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O. V. Kostenko, PhD in Law,
L.O. Shapenko, Candidate of Law, Associate Professor
(National Aviation University, Ukraine)

Artificial intelligence and immersive technologies in the aviation sector: certification, new standards and challenges

The impact of modern technologies on the aviation industry, including AI, ML, AR, and VR, is studied. The issue of AI certification in safety-critical aviation systems is being updated. Attention is focused on the need to develop new aviation standards for AI and ML, including the development of special certification systems to ensure safety in the aviation sector.

Today Industry 5.0. is a catalyst for the digital transformation of almost all spheres of modern society, and the use of Metaverse, immersive technologies, augmented reality (AR) and virtual reality (VR), artificial intelligence (AI) and machine learning (ML) makes this transformation an effective tool for the modernization of technical industries, primarily aviation one, especially regarding the development and improvement of modern regulatory acts [1].

The need to adapt regulatory acts in the aviation industry is relevant in terms of improving compliance with safety criteria [2]. To prepare the means of compliance necessary for the certification of the reliability of artificial intelligence in safety-critical systems, the latest developments in aeronautical standards that ensure the full life cycle of AI development are considered [3]. Simultaneously with the formation of standardized requirements for the development and application cycles of AI in the aviation industry, requirements for three key complex systems with ML components that form a new certification framework are being developed.

Today aviation systems and software developers can adapt traditional development processes to approaches based on machine learning and identify changes that are necessary to ensure product certification using AviaAI (aviation AI) [2].

The formation of new Avia AI aviation standards should cover the following areas:

- development of a special certification system for artificial intelligence in aviation primarily to ensure its reliability, especially in subsystems where safety is critically important. This system is necessary to ensure that AI technologies used in aviation meet the strict standards required for safety and operational efficiency, minimizing the number of failures in environments where the preservation of human life and strategic assets is prioritized [4].
- integration of machine learning (ML) components into aviation standards, which focus on the incorporation of AI/ML technologies into complex systems, in order to solve unique problems that arise throughout their development life cycle. This includes adapting existing standards to the specific requirements of AI/ML, ensuring safety and reliability of such components, as well as managing the risks associated with their use in safety-critical systems and subsystems [5].

- adaptation of traditional engineering processes in connection with the introduction of artificial intelligence and machine learning in aviation due to the need to re-evaluate established standardization approaches. This entails the need to modernize the existing methodology in order to provide effective support for the certification of products using AI/ML. Such adaptation includes the integration of new approaches to the development, testing and validation of systems to meet the strict requirements for safety and reliability in the aviation industry [6].
- development of new standards and intelligent visual guidance systems (VGS) to support emergency landings. The implementation of these standards can improve safety and operational efficiency in aviation, ensuring reliable and accurate control in critical situations. This approach emphasizes the importance of innovations in standardization to improve the performance of aviation systems in real conditions [7].

Research aimed at creating new modern aviation standards emphasizes the need to integrate artificial intelligence technologies into aviation systems without compromising and weakening all requirements and levels of aviation safety. It is also necessary to conduct research on the development and modernization of documentation creation cycles, which reflect the steps of creating all modules and subsystems of artificial intelligence algorithms and decision-making processes, in order to ensure transparency in the development of software products in accordance with regulatory requirements.

Effective certification requires close collaboration between software engineers, system designers, and regulatory bodies to agree on standards and practices that take into account the specifics of artificial intelligence technologies. Such interdisciplinary interaction is a key to creating a unified approach to the development, implementation, and certification of AI systems, ensuring their compliance with high security and reliability requirements.

In addition to AI/ML technologies, augmented and virtual reality technologies are actively being implemented in the aviation sector. The integration of Augmented Reality (AR) and Virtual Reality (VR) technologies into the aviation industry is transforming various aspects of the industry, from manufacturing and maintenance to generating passenger experiences and pilot training, namely:

- AR/VR technologies can significantly improve passenger experience, ensuring flight safety, usability, and navigation in complex airport structures [8];
- the use of augmented reality in aerospace production significantly accelerates all production processes and effectively increases the qualifications of the workforce, reduces training costs, improves control systems and procedures, and increases productivity [9];
- the use of virtual and augmented reality technologies significantly improves the teaching and training of pilots, makes it possible to optimize many processes of aircraft and flight management, and to modernize the cockpit and aircraft flight controls [10; 11];
- creation of a joint technological immersive environment in the aviation industry, with the aim of improving cooperation, visualization, and interaction between interested parties, increasing the quality and novelty of ideas, while reducing communication problems and costs [12].

Conclusions

The above shows that the issue of adapting the aviation industry to new technologies, in particular artificial intelligence (AI) and machine learning (ML), is quite relevant. Nevertheless, it is now extremely important to update the legal acts that regulate the use of immersive technologies, especially in safety-critical aviation systems, which, accordingly, requires the development of new certification standards to minimize the risks of using AI and ML in aviation.

It should also be emphasized that the application of augmented reality (AR) and virtual reality (VR) technologies offers great opportunities for aviation, transforming training programs for pilots, optimizing maintenance processes, and increasing the level of passenger safety. Their implementation accelerates production processes, reduces costs and improves productivity.

The prospects of using AR and VR to create an integrated technological environment that will improve interaction between process participants in the aviation industry, contribute to the generation of innovations, and reduce communication costs are also worthy of attention. AI, ML, AR, and VR technologies open up new opportunities for aviation, but their effective implementation requires modern legal regulation as well as adaptation of existing standards and procedures.

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