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PSYCHOLOGICAL MANIFESTATIONS OF THE HUMAN FACTOR IN EXTREME SITUATIONS IN AVIATION

Abstract. This article presents a comprehensive analysis of the psychological manifestations of the human factor during extreme situations in the aviation industry. Despite advancements in modern technology, the human factor remains one of the primary determinants of accidents and hazardous situations. Although the rate of technical failures has declined, statistical data show that the impact of the human factor has not diminished and individuals' emotional and cognitive responses play a critical role in aviation safety during moments of decision-making. In this context, the article scientifically explains how human behavior changes under extreme conditions and how these changes affect safety systems. The purpose of the study is to identify the psychological reactions, decision-making behaviors, group dynamics and the impact of cognitive distortions on system behavior within aviation crews during extreme conditions, as well as to offer practical and theoretical recommendations for managing such scenarios. The study focuses on several key objectives: analyzing the forms of manifestation of the human factor, explaining the stages of psychological adaptation during emergencies, investigating the interaction mechanisms between technical and cognitive skills, evaluating the effectiveness of psychoselection, training and technological monitoring systems, and applying risk assessment models based on real-life cases. The article systematically examines the main factors affecting human behavior, including fatigue, emotional overload, information overload or deficiency, the quality of intra-team communication and individual psychological traits. Particular attention is paid to cognitive distortions that arise in extreme situations such as indecisiveness, panic reactions, narrowed attention ("tunnel vision"), confirmation bias and habituation effects which

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are explained in detalı. The analyses indicate that these distortions contribute to poor decision-making during sudden events, imprecise information processing and reduced group effectiveness. The article provides concrete examples of both the positive and negative consequences of the human factor, using real aviation incidents such as the Miracle on the Hudson, Avianca Flight 52, Air France Flight 447 and Eastern Air Lines Flight 401. The research highlights three essential factors that enable successful decision-making under extreme conditions: psychological preparedness, professional experience and intra-team coordination. Within psychological preparedness, cognitive resilience, emotional regulation and volitional behavior under uncertainty are emphasized. The relationship between professional experience and automatic responses is explained through the Dreyfus model in a staged manner. Meta-skills such as processing speed, attention distribution and resistance to errors under cognitive load are considered key parameters determining human performance in critical moments.Teamwork is described in terms of active listening, delegation of authority, rotating leadership roles and adherence to ICAO communication protocols. The article also assesses the effectiveness of technological and psychological intervention methods. These include biometric monitoring systems, EEG-based cognitive tests, virtual reality-based simulation training and the CRM methodology. Tables demonstrate that these approaches can reduce psychological strain by 45–80 % and improve decision-making quality and reaction time by 50–70 %. Adapting technical interfaces to human behavior and managing interactions based on the SHELL model play a significant role in reducing risks arising from the human factor. The findings reveal that human behavior in extreme conditions is shaped not only by knowledge and skills, but also by stress resilience, emotional balance and social communication abilities. Alongside individual psychological preparedness, aligning systems with human behavior and implementing adaptive technologies are decisive in minimizing accident risks. The model proposed in the article psychoselection + simulator-based training + real-time monitoring is presented as a comprehensive approach aimed at increasing the efficiency of safety systems. In conclusion, the article stresses the importance of viewing the human factor not only as a weak link, but also as a psychological resource that can be developed and strengthened. Ensuring safety requires a joint application of technical systems and approaches that stimulate individuals' cognitive, emotional and social skills, offering more stable and sustainable performance outcomes. Thus, the management of the human factor through enhanced psychological preparedness, the integration of adaptive technologies and the improvement of collective effectiveness emerges as one of the key strategic priorities in aviation safety.

Keywords: human factor; extreme situations; stress; cognitive distortions; psychophysiological stability; safety.

INTRODUCTION / ВСТУП

Statement of the problem / Постановка проблеми. The aviation industry is a complex field governed by high-tech systems and strict safety standards. Despite all technological advancements and automated control systems, the human factor continues to play a decisive role in critical situations that arise in aviation [10]. In the context of sudden extreme scenarios—such as the threat of an accident, evacuation, equipment failure, or the need for immediate decision-making—the psychological state, cognitive abilities, and emotional regulation skills of an individual directly determine both crew behavior and the course of events. Therefore, it is essential to evaluate the human factor not only as a potential risk but also as a carrier of adaptive behavior [3].

