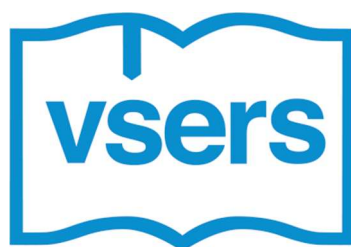


Jiří DUŠEK et al.

# DEVELOPMENT AND PERSPECTIVES OF MODERN TECHNOLOGIES IN EDUCATION IN THE FIELD OF CIVIL PROTECTION: FOCUS ON VIRTUAL REALITY



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**DEVELOPMENT AND PERSPECTIVES OF  
MODERN TECHNOLOGIES IN EDUCATION IN  
THE FIELD OF CIVIL PROTECTION:  
FOCUS ON VIRTUAL REALITY**

Jiří DUŠEK et al.



The College of European and Regional Studies

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## **ABSTRACT**

The publication explores the application of modern technologies, particularly virtual reality (VR), in the field of education and civil protection. The introductory chapter highlights the significance of civil protection education, outlining its specific characteristics and emphasizing the necessity of innovative approaches in this domain. The next sections examine the evolution, current state, and future prospects of virtual reality, tracing its early development, contemporary applications, and anticipated trends that could significantly influence its advancement.

Further chapters underscore the role of modern technologies in civil protection training, particularly the integration of VR with cybersecurity. Special attention is given to the practical application of VR as a tool for crisis management training and risk prevention. A detailed analysis is provided on the state of VR implementation in the Czech Republic, Slovakia, and Poland, mapping ongoing projects, current application, and companies specializing in VR solutions for crisis management, while also considering the role of higher education institutions in this field.

The publication includes a comprehensive SWOT analysis assessing the strengths, weaknesses, opportunities, and threats associated with VR adoption in the examined countries. The concluding chapters focus on the development and future perspectives of modern technologies in civil protection education, emphasizing their practical application across the three V4 countries. The work offers a thorough analysis of the current state and future potential of virtual reality in civil protection education and crisis management.

### **Keywords:**

Crisis management, modern technologies, simulation, virtual reality, education

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I21 Analysis of Education

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L86: Information and Internet Services; Computer Software

Q54: Climate; Natural Disasters and Their Management; Global Warming

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## INTRODUCTION

Civil protection is a key element ensuring the safety and security of citizens against both natural and human-induced disasters. In the V4 region, which comprises the Czech Republic, Slovakia, Poland, and Hungary, a wide range of projects and applications have been developed to support education and training in this field.

A major issue in the V4 region is the fact that many civil protection projects and applications are developed in isolation, within national borders. As a result, relevant activities in neighbouring countries often remain unknown or are developed in parallel, without awareness of each other. This duplication not only leads to inefficient use of resources but also hinders the sharing of valuable knowledge and experience that could benefit the entire region. Consequently, many similar projects are launched independently across the V4 countries, without making use of insights and successful practices from abroad.

This monograph aims to examine the current state and future perspectives of modern technologies in civil protection training in the Czech Republic, Slovakia, and Poland. Special attention is given to the potential for regional cooperation and knowledge sharing, which can significantly support the contribute to effective development of education in this field. It shall be pointed out that modern technologies, such as virtual reality, e-learning, and simulation, provide a wide range of possibilities for civil protection education. These technologies enable realistic simulation of crisis situation, which helps (not only) students to better understand the comprehensive processes and develop necessary skills for effective response in crisis situations.

Virtual reality, for instance, allows for the creation of realistic scenarios of disasters that students can experience and learn from without being exposed to actual danger. E-learning platforms provide easy access to study materials and courses, thus increasing the availability of education for a broader range of people.

These technologies also make it possible to personalize education according to individual needs of students, which contributes to a better understanding and long-term retention of acquired knowledge.

Regional cooperation is essential for the effective development of civil protection training. Projects funded by the Visegrad Group, such as "Development and Perspectives of Modern Technologies in Education in the Field of Civil Protection", demonstrate how knowledge can be shared across borders. This project, implemented in cooperation with institutions from the Czech Republic, Slovakia, and Poland, focuses on the development of modern technologies in education and their practical application. The aim is to create a platform for the exchange of knowledge and experience that could benefit the entire regional community.

It should be emphasized that regional cooperation offers numerous benefits, including shared cost for the development of new technologies, the exchange of experience and knowledge among experts from different countries, and the ability to respond more effectively to crisis situations that often transcend national borders. In the V4 countries, there are many examples of successful cooperation, such as projects focused on protection against flood and fire, which involve collaboration between neighbouring countries.

Nevertheless, despite these successes, there are still obstacles to effective cooperation and knowledge sharing between V4 countries. One of these challenges is the language barrier, which can limit communication and collaboration between experts from different countries. Another obstacle is the differing legislation and regulatory frameworks, which may hinder the implementation of cross-border projects.

To overcome these challenges, it is essential to develop effective mechanisms for sharing knowledge and experience. This could involve the creation of joint educational and training programs, organizing international conferences and workshops, as well as establishing platforms for the exchange of

information and expertise among professionals from various countries. These platforms should be built on modern technologies, such as online forums, social networks, and specialized applications for knowledge sharing.

