

VIRTUAL REALITY IN AVIATION: APPLICATION AREAS AND SWOT ANALYSIS

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Purpose: The main objective of the research is to identify and analyze areas of application of virtual reality in aviation. The specific objectives includes: (1) the assessment of the usefulness of virtual reality in pilot training, (2) conducting a SWOT analysis for pilot training, (3) the assessment of the potential of VR as a tool supporting the development of aviation personnel competencies and improving operational safety.

Design/methodology/approach: The research uses the literature analysis method, the survey method and the SWOT analysis. To assess the perceived usefulness of virtual reality in pilot training, a survey was conducted among 30 individuals at various stages of their aviation careers (from ATPL(A) to First Officer) training. Authors used internet questionnaire survey. SWOT analysis was carried out also for pilot training area.

Findings: Respondents closely related to pilot training (from ATPL(A) to First Officer) showed great interest in virtual reality. The study shows the potential of using virtual reality in supporting pilot training.

Practical implications: The results presented in the article can be treated as an introduction to larger studies and a broader discussion on the potential of using virtual reality in pilot training. The survey results indicate a positive interest of respondents in the use of virtual reality in aviation. This topic should be researched more extensively and practical actions should be taken in this direction.

Originality/value: As shown in the section on literature analysis, the topic of using virtual reality in aviation is not yet exploited. Hence the article shows an area that has great potential both in terms of research and application. Survey research were conducted on respondents closely related to pilot training (from ATPL(A) to First Officer). Based on the SWOT analysis, the article presents a view on the use of virtual reality in pilot training from various perspectives.

Keywords: virtual reality (VR), VR training, aviation, pilot training, survey.

Category of the paper: Research paper.

1. Introduction

The development of the Industry 4.0 concept has initiated changes in the way modern organizations operate. These changes apply to both the manufacturing and service sectors. A significant portion of these changes involves digitalization, which affects processes, services, and the entire economy. Enterprises are increasingly using IT solutions, e-services, and information and communication technologies (ICT). One of the key elements of digital transformation and Industry 4.0 is immersive technologies. These include virtual reality (VR) and augmented reality (AR). Of course, they can be used in entertainment (Epp et al., 2021; Stecuła, 2022), relaxation (Fagnäs et al., 2021), and culture (Jung et al., 2016; Kontogiorgakis et al., 2024), but they also have significant potential for application in other areas of human life. They find applications in medicine (Yeung et al., 2021), education (Stecuła, Pradela, 2024), industry (Henriques, Winkler, 2021; Van Wyk, De Villiers, 2009), etc. They enable the use of interactive environments, simulations, and training. The potential for application is enormous, especially as these technologies are currently developing. In industry, they can be used to increase the effectiveness of company training (Norris et al., 2019), shorten task completion times (Kangas et al., 2022), increase work safety (Haj-Bolouri et al., 2024) and many other purposes.

Aviation is among the many sectors that could benefit from the development of immersive technologies. It is characterized by a high degree of complexity, requiring precise training, rapid response to non-standard situations, and adherence to the highest safety standards. Due to the nature of air operations, their cost, and the limited availability of real-world crisis scenarios, virtual reality represents an area of exceptional potential. VR offers the ability to replicate dynamic, challenging, or dangerous situations. Such scenarios can be repeated without significant expense. Scenario rehearsal is conducted in a safe and controlled manner. VR has the potential to improve the quality of training, streamline decision-making processes, and develop the practical competencies of aviation personnel.

This article addresses the application of virtual reality in aviation. Based on a literature review and the authors' own experiences, the areas of aviation where VR has the potential and potential for application have been identified. The authors identify these areas and then conduct a SWOT analysis to assess their strengths, weaknesses, opportunities, and threats. The results can serve as a basis for formulating recommendations regarding VR implementation in the aviation sector, particularly in the context of training and improving personnel competencies.

2. Literature review

The authors examined the number of articles that deal with the topic of virtual reality in aviation. For this purpose, using the search engine in the Scopus database, they performed a quantitative analysis of the literature. Authors focused on articles that have both keywords “virtual reality” and “aviation”. The search formula was written as follows – formula (1):

$$KEY ("virtual\ reality")\ AND\ KEY ("aviation") \quad (1)$$

An analysis of scientific achievements collected in the Scopus database indicates that between 1991 and 2025, a total of 347 papers on the application of virtual reality in aviation were published. Although the first publications appeared in the early 1990s, for nearly two decades the number of studies was very limited, indicating a low interest in this topic. Only after 2015 was a significant increase in the number of publications observed, and a particularly dynamic increase was recorded after 2018, when the number of papers systematically increased, reaching over 20 articles per year since 2020. This trend confirms that VR research in aviation is still a developing niche – an area with significant exploratory potential that is only just beginning to be recognized by the scientific community. Research activity to date remains low compared to other sectors. This confirms the need for further in-depth analyses and the organization of knowledge in this area. Figure 1 shows the discussed data.