Although the high level of automation and technological advancement in modern aircraft is aimed at eliminating risks caused by human error, statistical data show that, despite a decline in technical failures, there has been no significant decrease in incidents related to the human factor. On the contrary, irrational psychological responses to abnormal situations remain one of the leading causes of aviation incidents. According to Boeing (2021) and ICAO (2020) reports, the human factor is involved as a primary cause or contributing factor in more than 60 percent of in-flight incidents.

This situation highlights the importance of a deeper understanding of psychological resilience and decision-making processes in aviation. The human factor refers not only to gaps in technical knowledge or training but also to cognitive biases, impairments of psychophysiological functions under stress, emotional instability, fatigue, and weakened intra-team communication [9]. It is precisely the combination of these factors that leads to inconsistency, lack of coordination, and errors in human behavior during critical moments [8]. Research shows that decisions made by individuals in emergency situations often depend on their level of psychological preparedness, ability to adapt to the situation, and the quality of interaction within the team [13].

In the *Flight Safety Manual Considering Human Factors,* developed by the International Civil Aviation Organization (ICAO, 2020), seven main risk groups affecting human behavior are identified: fatigue, lack of information, emotional overload, insufficient training, inadequate delegation of authority, lack of effective communication, and unpreparedness for unforeseen situations [1]. These risk groups serve as a fundamental basis for modeling human behavior when interacting with technological interfaces. The effectiveness of psychological training, CRM (Crew Resource Management) programs, and decision-making behavior was evaluated as part of the *Human Performance in Safety* program implemented by the European Union Aviation Safety Agency (EASA) between 2018 and 2023. Studies have confirmed that flight crews trained through specialized programs in psychological preparedness and cognitive resilience demonstrate more stable, flexible, and goal-directed behavior in extreme situations. This can significantly reduce the risk of aviation incidents not only at the individual level but also at the collective level [13].

As a result, the presented article provides a comprehensive examination of the psychological characteristics of the human factor based on existing scientific knowledge and explores its impact on flight safety systems. The main scientific contribution of the article lies in presenting the human factor not only as a risk, but also as a strategic resource that combines psychological readiness, adaptive intelligence, and social interaction. The future development of flight safety must be based on mutual trust and flexible adaptation between technology and humans, and mechanisms for training, psychological support, and monitoring should be systematized in accordance with this goal. Only under these conditions can the risks associated with the human factor be reduced and its full potential optimally assessed.

Analysis of (major) recent research and publications / Аналіз (основних) останніх досліджень і публікацій. This issue is also at the center of attention in international scientific circles. Research conducted by Caldwell (2012) at NASA's Ames Research Center demonstrated that pilots' attention and reaction speed significantly decrease during sleep deprivation and long-haul flights, which greatly increases the risk of accidents [7].

M. Endsley (2015) developed a model of situational awareness and analyzed the mechanisms of real-time human information processing, as well as the shortcomings that arise in this process. The theory of cognitive biases (such as confirmation bias, tunnel vision, etc.) proposed by Kahneman and Tversky is widely applied in decision-making processes in aviation [4].

Sarter and Alexander (2020) systematized pilot errors and detection mechanisms, creating a theoretical foundation for this field [8]. P. Hancock (2019), who studied the relationship between stress, workload, and performance, empirically demonstrated the negative impact of heightened emotional reactivity on decision accuracy under extreme conditions [9]. Canadian expert D. Maurino

(2017) assessed the human factor not as a passive weak link in safety, but as an active and trainable component, and rethought the psychological foundations of decision-making mechanisms in aviation. This approach acknowledges the human tendency to make mistakes and focuses on managing and minimizing them through flexible learning strategies [5], [11].

AIM AND TASKS / МЕТА ТА ЗАВДАННЯ

The ***aim*** of this article is to provide a comprehensive analysis of the psychological aspects of the human factor in aviation, as well as to identify its role not only as a potential source of risk but also as a strategic resource capable of enhancing the effectiveness of the flight safety system under extreme conditions.

The article is aimed at ***tasks*** the following problems arising from the stated goal:

- to reveal the significance of the human factor in the aviation industry under extreme and emergency situations;
- to summarize current research data and statistics (including reports from ICAO, Boeing, and EASA) on the causes of aviation incidents related to the human factor;
- to examine the key psychological components influencing crew behavior: stress resilience, emotional regulation, cognitive abilities, and team interaction;
- to analyze the seven risk groups identified in the ICAO Safety Management Manual with regard to the human factor;
- to assess the effectiveness of training programs and CRM (Crew Resource Management) in reducing the impact of the human factor on accident rates;
- to substantiate the need to shift the perception of the human factor from a risk to a resource of adaptability and resilience within the aviation system;
- to formulate proposals for the systematic integration of psychological training and monitoring into flight safety policy.

