accurately reproduce real-time scenarios such as trajectory-based operations and remote tower control systems. During martial law, mobile or cloud-based simulators should be prioritised to reduce risks from potential attacks and ensure training continuity. Such an approach can be used not only for upgrades to controller training equipment but also promotion of long-term sustainability, positioning Ukraine as a vital participant in the European ATM network.

Hybrid educational programmes should be developed and implemented in the training of future ATC controllers, combining online theoretical courses with offline practice on simulators in safe regions of Ukraine or abroad. Theoretical modules can be provided in a hybrid (online and offline) format based on an aviation training institution in Ukraine. For offline practice, it is necessary to organise simulator sessions in potentially safe regions of Ukraine (e.g., Lviv region) or abroad, in cooperation with institutions in EU countries such as the Czech Republic or Romania. Additionally, it is necessary to integrate assessment tools, such as the Competency-based training and assessment (CBTA) system (IATA, 2024), for remote tracking of progress through digital portfolios and periodic assessments. This hybrid model aligns with global trends in digital education by ICAO e-learning initiatives and supports the training of aviation professionals for Ukraine's post-war aviation recovery.

It is necessary to improve the psychological training of cadets and their stress resilience development by mandating courses focused on vital professional qualities, such as stress management, critical thinking, and decision-making in crises situations, using high-fidelity simulators. This requires the integration into existing curricula by mid-2026 of annual courses covering key competencies: stress management (mindfulness and feedback techniques), critical thinking (scenario-based problem solving), and crisis decision-making (e.g., emergency response such as aircraft diversion). This can be achieved through cooperation with organisations such as EUROCONTROL, utilising the "Yellow-Blue Roadmap" for Ukraine program (EUROCONTROL, 2023), which includes specialised seminars, competency training, peer support programmes, and psychological assessments of aviation professionals.

It is necessary to accelerate the harmonisation of educational programmes for Ukraine's aviation institutions with EASA and EUROCONTROL Specifications for the ATCO Common Core Content Initial Training (EUROCONTROL, 2015) to ensure international recognition of Ukrainian air traffic controller certificates and support further harmonisation within Ukrainian integration into European Union, as well as the swift restoration of civil aviation after the Russian-Ukrainian War. This requires the alignment of Ukrainian air traffic controller training programmes with the EASA requirements for air traffic controller licensing under Commission Regulation (EU) No. 2015/340 (2015), including basic training in subjects such as aviation law, meteorology and human factors, as well as specialised training in operational procedures and emergencies for specific air traffic control units. It is also necessary to adopt the EUROCONTROL's CBTA (competency-based training and assessment) principles, which ICAO endorses as the most effective method for training air traffic controllers, focusing on performance standards rather than rote memorisation. This includes the introduction of proficiency testing of future air traffic controllers by instructors through on-the-job training.

These recommendations contribute to the debate on improving the current training system for air traffic controllers in Ukraine in conditions of the Russian-Ukrainian war, offering practical advice on developing and integrating hybrid educational programmes in accordance with ICAO and the European Aviation Safety Agency standards, using the Ukrainian State Flight Academy as an example. Presented proposal aims to improve the psychological training and stress resilience of air traffic controllers by introducing mandatory courses on development of key professional qualities, such as stress tolerance, critical thinking, and decision-making during crisis situations, utilising high-complexity simulators that address modern challenges in the aviation industry.

The study results highlighted the need to maintain the continuity and quality of air traffic controller training in Ukraine in line with international standards and requirements, especially amid the closure of Ukrainian airspace due to Russian aggression. Improvement of the training system is essential during the Russian-Ukrainian war through adaptation of training to the closed airspace conditions and addressing the decline in practical skills caused by the lack of real flights. This presents a critical problem, as without regular practice, the certification and competence of air traffic controllers gradually diminish, risking the safety of civil aviation recovery in Ukraine after the war. The study also concluded that the training organisation should modernise Ukraine's outdated air traffic control training facilities through international cooperation. This involves attraction of technical assistance from organisations such as ICAO, EASA, or EUROCONTROL to upgrade simulators and introduce the latest systems compatible with modern air traffic control frameworks such as SESAR, while enhancing virtual and simulation methods to sustain skills without physical access to airspace. Other studies supports this approach, demonstrating that virtual training can reduce costs and ensure remote training, prioritising interoperability of air traffic control systems.