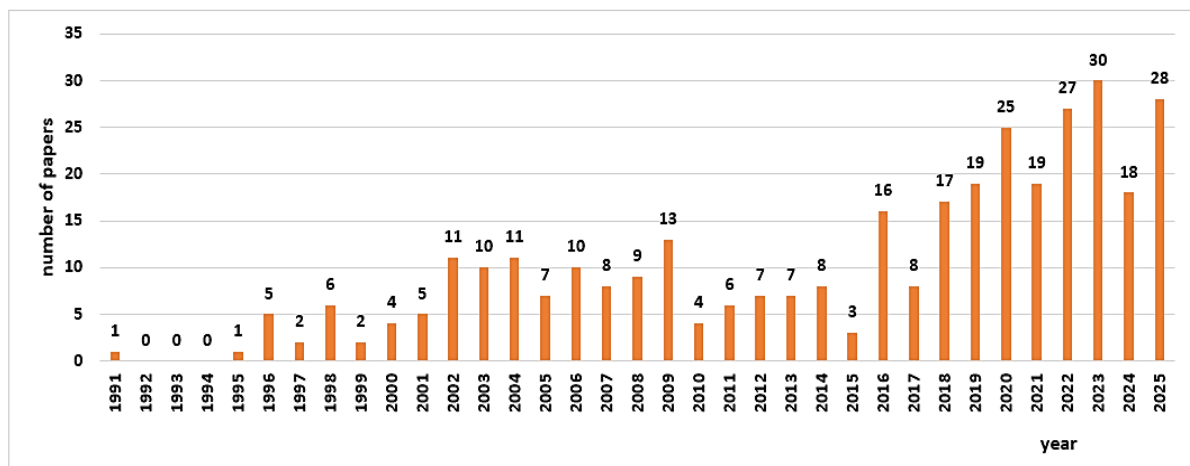


Figure 1. Number of papers in the Scopus database with the keywords „virtual reality” and „aviation” published by year; n = 347 (data state on November 15, 2025).

In the next step, the authors analyzed the structure of publications by subject area, based on data obtained from the Scopus database. The analysis shows that the application of virtual reality in aviation is clearly dominated by technical fields. The largest number of publications were assigned to Engineering (203 documents, almost one-third of all publications) and Computer Science (129 documents), confirming that research on VR in aviation focuses primarily on technological, design, and simulation aspects. Social Sciences (75) and Mathematics (55) also have a high representation, reflecting the interest in training processes,

behavioral analysis, and modeling. A significant, though smaller, group of publications comes from the areas of Medicine (43), Psychology (19), and Neuroscience (15), indicating a growing interest in the impact of immersive environments on perception, stress, cognitive responses, and the safety of VR users. The fields of Physics and Astronomy (23) and Materials Science (19) encompass studies on modeling physical environments, human-machine interaction, and device technology. However, fields such as Business, Management and Accounting (6) and Economics (4) are marginally represented, demonstrating that economic, organizational, and managerial analyses of VR in aviation remain underdeveloped. Figure 2 shows the mentioned data in details.