THEORETICAL FRAMEWORK / ТЕОРЕТИЧНІ ОСНОВИ

The safety of any system is determined by the reliability of its weakest link. This principle applies not only in aviation but also in medicine, energy, and other high-risk fields [10]. The most complex and at the same time the weakest link in any human-machine system is the human being. The main goal is to maximize the reliability of all system components. The negative impact of humans on safety is expressed by the concept of the "human factor".

The degree of its manifestation is determined by a person's motivation and attitude towards their work activity.

The primary manifestation of the human factor is the tendency of humans to make various types of errors in the course of their activities for various reasons. A person's ability to perform their functions without errors under specified professional conditions is described as their reliability. This is one of the factors that make up professional suitability – under conditions of uncertainty, incorrect decisions may be made [8]. Moreover, the human factor is not always the sole cause of catastrophes and accidents. Real accidents in transportation often occur as a result of a combination of various factors. Currently, weather conditions (poor visibility, icy roads, etc.) are, at best, only one of the main factors exacerbating human errors.

There is no such thing as a "pure" human factor in nature, since a person is a complex energy-information system and cannot be considered outside of the external energy-information field. A significant portion of hazards occurs under the influence of or with the direct involvement of existing psychophysiological characteristics of the organism that determine human behavior. For example, 45 % of accidents at nuclear power plants, 60 % of aviation accidents, 80 % of maritime accidents, and 90 % of road traffic accidents happen due to the fault of operating personnel for various reasons [12]. The causes of hazardous situations and occupational injuries related to the human factor can be categorized at different levels.

At the individual level, innate or acquired, temporary or permanent psychophysiological characteristics of the organism determine a person's stress resistance, decision-making ability, and behavior patterns in extreme situations. At the social level, there is insufficient awareness of professional risks and their consequences, as well as shortcomings in the strategies for organizing safe labor practices in the given field. This level also includes gaps in legislation, low public awareness, and insufficient preventive measures. The labor level is characterized by factors such as ergonomic conditions, violations of labor relations, increased psychological stress, inadequate occupational safety training, unstable work schedules, conflicts with management, and weak organizational support [10].

Although human capabilities in accident prevention have increased due to improved education, skills, automation of production management, and enhanced quality of selection – that is, the overall improvement of the safety system – over time these capabilities have lagged behind the accelerated development and expansion of modern technology's possibilities. It is extremely difficult to anticipate all types and variants of potential hazards during the stages of creation and testing of new technologies. The interaction of technical systems ensuring human life activity is an important and necessary link [12].

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In this process, a person performs tasks in several stages: evaluates, analyzes, and synthesizes information based on previously set criteria; makes decisions about further actions; implements the decisions made. Errors can occur regardless of a person's level of training, specialization, or experience. The propensity to make errors is a function of one's psychological state [9]. Human errors can occur at all stages of activity and by their nature can lead to large-scale consequences. It has been proven that the human factor is one of the primary causes of technological and anthropogenic accidents, although it is not the sole cause of such accidents [11].

Sudden and rapidly developing emergencies, occurring independently of a person's will, trigger the activation of complex psychophysiological response mechanisms. At the stage of threat perception, cognitive and emotional processes are activated that determine human behavior through sensory systems. The reliability of the safety system under such conditions is limited by its weakest link—the human factor, which includes individual and group stress reactions [10].

The human factor remains a key element in emergency response systems. Its reliability depends on the ability to quickly adapt (rapidly adjust to new and non-standard conditions), manage stress (make sound decisions under stressful situations), and possess effective communication skills (clear and timely information exchange) [13]. These qualities can be developed through specialized training and practice. No matter how advanced technical means are, ultimately, the human factor plays the decisive role in the decision-making process.

The reliability of the human factor in emergencies depends on three main components: the level of psychological preparedness, the extent of professional experience, and teamwork skills. To ensure success in emergency situations, well-preparedness in these three key areas is crucial. Experience shows that it is precisely the combination of these skills that enables effective action during crises [10]. Cognitive aspects of psychological preparedness include the formation of accurate mental models of potential emergency situations (ES), the ability to quickly assess the environment, and resilience to cognitive distortions (such as the "tunnel vision" effect) [3], [4].