For example, F. Pérez Moreno *et al*. (2022) demonstrated that machine learning can dynamically adjust key parameters of air traffic complexity within simulators. Without such improvements, Ukraine risks losing qualified personnel, which could delay aviation's post-war recovery by months. G. De Rooij *et al*. (2022) investigated a model of collaborative ATC where automation handled individual flights while maintaining human involvement to prevent skill degradation. This was the first detailed task model with the potential to modernise ATC training with simulators for mixed conflicts, qualification analysis of delegation impacts, proposals for "smart" distribution of basic flights, and compatibility with SESAR. In Ukraine, during the period of martial law, similar hybrid programmes with automation for safe regions are needed for controller training, with the approval of EASA/EUROCONTROL, to support the restoration of Ukrainian aviation. Investment is also needed in digital platforms that incorporate AI for personalised training, as described in the model developed by A. Degas *et al*. (2022), where the Descriptive, Predictive, Prescriptive model with explanatory AI achieved a 7.7% accuracy in predicting controller reactions. Development of simulated environments with explanatory AI improves awareness of system decisions among controllers, reduce errors, and build trust. A. Degas *et al*. (2022) emphasised the significance of user-oriented AI that considers controllers' cognitive states and provides integration for predicting aircraft trajectories and potential conflict situations, enabling more personalised and flexible training. M. Kaya & S.S. Ateş (2023) proposed AI-driven radio communication analysis to reduce errors, while R. García *et al*. (2023) suggested AI-based automatic recognition of flight call signs to

increase recognition accuracy, lessen workload, and improve situational awareness. M. Jameel *et al*. (2023) recommended digital assistants for ATC training, focusing on enhancing teamwork between human controllers and autonomous systems. J. Zuluaga-Gomez *et al*. (2023) developed an innovative AI-based system for training air traffic controllers using a virtual pilot simulator, which is an automated alternative to traditional training. This system has significant potential for modernising air traffic control training, particularly in resource-constrained environments such as Ukraine during martial law. Automation of the pilot role supports hybrid programs with online simulations, reducing dependence on instructors and ensuring training in safe regions. Compliance with ICAO standards (e.g. CBTA through error simulation) facilitates international certification, and open source facilitates implementation through partnerships with EASA or EUROCONTROL. These findings support the overall conclusion of this study: hybrid educational programmes combining air traffic controllers' training with online simulations and using AI to simulate realistic ATC scenarios improve training effectiveness.

Improvement of the organisation of training involves analysing modern foreign practices to update existing methods and develop hybrid educational programmes for training controllers in Ukraine. These findings align with those presented by O. Danylko *et al*. (2023) in an analysis of the training of aviation specialists in the USA, Europe, and Asia, and recommended the exchange of experience and adaptation of available courses for positive changes in Ukraine's domestic aviation training system. This study reaffirmed these findings, highlighting the importance of integrating technologies into updated educational programmes for training air traffic controllers in Ukraine. The study also emphasised that improvement of simulator training with AI optimises programmes and adapts them to military conditions. Another key finding of presented study was the need to develop and implement hybrid educational programs for training controllers that combine online theoretical courses with offline practice on simulators in safe regions of Ukraine or abroad. The war has isolated Ukraine's aviation sector, making the need for partnerships with foreign ANSPs (Air Navigation Service Providers) evident. These include internships, funding, and exchange programmes, which help compensate for the lack of domestic resources. International cooperation is vital for enhancing the competencies of Ukrainian air traffic controllers in the context of restricted airspace caused by the Russian-Ukrainian conflict. EUROCONTROL, via the European Special Solidarity Fund, already funds training and skills retention, covering personnel costs. Without such international support, the post-war recovery of Ukrainian civil aviation could take years and risk significant economic losses.