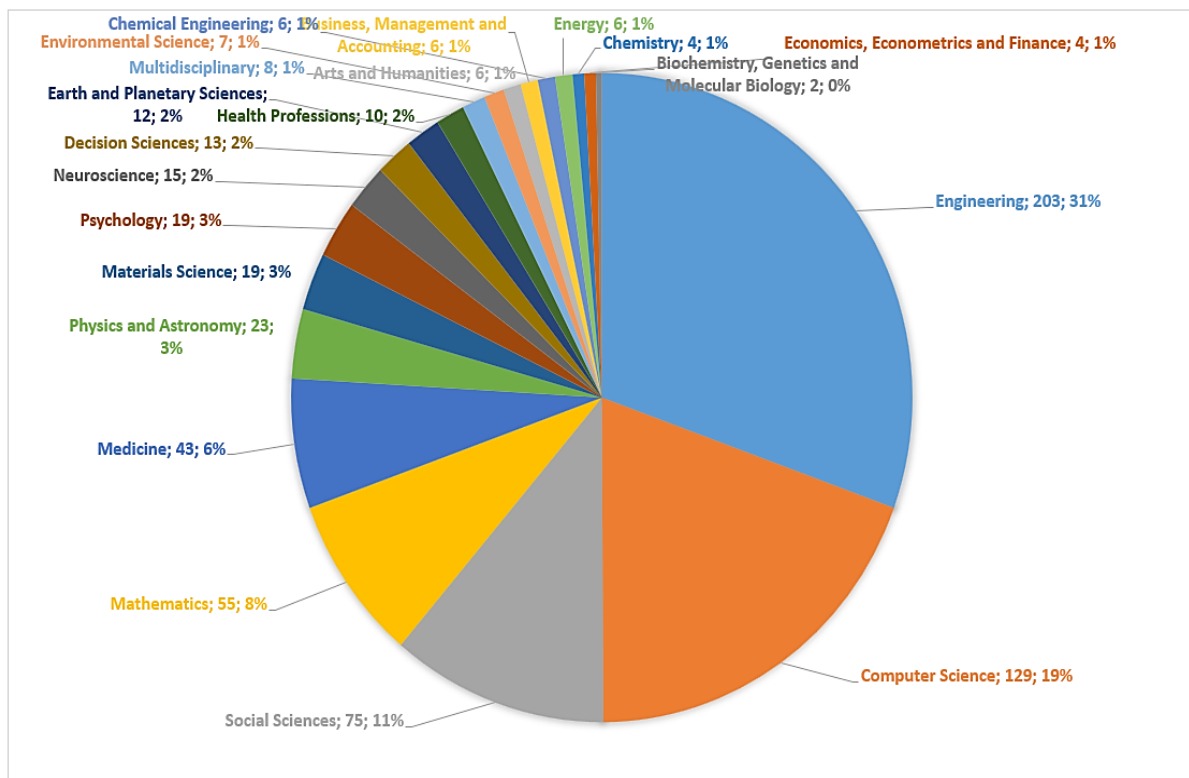


Figure 2. Number of papers in the Scopus database with the keywords „virtual reality” and „aviation” ordered by subject area; n = 347 (data state on November 15, 2025).

The results of the analysis confirm that the literature on VR in aviation is clearly interdisciplinary in nature, but the distribution of publications indicates a dominance of technical research over social or organizational research. At the same time, areas such as management, education, ergonomics, and cost-effectiveness remain underexplored, creating room for further research and representing a scientific niche with significant development potential.

Among papers that were published in 2025-2024, there are different topics and perspectives of research. There are articles on general training and simulation in aviation which uses virtual reality or its elements (Bayro et al., 2025; Larkin et al., 2025; Malmquist et al., 2025; McCullins et al., 2025). Some of the papers discuss and examined the topic of pilot flight simulator training (Kimura et al., 2024; Somerville et al., 2025). Another paper refers generally to immersive

technologies in aviation (Wild et al., 2025). Other authors present and study VR and AR interaction modes in airport control towers (Bagassi et al., 2024). More technological paper (Thijssen et al., 2025), explores the integration of live, virtual, and constructive environments in fighter pilot training through Link-16. Another paper develops methodology for enablement of human digital twins for quality assurance in the aerospace manufacturing domain (Colaw et al., 2025). Digital twins in the context of VR are also discussed in other papers (Jayasree et al., 2025; Ren et al., 2024). There is also a paper which presents research on development and validation of spatial disorientation scenarios using virtual reality and motion simulator (Kim et al., 2025). Other authors presents an iterative design method for advancing air traffic control and management training through immersive VFR 3D map visualization (Patrick et al., 2025). There is also a paper on effects of a VR-based procedure trainer on vision and cybersickness in senior airline pilots (Collet et al., 2025). Mental health and readiness for professions within aviation is also examined (Ćosić et al., 2025). Another group of papers are those on work safety and education about aviation safety (Dodoo et al., 2025; Scorgie et al., 2024; Zhu, 2025).

A literature review shows that the topic of VR research in aviation is very diverse and covers many areas – from general training and simulation, through work on pilots, to research on technical personnel, security services, and psychological issues. The range of publications indicates that this area is still developing rapidly, with immersive technologies gradually being implemented in increasingly new operational contexts. Despite growing interest, many topics remain under-researched, highlighting the significant potential and need for further scientific analysis.

3. Materials and methods

The research uses the literature analysis method, the survey method and the SWOT analysis. To assess the perceived usefulness of virtual reality in pilot training, a survey was conducted among 30 individuals at various stages of their aviation careers (from ATPL(A) to First Officer) training. The survey covered six thematic areas, allowing for the assessment of VR's potential in practical flight training. The authors used an online survey, Google Forms, the survey was sent via email, the results were collected and then the authors analyzed the results and presented them in the next chapter. Participants assessed, among other things:

- experience using VR,
- training areas where VR is most useful,
- training stages where VR could support learning,
- subjective assessment of VR's usefulness in pilot training, and
- possibility of formally incorporating VR as a preparation element for simulator sessions or training flights.

The obtained results enabled the identification of key VR applications and an assessment of the perceived value and limitations of this technology from the perspective of future pilots.

The main objective of the research is:

- to identify and analyze areas of application of virtual reality in aviation,

The specific objectives of the research are set as follows:

- assessment of the usefulness of virtual reality in pilot training,
- conduct a SWOT analysis for a selected area – pilot training,
- assess the potential of VR as a tool supporting the development of aviation personnel competencies and improving operational safety.