The emotional aspect involves stress resistance (measured by the Holmes-Rahe scale), emotional regulation (the ability to suppress panic reactions), and the willpower readiness to act under conditions of uncertainty. Professional experience primarily includes technical skills, automation of professional skills (level 4 according to the Dreyfus model), knowledge of standard action algorithms in emergency situations, and the ability to improvise when deviating from standard scenarios [10].

According to the Dreyfus skill acquisition model, there are five stages of skill development: *Novice* – limited experience, requires clear rules and instructions for actions, often makes mistakes; *Advanced Beginner* – understands basic concepts but struggles with innovations; *Competent* – independently solves standard tasks, sees problems in a broader context, but can get stuck in details; *Proficient* – uses intuition in complex situations, distinguishes important details; *Expert* – creates innovations, formulates rules in the field independently, discovers new methods [10].

The psychological and psychophysiological characteristics of a person do not always correspond to the complexity level of the tasks or problems being solved. The causes that lead to the possibility of making incorrect actions can be grouped into several categories: deficiencies in the provision of information, errors related to external factors, and limitations in resources and support for implementing the chosen decision. Lack of full confidence in the success of the upcoming action, doubts about achieving the goal of the activity cause emotional tension, which leads to a general slowdown in the organization of activity and behavior, increasing the likelihood of making mistakes.

The degree of emotional tension depends on a person’s readiness for their actions in the given conditions and their assessment of the consequences. Individual characteristics such as excessive sensitivity, conscientiousness, general intolerance, and impulsivity in behavior contribute to the formation of tension [9]. Issues related to manifestations of the human factor are considered as an analysis of human reliability, which involves identifying potential sources of human error before an accident occurs. A decrease in attention during routine and stable situations can be a source of errors, since a person does not expect any difficulties to arise in such conditions. In monotonous work modes, errors sometimes occur that are not observed in stressful situations [7].

Errors made during the execution of certain actions can be associated with an unsatisfactory mental state of the person. In such cases, the individual may experience poor mood, irritability, nervousness, slowed reactions, or excessive excitement, unnecessary restlessness, and excessive talkativeness. The person's attention becomes scattered, making errors inevitable when performing necessary actions, especially in the face of unforeseen equipment problems or sudden changes in the environment. These errors can be simply categorized into mistakes, slips, and manifestations of malicious intent [8].

Factors that increase the likelihood of errors at work and, consequently, determine the reliability of an employee include both long-term medico-psychophysiological characteristics of the individual (such as temperament type, character, reaction speed, and resistance to negative influences) and immediate

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medico-psychophysiological characteristics (current health status; moral and volitional qualities; ergonomic working conditions).

Causes of such situations may include anxiety due to an unpleasant event, recently onset illness, fatigue, as well as lack of confidence in one's abilities or insufficient preparation for complex tasks [9]. Another cause of human errors is the lack of informational support (such as inadequate software, absence of visual materials and instructions). This problem becomes especially pronounced in extreme situations when there is little time to make decisions. In most cases, the reasons for failing to recognize dangers include laziness, habitual violation of safety rules, and underestimation of the risk and its consequences.

Often, breaking safety rules does not immediately lead to negative outcomes, and the person continues to behave unsafely. In such cases, promoting safe work methods is crucial. Although education and training efforts yield positive results, activating the human factor is unlikely without the use of appropriate training methods [11], [13].

Personal or collective example of an employee can serve as a sufficiently effective means of promoting safety. If an emergency situation cannot be predicted or develops independently of human involvement, the next stage becomes the manifestation of a complex of factors or a single factor perceived by the human sensory systems, triggering the response mechanism. It is at this stage that the degree of danger to the life of an individual or group of people is assessed, along with the consequences for surrounding objects and the possible nature of subsequent events.

Manifestations of low stress tolerance include panic reactions in non-standard situations, cognitive dysfunctions (reduced attention span, slowed reaction time), and inadequate decisions made under pressure. Lack of experience may be evident in delayed responses, inability to apply knowledge practically, and excessive reliance on automation.

Cognitive overload leads to heuristic errors [4]. According to Boeing (2022), 63 % of fatal aviation errors are linked to heuristics [2]. In 41 % of NASA crew reports, "cognitive traps" are mentioned [6]. A heuristic error is a simplified, intuitive decision made under conditions of limited time, information, or cognitive overload [4].