Another substantial conclusion was made regarding the need to strengthen psychological training and develop stress resilience through mandatory courses on developing professionally relevant qualities, such as stress management, critical thinking, and decision-making under pressure. These courses should utilise high-fidelity simulators that reflect current aviation challenges. The relevance of these findings was supported by other experts who have investigated fatigue as a critical risk factor in air traffic management (Wu & Sun, 2022; Polishchuk *et al*., 2024). V. Polishchuk *et al*. (2024) proposed a three-stage approach to identifying fatigue to ensure safety: technical assessment, expert assessment, and uncertainty modelling combined with logical inference. N. Wu & J. Sun (2022) suggested the mandatory detection of controller fatigue through radio communication, while J. Zhang *et al*. (2023) emphasised the role using biosensors for fatigue diagnosis and automatic alerting when fatigue thresholds are reached. C. Ye *et al*. (2022) addressed recognition of levels of mental fatigue, particularly through language comprehension assessments. The use of machine learning to detect, monitor, and recover from physical fatigue as a primary safety measure during air traffic control was proposed by A. Lambay *et al*. (2024). However, some aspects of this study differ from previous findings. It highlights that controller fatigue is higher in real operational conditions compared to training centres, increased traffic boosts cognitive load, yet fatigue is not the primary cause of incidents. Therefore, according to the study's results, it was recommended to adopt a systematic approach to enhancing the training of air traffic controllers, focusing on the implementation of innovative technologies that support complex competency models by combining technical knowledge with skills such as stress management and decision-making under pressure.

This study underlined a different and vital approach: in the context of the psychological trauma of war, fatigue, and personnel losses, the improvement of operational efficiency and stress adaptation for future controllers should be prioritised. Therefore, improved training amid wartime should primarily involve developing cognitive skills enabling controllers to better cope with stress and multitasking in high-pressure environments. Furthermore, automatic fatigue notification systems could be integrated into training scenarios to simulate real air traffic management and enhance safety. This conclusion was reinforced by S. Ceken (2025), determining a positive correlation between cognitive flexibility and psychological resilience among 217 controllers surveyed. Another substantial conclusion of the study was the need to accelerate the harmonisation of educational programmes with the requirements of EASA and EUROCONTROL to ensure the recognition of

Ukrainian air traffic controllers' certificates abroad and further harmonisation in the context of Ukraine's European integration and the prospects for a rapid restoration of civil aviation after the end of the Russian-Ukrainian war. The results of proposed study confirmed this approach, offering practical advice on the development and integration of hybrid educational programmes harmonised with the standards of the European Aviation Safety Agency using the example of the Ukrainian State Flight Academy. Early planning for the restoration of Ukrainian civil aviation and replenishment of human resources is critical.

The study demonstrated that enhancing the training of air traffic controllers in Ukraine requires a comprehensive approach, combining technology, international aid, and psychological support. The war has transformed challenges into opportunities for modernisation of Ukrainian civil aviation sector, notably improving the training effectiveness of aviation specialists, especially air traffic controllers. Recommendations and measures to improve the organisation of air traffic controller training in Ukraine, based on research findings, will ensure continuity and lay the groundwork for the country's aviation industry's recovery after the war. However, without swift implementation, the risks will remain high. Investment and international assistance are essential. This approach will not only secure the safety of Ukraine's civil and transport aviation in the post-war period but also contribute to the rapid economic recovery through aviation activities.

Conclusions

The study aimed to identify ways to improve the training system for air traffic controllers in Ukraine during the Russian-Ukrainian War, and this goal was successfully achieved. Therefore, the following tasks were completed: the main issues in organising high-quality professional training for air traffic controllers in Ukraine during the war were analysed, and their causes identified; the features of organising educational processes in different countries were examined, the specifics of the organisational system for training air traffic controllers were determined, the utilisation of modern information technologies in training was evaluated; modern methods for developing operators' competencies in complex systems and organising training were analysed, indicators and criteria for air traffic controller readiness for professional activity were improved, and directions for enhancing the training of air traffic controllers in Ukraine during wartime were proposed. Based on the study's findings, the main challenges for effective training of air traffic controllers in Ukraine during wartime include limited access to practical classes, financial constraints, personnel losses, psychological stress, security risks, and non-compliance with international standards. To address these issues, it is necessary to expand international cooperation for access to training centres and programme, secure funding for equipment upgrades, adapt training curricula to modern challenges by incorporating problem-based learning, AI, and virtual reality technologies; and develop realistic, practical simulations. Modern educational approaches in air traffic control training primarily rely on automated systems such as simulators, knowledge assessment tools, and educational process organisation technologies that often utilise mathematical models of controllers' activities.