The collected responses allowed us to identify key areas of VR application in aviation training and formed the basis for further analysis presented in the Results section.

4. Results

Virtual reality technology is one of the dynamically developing tools supporting the training process in aviation. It enables the creation of immersive environments in which the user can perform activities identical or similar to real aviation operations, while maintaining complete safety and very low costs compared to traditional training. VR is currently being used in an increasing number of areas, and its implementation is supported by both the rapid development of hardware (VR goggles, controllers, motion tracking) and software that enables realistic reproduction of the cockpit, passenger cabin, airport infrastructure and emergency situations.

This study has identified six key areas where VR has particular potential in the context of civil aviation:

- pilot training – cockpit, procedures, emergency situations,
- cabin crew training – evacuation, critical situations, passenger service,
- air traffic controller training – visualization of traffic and unusual situations,
- safety management – crisis scenarios and incident analysis,
- academic education – support for aviation students and trainees,
- maintenance and technical service – training for mechanics and technicians.

Of the areas mentioned, pilot training proved to be the most important, both in terms of research and practice. It is here that the most important stages of acquiring procedural skills are concentrated, and the learning process itself requires both repetition and access to specialized equipment, such as FNPT II, FTD or FFS simulators. For this reason, the analysis of the survey results has been fully integrated into the segment concerning pilot training, where VR found the greatest support among respondents.

4.1. Pilot training

Pilot training is an area where the use of VR technology is most natural and most frequently discussed in literature. This is due to the fact that a large part of the pilot training process is based not on flight dynamics alone, but on procedural skills, knowledge of the cockpit layout and automation of flight operations. Pilots must not only gain the necessary flight time, but also demonstrate precise responses to checklists, flows, emergency situations and operating procedures. Often, these elements are more demanding than the actual piloting of the aircraft. VR fits perfectly into this model of skill acquisition – it allows for multiple, unlimited repetitions of activities, work in a 1:1 cockpit scale, and the performance of procedures in a manner consistent with natural hand movements. This is particularly important prior to training on expensive, certified FSTD devices, where each hour is limited and costly.

In the first part of the survey, participants were asked about the stage of their aviation career. The results are presented in the chart below (Figure 1).

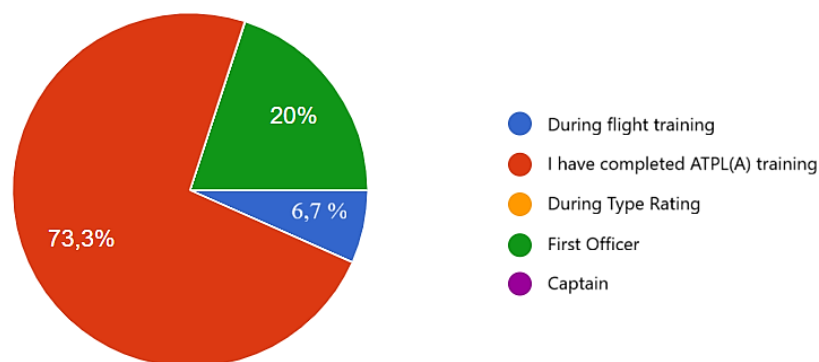


Figure 1. Responses to the question "What stage of your aviation career are you currently at (single-choice question)?" (n = 30).

The interpretation of the data shows that the study was dominated by pilots who had completed ATPL(A) training (73.3%) and active First Officers (20%). Only 6.7% were trainees undergoing basic training. This means that the vast majority of respondents had undergone theoretical and simulator training, so their opinions on VR are based on real experience of practising procedures and working in the cockpit. The high level of experience of the group increases the reliability of the results.

In the second question, respondents were asked about their experience with virtual reality. Among the 30 people, only one person had never used VR. The question concerned not only the use of virtual reality in aviation but also the general experience with this technology. Figure 2 shows the results.

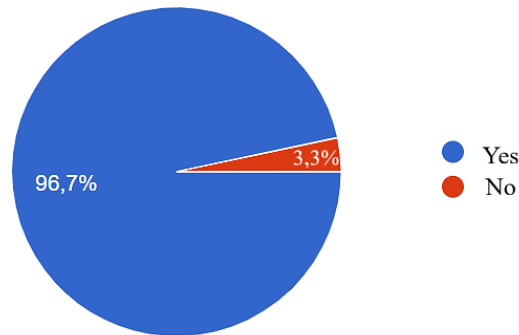


Figure 2. Responses to the question "Have you ever used VR (not just for aviation purposes; multiple choice question)?" (n = 30).

Then, pilots were asked which elements of training could benefit most from the use of VR. The results are presented in the chart below (Figure 3).