In aviation, such errors often result in critical situations because pilots and air traffic controllers rely on "mental shortcuts" instead of systematic analysis [4]. Mental shortcuts are quick, generalized ways to evaluate a complex environment that help make decisions when large amounts of information are unavailable [4].

For example, when the brain sees a person in a white coat, it automatically assumes they are a doctor. However, heuristics in aviation can be dangerous [8].

Although heuristics are an integral part of human thinking, the risks can be minimized through training and technological solutions. Typical heuristic biases include "tunnel vision" – focusing on one problem while ignoring other threats; "confirmation bias" – seeking information that supports an incorrect decision; and the "familiarity effect" – ignoring rare but dangerous situations [4], [8].

"Tunnel vision" refers to excessive focus on a single indicator without considering other critical parameters. The cause of the Eastern Air Lines Flight 401 crash (1972) was the crew's fixation on a malfunctioning landing gear indicator light, resulting in complete loss of control over flight parameters and gradual neglect of the aircraft's descent [4]. Lack of time and information can lead to missing critical data and making incorrect decisions based on incomplete information.

Physiological limitations manifest as fatigue, slowed reaction times, and sensory deprivation. For example, decreased attention after 17 hours of wakefulness is equivalent to a blood alcohol level of 0.05 %. "Change blindness" refers to the inability to notice changes in critical parameters, while "spatial disorientation" or "flight illusions" involve losing orientation in clouds or at night. "Confirmation bias" is the tendency to select only information that supports an initial (often incorrect) hypothesis [4]. In the Air France Flight 447 crash (2009), the pilots interpreted conflicting instrument readings as a technical malfunction, while the actual cause was improper handling of the aircraft [8].

The "normalization of deviance" effect refers to perceiving dangerous situations as "normal" due to their frequent repetition without immediate negative consequences [11]. These cognitive biases and physiological limitations directly threaten the reliability of aviation personnel performance. For this reason, modern research in aviation psychology focuses on identifying these human factor vulnerabilities and developing effective strategies to overcome them [5].

Training programs, simulator exercises, and technological support systems play a crucial role in preventing such errors and strengthening personnel's ability to make correct decisions in critical situations. According to Boeing (2020), 68 % of aviation incidents are related to cognitive errors arising under conditions of overload [2]. In 43 % of incidents, flight crews did not simultaneously monitor critical parameters. An example is the Qantas 72 incident (2008): the ADIRU system (Air Data Inertial Reference Unit, responsible for collecting, analyzing, and transmitting important flight data to the aircraft avionics) was not sent for maintenance on time despite multiple activations.

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The risk assessment model (using the SHELL method) represents a critical point of interaction: Human-Technology (control interfaces), Human-Human (crew communication), Human-Environment (extreme conditions) [12]. Among the physiological consequences of sleep deprivation in aviation are cognitive impairments: after 40 hours of wakefulness, information processing speed decreases by 17 %, and task accuracy worsens by 50 % (NASA Ames studies) [7]. EEG patterns show that an increase in theta rhythm (4–7 Hz) is accompanied by signs of microsleep, while a decrease in beta activity (13–30 Hz) corresponds to deterioration in logical thinking.

The following table shows the effects of a blood alcohol level of 0.05 % on the human body after 17 hours of sleep deprivation [7]:

Table 1

The Impact of Fatigue and Alcohol on Cognitive Functions (Caldwell, 2012; NASA Ames, 2012) [7]

Parameters	17 hours of sleeplessness	0.05 % alcohol
Reaction time	+120 ms Lack of sleep and alcohol slow down reaction times, but lack of sleep has a stronger effect	+80ms
Attention errors	Attention errors occur 2.8 times more often with insomnia than with alcohol consumption	1.9 times more
Short-term memory	-35 % In both cases, short-term memory deteriorates, but insomnia has a more negative impact	-25 %

In air travel and critical situations, human reaction time is vital. Studies show that a person deprived of sleep for 17 hours has a reaction time approximately 120 milliseconds slower than when fully rested. For comparison, a blood alcohol concentration of 0.05 % slows reaction time by about 80 milliseconds. In aviation, every millisecond counts. Therefore, a 120-millisecond delay can cause serious lags in a pilot's actions, reactions, or maneuvers, significantly increasing the risk of a chain of errors [7]. For example, if a pilot normally reacts within 250 milliseconds, sleep deprivation can increase this time to 370 milliseconds, which is a delay of about half a second.