An analysis of modern technologies revealed promising prospects for integrating AI, particularly digital controllers and AI-based simulators. Key indicators of air traffic controllers' readiness include stress resilience, decision accuracy, knowledge of regulatory frameworks, and proficiency with automated systems. Meanwhile, methods for assessing readiness for professional duties require refinement, especially regarding the integration of modern air traffic control systems and the adaptation of future controllers to new technologies. An analysis and synthesis of the regulatory framework for evaluating and monitoring essential professional qualities of air traffic controllers was conducted following International Civil Aviation Organisation standards. The results highlighted the need to improve indicators and criteria for assessing the preparedness of future ATC controllers. An expanded set of assessment criteria was proposed, encompassing psychophysiological, intellectual, theoretical, and practical aspects. Considering the specifics of ATC controllers' professional duties, four levels of readiness – low, sufficient, medium, and high – were identified and refined. Drawing on experiences from the Ukrainian State Flight Academy, measures were proposed to improve training, including modernising simulators, introducing hybrid training models, enhancing psychological training, and aligning training programmes with European standards. These measures aim to ensure continuity and high quality in air traffic controller training, creating prerequisites for Ukraine's aviation industry to recover swiftly after the war. Further research should address development of standardised methods for real-time assessment of the professionally relevant qualities of air traffic controllers.

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Напрямки удосконалення організації підготовки диспетчерів управління повітряним рухом в Україні в умовах російсько-української війни

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■ **Анотація.** Актуальність теми дослідження зумовлена необхідністю забезпечення безперервності та якості підготовки диспетчерів управління повітряним рухом в Україні відповідно до міжнародних стандартів та вимог в умовах закриття повітряного простору України для цивільної авіації через російську агресію та її наслідки. Метою дослідження було обґрунтування напрямків удосконалення організації підготовки диспетчерів управління повітряним рухом в Україні в умовах російсько-української війни. Для дослідження було використано методи аналізу, порівняння, узагальнення. В ході дослідження було визначено основні проблеми якісної організації професійної підготовки диспетчерів в Україні в умовах російсько-української війни, які мають як воєнні так і системні причини. Було окреслено особливості організаційної системи підготовки диспетчерів управління повітряним рухом в різних країнах. Виконано узагальнення нормативно-правового забезпечення оцінки та моніторингу професійно-важливих якостей диспетчерів управління повітряним рухом відповідно до вимог Міжнародної організації цивільної авіації. Було виконано узагальнення характеристик чотирьох рівнів готовності майбутніх диспетчерів до професійної діяльності – низького, достатнього, середнього та високого з урахуванням специфіки професійних обов'язків. Запропоновано розширений комплекс критеріїв для оцінки готовності майбутнього диспетчера управління повітряним рухом управління повітряним рухом до професійної діяльності. З урахуванням практичного досвіду роботи Української державної льотної академії було запропоновано комплекс заходів для підвищення ефективності автоматизованого тестування та оцінювання знань майбутніх диспетчерів управління повітряним рухом. Практична цінність данного дослідження полягає в обгрунтуванні рекомендацій щодо вдосконалення існуючої системи підготовки диспетчерів управління повітряним рухом в Україні, які враховують реалії воєнного стану. Їх реалізація допоможе подолати поточні виклики забезпечення організації якісної підготовки диспетчерів управління повітряним рухом в Україні. В подальшому це створить основу для швидкого відновлення та розвитку української авіаційної галузі після закінчення війни

■ **Ключові слова:** професійна підготовка; цивільна авіація; рівні готовності до професійної діяльності; методи оцінки професійної придатності; професійно-важливі якості