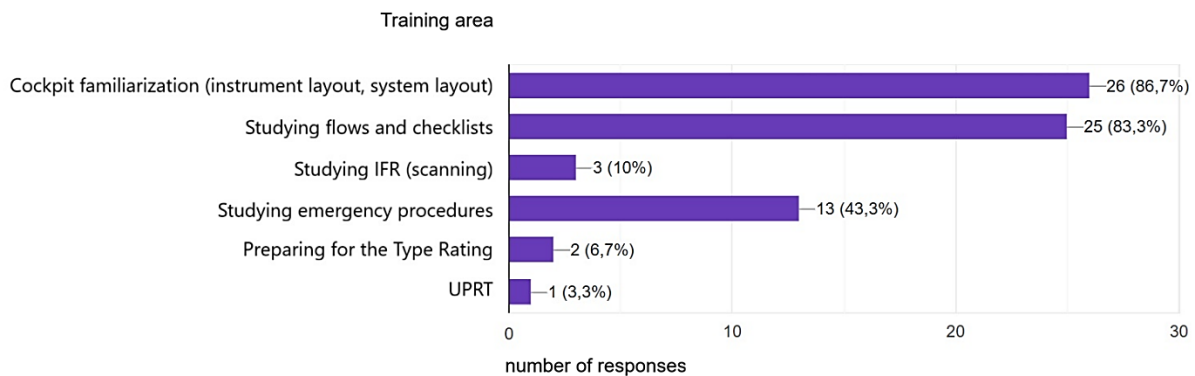


Figure 3. Responses to the question "In what areas of pilot training could VR be most useful (multiple choice question)?" (n = 30).

The analysis of the results shows three main areas:

- Familiarisation with the cockpit – 86.7% – this is the highest-rated element. VR allows you to learn the location of switches, instruments, panels and the logic of the cockpit layout. Respondents emphasised that during their first sessions in FNPT or FFS simulators, the greatest difficulty was finding the right cockpit elements and understanding their layout. VR largely eliminates this problem.
- Learning flows and checklists – 83.3% – the second most frequently mentioned area is learning procedures. VR allows the user to perform sequences of actions in accordance with the logic of the aircraft, repeat them multiple times, and build motor automation. Many pilots emphasised that VR would allow them to prepare much better for their first sessions in FSTD simulators.
- Emergency procedures – 43.3% – in emergency situations, pilots perform procedures according to checklists and procedural memory. VR allows them to train for rare scenarios in a safe environment. Respondent indicated this element as a valuable addition to traditional training.

Lower percentages in other areas (IFR – 10%, preparation for Type Rating – 6.7%, UPRT – 3.3%) do not mean a lack of value, but rather that VR is perceived primarily as a procedural tool and only secondarily as a tool for learning complex situational awareness.

In the next survey question, pilots assessed at which stage of training they believed VR technology could bring the greatest benefits. The results are presented in the chart (Figure 4).

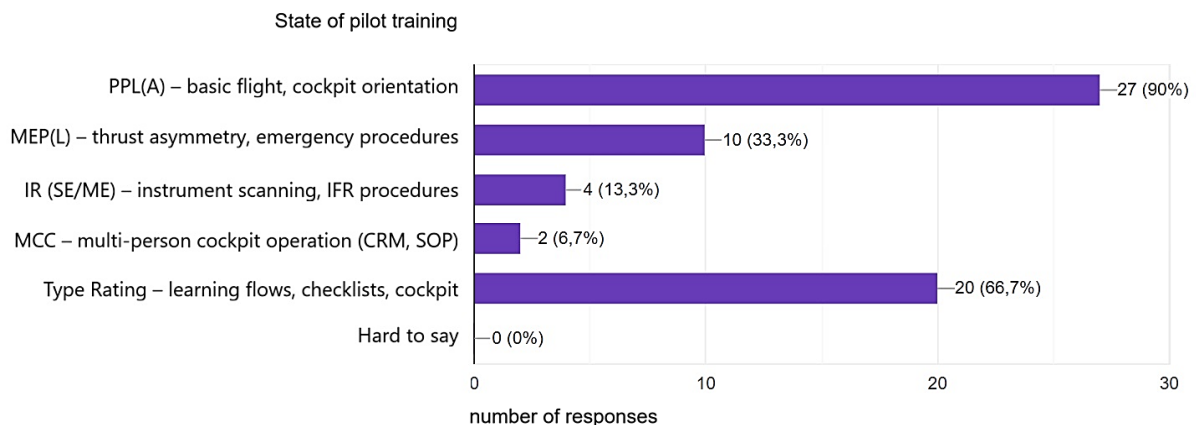


Figure 4. Responses to the question "At what stage of pilot training do you think VR technology could be most useful (multiple choice question)?" (n = 30).