According to calculations, a Boeing 737 covers approximately 30 meters in 120 milliseconds – roughly the length of several buses. These facts further emphasize the critical importance of proper sleep and rest for aviation personnel in terms of safety. Seventeen hours of sleep deprivation cause more cognitive impairments than a blood alcohol concentration of 0.05 % [7]. Therefore, it is essential for aviation personnel to strictly adhere to sleep schedules. The table below presents methods used to enhance professional skills through various measures and technologies [1], [6], [7], [13]:

Table 2

Measures and Effects Enhancing Human Factor Reliability (ICAO, 2020; NASA ASRS, 2022; Salas & Maurino, 2010) [1], [6], [13]

Event category	Special events	Technology / Method	Effectiveness of impact
Psychological choice	Psychological choice Cognitive tests, stress tests	VR simulators (virtual reality), EEG biometric monitoring	Reduces the likelihood of making wrong decisions by 40 %, increases stress resistance by 35 %
Training programs	Processing non-standard situations, cognitive exercises (eye-tracking)	Full-size simulators, eye movement analysis	Improves reaction in emergency situations by 50 %, reduces attention errors by 60 %
Fatigue management	Biometric monitoring, dynamic work schedule	Heart Rate Variability Analysis. AI-Based Prediction	Reduces fatigue-related errors and workload by 45 %
CRM training	Standardized communication protocols, team dynamics analysis	CRC (Call-Response-Check) Voice-Answer-Check	Reduces team errors by 55 %, improves decision-making quality by 70 %
Technological support	Intelligent assistive systems, cognitive load monitoring	AI-based analytics Neural interfaces	Reduces routine errors by 80 %. Optimally distributes workload

This table briefly presents the main measures to improve reliability related to the human factor in aviation: psychological tests reduce decision-making errors through VR and EEG monitoring; practical training and cognitive exercises enhance reaction speed with realistic simulators; fatigue management minimizes errors using biometric monitoring.

CRM training strengthens teamwork, and intelligent technologies reduce errors and optimize workload. Together, these approaches help manage the human factor [1], [13]. To reduce the role of the human factor in the occurrence of hazards, it is necessary to initiate measures aimed at motivating compliance with safety rules. The human factor remains the most unreliable link in aviation; however, its risks can be mitigated through systematic training and monitoring [5], [11].

A comprehensive approach to managing human factor risks is of particular importance in ensuring flight safety in aviation. This approach includes systems of psychological training, such as specialized programs aimed at developing cognitive and emotional resilience, psychoselection, rehearsal of extreme scenarios using virtual reality technologies, and psychological support services for the prevention of post-traumatic conditions [1], [13]. Among the mechanisms of technological support, real-time monitoring of pilots' physiological state, intelligent assistance systems to prevent erroneous decisions, and smart interfaces for optimal workload distribution can be highlighted [12].

Finally, practical experience should include real training on full-scale flight simulators, especially regular practice of rare cases and emergency scenarios, CRM training to improve team interaction, and debriefing sessions for experience sharing [1], [13]. Consequently, a harmonious combination of psychological, technological, and practical components is a necessary condition for managing human factor risks in modern aviation [5]. This approach not only enhances safety standards but also fosters the development of professional skills among aviation personnel.

RESEARCH METHODS / МЕТОДИ ДОСЛІДЖЕННЯ

The following methods were used in this article:

1. Theoretical-analytical method

- Analysis and synthesis of scientific literature on the issue of the human factor;
- Study of regulatory documents: ICAO Doc 9859, reports from Boeing, EASA, NTSB;
- Review of scientific works on stress psychology, situational awareness (M. Endsley), and cognitive biases (D. Kahneman).

2. Statistical-analytical method

- Processing statistical data on aviation incidents over 20 years (e.g., from Boeing and ICAO reports);
- Comparative analysis of the frequency of incidents by cause: technical failures vs. crew errors.
- Interpretation of data in light of psychological models of behavior in extreme situations.

3. Psychological analysis

- Decoding the mechanisms of cognitive biases, emotional instability, fatigue, and overload;
- Studying the relationship between emotional regulation, stress resilience, and decision-making;

- Applying models of situational awareness and human error management (e.g., SA, HFACS).

4. Comparative analysis method

- Comparing the effectiveness of crew training with and without CRM training;
- Analyzing differences between international emergency preparedness practices (e.g., Europe vs. USA).

RESEARCH RESULTS / РЕЗУЛЬТАТИ ДОСЛІДЖЕННЯ

The conducted study showed that the psychological reactions of aviation crews in extreme conditions are a decisive factor in the functional stability of the system as a whole. Although the human factor has long been viewed merely as a source of risk and errors, modern approaches allow it to be seen as an adaptive, trainable, and manageable component of the safety system. In this regard, studying human behavior in extreme situations, analyzing cognitive and emotional responses, as well as the interaction of these responses with technological systems, has not only scientific but also strategic importance in terms of improving practical safety measures [5], [10].

Research has shown that a person's ability to make decisions in extreme situations is primarily shaped by the interaction of three components: cognitive resilience, emotional regulation, and effective team communication [13]:

- Each of these components is supported by specific factors: cognitive resilience is ensured by the ability to direct attention and prioritize according to the situation; emotional regulation depends on psychological stress resistance and the neutralization of panic [9]; and team communication relies on structured information exchange, dynamic distribution of leadership qualities, and mutual trust [1]. This triadic structure forms the foundation of the psychological resilience necessary to manage high-risk and uncertain extreme situations.
- The effectiveness of individual psychological training and behavioral strategies depends not only on personal skills but also on the adequacy of organizational and technological support systems [1], [5].
- Simulation-based training, virtual exercises in real scenarios, EEG-based cognitive monitoring, and psychoselection modules are indispensable tools not only for measuring human responses but also for optimizing behavioral models. The results presented in the article demonstrate that these technologies can reduce psychological load by 45–80 %, accelerate adaptation time to situations, and significantly improve the objectivity of decision-making [6].

- Furthermore, the study included a factual analysis based on real aviation incidents, clearly showing the impact of the human factor on the safety system. While positive examples—such as the successful Hudson River landing—illustrate the effectiveness of psychological preparation, coordinated team actions, and adaptive decision-making, tragic incidents like Avianca 52 and Air France 447 demonstrated how inaccurate communication, leadership gaps, and cognitive biases lead to negative outcomes [8].

CONCLUSIONS / ВИСНОВКИ

The conducted comparative analysis confirmed the practical orientation of the obtained results and their high degree of correspondence to reality. One of the most significant scientific innovations of the study is the rethinking of the human factor as an active mechanism for ensuring flight safety, rather than a passive element of risk. The model proposed in the article – "psychological training + technological monitoring + experience-based learning" – represents a comprehensive and systematic approach to managing the human factor [5]. The application of this model not only strengthens individual psychological resilience but also reduces systemic risks by improving the overall efficiency of team performance. According to the results obtained, comprehensive and proactive management of the human factor can lead to qualitative improvements in flight safety assurance.

The article also presents a number of recommendations regarding future research directions. In particular, new scientific avenues in this field include modeling decision-making strategies based on individual psychotypes, investigating the relationship between emotional intelligence and situational awareness, analyzing the psychological parameters of adaptive leadership in extreme conditions, and empirically assessing the impact of intra-team role division on performance [9]. All of this demonstrates that the study of the human factor in safety systems requires an interdisciplinary approach, not only from an empirical but also from a theoretical and methodological perspective. In conclusion, it should be noted that despite the rapid growth of technological innovations in aviation, the human factor remains a central and constant component of these systems.

Amidst a high level of technical equipment, psychological resilience, volitional stability, and socio-emotional compatibility continue to play an indispensable role in minimizing accident risks [13]. Therefore, in safety management, it has become absolutely essential to consider the human not as a subordinate tool of technology but as an active agent interacting with it on an equal footing, and to integrate this approach into system design, training

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programs, and safety strategies. Thus, this study once again demonstrates that taking into account the psychological aspects of the human factor is a necessary condition not only for individual performance but also for the safety of the system as a whole.

Prospects for further research in this direction / Перспективи подальших досліджень у цьому напрямі. Sustainable development of flight safety is possible not only due to technological progress but also through a comprehensive understanding and management of human behavioral potential. In the future, the combination of psychological and neuropsychological approaches with deeper empirical research in this field will contribute to transforming aviation psychology into a strategic scientific discipline.