Interpretation of results are as follows:

- PPL(A) – 90% of responses – this stage covers the basics of flying and the first encounter with the cockpit. Respondents felt that VR would be extremely valuable here, as it allows them to freely explore the cabin layout, learn checklists and practise basic procedures without time or cost pressures.
- Type Rating – 66.7% of responses – the second most important stage according to the respondents. Pilots beginning training on a given type of aircraft must learn a huge number of procedures in a short period of time. VR could improve the learning of flows, panel layout and intensive procedural training before entering the FFS simulator.
- MEP(L) – 33.3% of responses – this stage includes assistance in flying multi-engine aircraft and learning emergency procedures related to thrust asymmetry. VR could support checklist response training and build automation of actions in emergency situations.
- IR (SE/ME) – 13.3% of responses – the lower value is due to the fact that IFR training is largely based on working with instruments and precision piloting, which fully requires certified simulators. VR, on the other hand, can support procedural elements – e.g. pre-take-off sequences, aircraft configuration, briefing.
- MCC – 6.7% of responses – this stage is mainly based on crew communication and cooperation. VR can simulate the cockpit environment, but it does not replace the dynamics of two pilots working together in a simulator.

In the next question, respondents were asked to mark on a scale from 1 to 5 to what extent virtual reality can be useful in pilot training. The most frequently chosen rating was 4 points, 80% of respondents chose this answer. The average rating was 3,9. three-person teams took 5 points, while 1, 2 and 3 points were chosen by exactly one person each. Figure 5 shows the results.

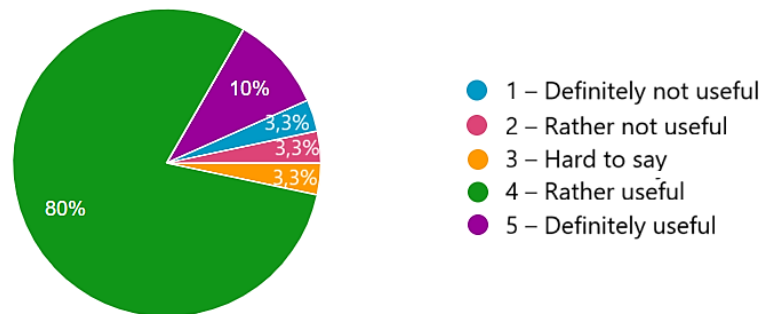


Figure 5. Responses to the question "To what extent could VR be useful in pilot training?" (n = 30).

In the last question, respondents were asked whether, in their opinion, virtual reality should be a formal element of pilot training. 96.7% of people chose the answer "yes, but only as an optional tool". Only one person answered "no" to this question. Nobody selected the answer "yes", and "hard to say". This means that virtual reality is met with interest and future pilots see its potential for use in flight training, although none of the respondents stated that virtual reality should be incorporated as a tool for everyone during training. Figure 6 shows the results. An illustrative example of a person undergoing virtual reality flight training is presented in Figure 7.

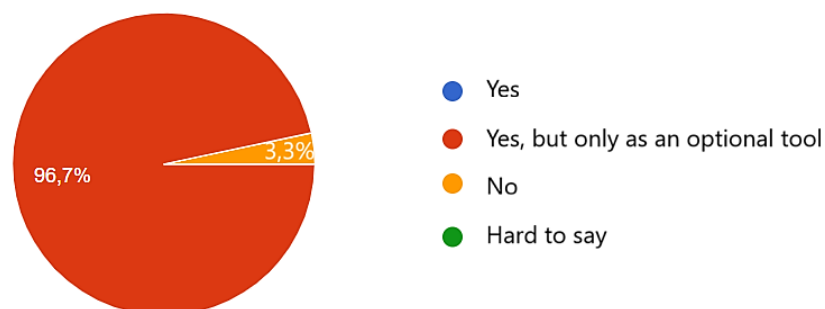


Figure 6. Responses to the question "In your opinion, could VR be incorporated as a formal element of preparation for simulator sessions or training flights in an aircraft?" (n = 30).



Figure 7. An illustrative example of a person undergoing virtual reality flight training (authors' own work).

4.2. Cabin crew training

VR enables realistic simulation of emergency situations such as fire, smoke, decompression or aircraft evacuation. Training for these situations usually takes place in an infrastructure-limited environment, and conducting a full simulation can be costly or difficult to organize. VR enables these events to be safely replayed multiple times, developing the ability to act under pressure, work as a team and communicate with passengers in stressful conditions. This is particularly important because a large part of the cabin crew's duties relate to rare and emergency situations that cannot be practiced in real conditions.

4.3. Training for air traffic controllers

In the area of air traffic control, VR can reproduce both typical and rare operational situations. Controllers can observe aircraft movement in three-dimensional space, simulate unusual situations, transponder malfunctions, airspace violations or incorrect pilot maneuvers. In addition, VR allows for training scenarios involving sudden increases in traffic or radio communication disruptions. VR training can significantly increase an air traffic controller's situational awareness and improve decision-making.