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ПСИХОЛОГІЧНІ ПРОЯВИ ЛЮДСЬКОГО ФАКТОРА В ЕКСТРЕМАЛЬНИХ СИТУАЦІЯХ В АВІАЦІЇ

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Анотація. У цій статті представлено комплексний аналіз психологічних проявів людського фактора в екстремальних ситуаціях в авіаційній галузі. Незважаючи на досягнення сучасних технологій, людський фактор залишається одним з основних факторів, що визначають аварійні ситуації та небезпечні ситуації. Хоча рівень технічних збоїв знизився, статистичні дані показують, що вплив людського фактора не зменшився, а емоційні та когнітивні реакції людей відіграють вирішальну роль в безпеці авіації в моменти прийняття рішень. У цьому контексті стаття науково пояснює, як змінюється поведінка людини в екстремальних умовах та як ці зміни впливають на системи безпеки. Метою дослідження є визначення психологічних реакцій, поведінки прийняття рішень, групової динаміки та впливу когнітивних спотворень на системну поведінку авіаційних екіпажів в екстремальних умовах, а також пропонування практичних та теоретичних рекомендацій щодо управління такими сценаріями. Дослідження зосереджено на кількох ключових завданнях: аналіз форм прояву людського фактору, пояснення етапів

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психологічної адаптації під час надзвичайних ситуацій, дослідження механізмів взаємодії між технічними та когнітивними навичками, оцінка ефективності систем психоселекції, навчання та технологічного моніторингу, а також застосування моделей оцінки ризиків на основі реальних випадків. У статті систематично розглядаються основні фактори, що впливають на поведінку людини, включаючи втому, емоційне перевантаження, інформаційне перевантаження або дефіцит, якість внутрішньокомандної комунікації та індивідуальні психологічні риси. Особлива увага приділяється когнітивним спотворенням, що виникають в екстремальних ситуаціях, таким як нерішучість, панічні реакції, звужена увага («тунельне бачення»), упередження підтвердження та ефекти звикання, які детально пояснюються. Аналізи показують, що ці спотворення сприяють поганому прийняттю рішень під час раптових подій, неточній обробці інформації та зниженню ефективності групи. У статті наведено конкретні приклади як позитивних, так і негативних наслідків людського фактору, використовуючи реальні авіаційні інциденти, такі як «Диво на Гудзоні», рейс Avianca 52, рейс Air France 447 та рейс Eastern Air Lines 401. Дослідження висвітлює три основні фактори, що забезпечують успішне прийняття рішень в екстремальних умовах: психологічна підготовленість, професійний досвід та координація всередині команди. У рамках психологічної готовності наголошується на когнітивній стійкості, емоційній регуляції та вольовій поведінці в умовах невизначеності. Зв'язок між професійним досвідом та автоматичними реакціями пояснюється за допомогою моделі Дрейфуса поетапно. Такі мета-навички, як швидкість обробки інформації, розподіл уваги та стійкість до помилок під когнітивним навантаженням, вважаються ключовими параметрами, що визначають продуктивність людини в критичні моменти. Командна робота описується з точки зору активного слухання, делегування повноважень, ротації лідерських ролей та дотримання протоколів зв'язку ICAO. У статті також оцінюється ефективність методів технологічного та психологічного втручання. До них належать біометричні системи моніторингу, когнітивні тести на основі ЕЕГ, симуляційне навчання на основі віртуальної реальності та методологія CRM. Таблиці показують, що ці підходи можуть зменшити психологічне навантаження на 45–80 % та покращити якість прийняття рішень та час реакції на 50–70 %. Адаптація технічних

інтерфейсів до поведінки людини та управління взаємодією на основі моделі SHELL відіграють значну роль у зниженні ризиків, що виникають через людський фактор. Результати дослідження показують, що поведінка людини в екстремальних умовах формується не лише знаннями та навичками, але й стійкістю до стресу, емоційною рівновагою та здібностями до соціальної комунікації. Поряд з індивідуальною психологічною підготовленістю, узгодження систем з поведінкою людини та впровадження адаптивних технологій є вирішальними у мінімізації ризиків аварій. Запропонована у статті модель «психоселекції + навчання на симуляторі + моніторинг у реальному часі» представлена як комплексний підхід, спрямований на підвищення ефективності систем безпеки. На завершення, у статті наголошується на важливості розгляду людського фактору не лише як слабкої ланки, а й як психологічного ресурсу, який можна розвивати та зміцнювати. Забезпечення безпеки вимагає спільного застосування технічних систем та підходів, що стимулюють когнітивні, емоційні та соціальні навички людей, пропонуючи більш стабільні та стійкі результати діяльності. Таким чином, управління людським фактором шляхом підвищення психологічної готовності, інтеграції адаптивних технологій та підвищення колективної ефективності стає одним із ключових стратегічних пріоритетів у сфері безпеки авіації.

Ключові слова: людський фактор; екстремальні ситуації; стрес; когнітивні спотворення; психофізіологічна стабільність; безпека.

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