4.4. Security management

VR allows for realistic recreation of crisis situations, such as aviation incidents, system failures, rescue operations, and mass-casualty events. As a result, it can support the safety management system (SMS) through training simulations and corrective action exercises in a risk-free environment. In addition, it is possible to reconstruct aviation accidents in a three-dimensional environment, which facilitates the analysis of causes and the promotion of a safety culture.

4.5. Academic education

VR enables aviation students to learn the basics of aerodynamics, flight mechanics, navigation, meteorology and on-board systems in an interactive and engaging way. Students can analyse the operation of electrical, hydraulic and fuel systems in an aircraft, manipulate virtual structural elements and perform experiments that would be impossible in a traditional lecture hall. VR also supports theoretical courses by enabling the observation of aviation phenomena in a three-dimensional environment.

4.6. Maintenance and technical service

VR is increasingly used in aircraft mechanic training. Technicians can learn maintenance, diagnostic and repair procedures on virtual aircraft models without the risk of damaging structural components. They can perform inspections, learn about system design and practise step-by-step procedures, which speeds up their adaptation to the work environment and reduces training costs.

5. SWOT analysis

This chapter shows the SWOT analysis carried out for the selected area among the mentioned. This area is pilot training. Table 1 presents the analyzed strengths, weaknesses, opportunities, and threats of the use of virtual reality for pilot training.

Table 1.
SWOT analysis of VR application in pilot training

The area of SWOT analysis	The most important elements in the given area
Strengths	<ul style="list-style-type: none"> • Modern and interactive tool for learning procedures (flows, checklists). • Ability to repeat activities multiple times. • Progress monitoring (quick feedback). • Realistic 3D cockpit representation. • High level of immersion. • Training availability regardless of weather conditions. • Safe emergency procedures training. • Support for building situational awareness.
Weaknesses	<ul style="list-style-type: none"> • Lack of physical sensations and feelings from the cockpit. • Contraindications to VR use. • Side effects experienced by some individuals (e.g., dizziness, nausea, etc.) while using VR. • Variable quality of equipment and cockpit representation. • Limited operation in a multi-person cockpit. • Lack of formal EASA certification.

Cont. table 1.

Opportunities	<ul style="list-style-type: none"> • Incorporating VR training as preparation for simulators. • Support prior to Type Rating training. • Development of remote and home training. • Possibility of standardizing learning flows and checklists. • Reducing procedural training costs. • Introducing VR as a tool for self-preparation before flight.
Threats	<ul style="list-style-type: none"> • Lack of formal regulations and EASA recognition of VR. • Risk of developing bad habits due to poor-quality models. • Rapid obsolescence of VR equipment and the need for frequent updates. • Training effectiveness depends on the quality of hardware and software. • Possible instructor reluctance to adopt new methods. • Risk of over-reliance on simulation at the expense of real-world experience.

An analysis of its strengths indicates that virtual reality can be a modern and interactive tool supporting pilot training. It enables realistic representations of the cockpit, procedures, and checklists. VR also allows a user to repeat tasks many times in safe conditions. Users can practice various scenarios without the risk of an aircraft accident. This allows pilots to practice both basic procedures and complex emergency scenarios. Such VR sessions are without risk. The high level of immersion increases trainee engagement. VR offer also progress monitoring and instant feedback. Such elements enhance the quality of the learning process. VR is also becoming a tool independent of weather, aircraft availability, or training center schedules.

The weaknesses of VR indicate the need for careful implementation of this technology in pilot training. The most significant limitation is the lack of a realistic representation of kinesthetic sensations (which play a crucial role in aviation). VR can help with scenario practice, but the technology isn't yet developed enough to fully replicate all the technical requirements and realistic sensations – equal to a real flight. Furthermore, VR can cause side effects for some people. These include nausea, dizziness, eye strain, disorientation, headaches, and many others. This limits the user base. The varying quality of available hardware and software also poses a challenge. Different headsets and applications can have different quality and level of realism. Crew synchronization issues may arise in multi-person training sessions. Also, the lack of formal EASA certification for VR means this technology cannot yet replace traditional training methods.

VR development in aviation is also an opportunity. Virtual reality can serve as a preparatory stage before training on advanced simulators or before starting a Type Rating course. This allows for a more balanced knowledge level among students and accelerates the learning process. The technology also facilitates the development of remote learning options. VR applications can be played even at home. This can reduce training costs. Another significant opportunity is the possibility of standardizing the learning of procedures, checklists, and flows, which will facilitate the alignment of competencies between different training centers. VR could become a popular tool for self-preparation before a flight, increasing pilots' efficiency.

Using VR is pose also many risks. The risks associated with the use of VR stem primarily from formal and technological issues. The first one is the lack of official regulations and EASA recognition of VR. This currently prevents this technology from playing a full role in the training process. Lack of recognition its potential limits its wide-scale implementation. There is also the risk of developing inappropriate habits if VR models or procedures are inaccurate or outdated. Rapid technological advances mean that equipment can quickly become outdated. This technology (including, first of all, VR applications' quality) requires frequent upgrades. Furthermore, the effectiveness of training depends on the quality of the software, and the reluctance of some instructors to use new methods may delay the adoption of this technology. Overreliance on VR could also reduce the emphasis on gaining experience in real-world conditions, which remains crucial to a pilot's work.

6. Discussion

The results obtained in the above study show that virtual reality technology is perceived by the aviation community as a tool supporting procedural training. Pilot training clearly stands out among the applications of virtual reality. The results show consistency with pilot training procedures, which are mostly based on procedural knowledge, familiarity with the cockpit layout, and standard and non-standard operating procedures. These elements can be effectively utilized by an artificial training environment based on VR technology.

The helpful application of VR is confirmed by a high percentage of respondents who perceive virtual reality as a tool for familiarizing themselves with the cockpit, procedures and checklists, rather than as a replacement for a certified simulator or a real aircraft.

The VR analysis shows the greatest interest among respondents in the early stages of training, such as PPL(A) and Type Rating. During these stages of training, pilots must acquire as much knowledge as possible in the shortest possible time, often before entering the cockpit. Analyzing the respondents' answers, it can be concluded that VR seems to fill the gap by providing an unlimited number of repetitions in an environment that replicates the real cockpit.

Lower ratings for IFR, MCC and UPRT training do not indicate that VR is not useful in these areas. Instrument Flight Rules training requires precise interpretation of instruments and high fidelity flight dynamics, which are best provided by certified simulators. MCC training, on the other hand, is based primarily on real-time crew cooperation between two pilots. These results only emphasize that VR can currently be used as a supplement to training rather than a tool that completely replaces traditional flight training.

Compared to existing literature on the subject, an important contribution of this study is the clear distinction between training stages and training objectives. Most studies present VR as a training innovation. In our research, we demonstrate the application of this technology,

especially for selected training stages. The strong preference for VR in the PPL(A) and Type Rating stages indicates that VR may be most effective when used to build basic procedural competencies rather than advanced operational decision-making skills.

From a practical point of view, the results suggest several important conclusions for training centers. Firstly, VR can become a key tool in preparing for simulator sessions. In this way, the technology can ensure that trainees arrive at FNPT, FTD or FFS sessions with a higher level of procedural readiness. This solution can reduce training time and the costs associated with extended training. The use of VR can also standardize the initial knowledge level of students.

The SWOT analysis further confirms these conclusions, highlighting the strengths of VR. These include cost-effectiveness, flexibility and security. Weaknesses include aspects related to technological limitations and lack of certification. Opportunities include the potential for rapid development of VR equipment and growing acceptance in the aviation community, while threats include regulatory constraints. These factors should be carefully considered when planning the implementation of VR-based training solutions.

The research conducted for the article has its limitations. The survey was conducted among a relatively small group of 30 respondents. In addition, the sample consisted mainly of pilots who had completed ATPL training and active first officers, which may affect the perception of the usefulness of VR compared to student pilots or instructors. The study was also based on the opinions reported by the respondents themselves rather than on objective measurements of results, which means that the results reflect the perceived rather than the measured effectiveness of the training.

Future research should focus on larger and more diverse groups of respondents. It should include instructors, examiners, and training managers. Experimental studies comparing groups of students who have undergone training using VR technology and those who have not would also be an important analysis. In addition, research on multi-user VR environments could help overcome barriers at training stages such as MCC.

Overall, the discussion confirms that virtual reality has significant potential as an auxiliary training tool. Combining this technology with current training methods can significantly improve procedural readiness and contribute to a more effective learning process.

7. Summary

This article discusses the topic of the use of virtual reality in aviation. The article presents the areas in which virtual reality has the potential to be used. The focus is especially on the area of pilot training. Survey research and a SWOT analysis were conducted for this area. The identified areas of VR application demonstrate the wide range of possibilities offered by this technology in aviation. A key area remains pilot training, where VR allows for safe and

repeatable practice of procedures, increased cockpit awareness, and preparation for advanced simulator sessions. Analysis of the surveys confirms that this technology is viewed positively by the aviation community and that its implementation can bring educational and operational benefits.

The survey results confirm that pilots perceive VR as a valuable tool supporting the learning of procedures and cockpit familiarization. VR provides the greatest benefit during the preparation phase for practical training and simulator sessions, particularly in the areas of flows and checklists. Respondents also indicated VR's high usefulness in practicing basic emergency scenarios. Although VR will not replace certified simulators in the near future, it can significantly improve pilot preparation and reduce the costs of procedural training.

Acknowledgements

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