The development of modern technologies in education in the field of civil protection offers a wide range of opportunities for improving preparedness and response in crisis situations. However, it is necessary to overcome barriers that hinder effective cooperation and knowledge sharing among V4 countries. This monograph provides a detailed analysis of current projects and applications in the Czech Republic, Slovakia, and Poland, and explores the possibilities of regional cooperation and knowledge sharing for the effective development of civil protection.

The goal is to offer a comprehensive insight into the current state and future perspectives of modern technologies in this field of education and to propose methods for improving regional cooperation. It shall be pointed out that the effective development of civil protection directly impacts the security and protection of citizens, making it crucial to address this issue with particular attention.

In conclusion, it should be noted that regional cooperation and knowledge sharing represent key components for the effective development of education in the field of civil protection. Projects involving cooperation between institutions from various countries can bring significant benefits, from cost-sharing to the exchange of experience and expertise. It is essential to further develop such projects and create conditions for the effective sharing of knowledge and experience across borders. Such an approach may contribute to better preparedness and response to crisis situation in the V4 region, ultimately strengthening the security and protection of citizens (see Ivančík, 2021, for more details).

# 1 SECURITY EDUCATION AND ITS SPECIFICS

Security studies is a discipline that encompasses the fields focused on comprehensive evaluation and management of risks, the protection of individuals, as well as safeguarding both material and immaterial values and the environment. This discipline focuses on developing preventive measures, addressing the emergence of extraordinary events, and managing crisis situations. Providing training and education for such a wide range of tasks is challenging, and from a practical standpoint, it is not always feasible to prepare for every scenario that might arise. Standard responses cannot always be rehearsed, as each situation has its own specificities, and its progression is influenced by multiple factors (Halúsková, Mošková, 2022).

The term security education refers to university-level education, the training of members of security forces, and the education of the professional public in the field of civil protection. Security education is not only about raising the educational and professional level of security personnel, experts, and managers, but it can also be viewed as an effective educational system for building security awareness and shaping attitudes towards security behaviour and actions. This takes place within the framework of lifelong learning, from pre-school education to the education of economically active citizens (Kováčová, Klimo, 2013). The security training system must be designed in such a way so that it enables the acquisition and mastery of knowledge and methodologies for analysing the security environment and its factors in relation to various objects, identifying and assessing security risks and threats, forecasting their development, determining procedures and measures to manage security risks and threats, and planning and organizing risk management and security and crisis management measures in accordance with available resources and capacities, as well as designing and managing complex security systems (Kováčová, 2010).

Security education involves the preparation of professionals and experts to address threats and risks that affect the security of individuals, communities, states, and the international environment. In its non-military aspects, this concept focuses on areas such as cybersecurity, environmental threats, terrorism, migration, public safety, health, and humanitarian aid. Security education is thus a key component in ensuring the protection of individuals, organizations, and systems against various types of threats, including those in cyberspace. Its aim is to raise awareness of risks and develop correct habits that help prevent security incidents. Security education has its own specific characteristics depending on the target group, the type of threats, and the environment in which the training takes place. Individual aspects of security education include:

1. Purpose and goals of security education – security education serves multiple essential purposes:
  - Raising awareness of risks in the field of cybersecurity.
  - Teaching correct behaviour in the digital environment to minimize security risks.
  - Promoting a culture of security within organizations, including the creation of an environment in which every employee feels responsible for the protection of information and data.
2. Target group – for security education to be effective, it must be tailored to the specific needs of different groups. Target audiences can be categorized as follows:
  - Employees in organizations: These individuals require general knowledge of cyber threats such as phishing, malware, and secure password management.
  - Technical experts: These individuals need more in-depth, technically oriented training on security protocols, encryption, penetration testing, and other advanced cybersecurity methods.

- Customers and the general public: These users benefit from simplified training focused on personal data protection, safe internet use, and fraud prevention.
  - Top management: Executives and senior leaders need strategic-level education on the development and implementation of cybersecurity policies and risk management strategies within organizations.
3. Methods of security education – security education can be delivered in various forms, depending on specific needs and available resources. These include:
- Training and workshops: Interactive sessions allowing participants to gain both theoretical knowledge and practical skills in the field of security.
  - Online courses and e-learning: A flexible solution suitable for organizations with multiple branches or for individuals who cannot attend in-person training.
  - Simulations and testing: Practical exercises evaluating employee responses to cyber threats, such as phishing attempts or simulated incident scenarios.
  - Drills and gamified scenarios: Role-playing of model situations aimed at developing hands-on skills and improving decision-making under real-world conditions.
  - Awareness campaigns: Educational campaigns using materials such as posters, infographics, and videos, which contribute to raising awareness of the most common threats.
4. Specificities of cybersecurity education – cybersecurity education has its unique characteristics that need to be considered during planning. Specifically, these include:
- Rapid pace of technological change: Cybersecurity is a fast-evolving field where new threats and technologies constantly emerge.

Educational programs must therefore remain flexible and regularly updated.

- Interdisciplinary nature: cybersecurity covers not only technical aspects but also legal, organizational, and behavioural dimensions. Comprehensive education must address all these areas.
- Different skill levels: Education must be tailored to the skill level of each target group. Beginners may need basic training in personal data protection, while professionals require a focus on advanced security techniques.
- Psychological and motivational factors: Effective training should motivate individuals to adopt secure habits and apply them not only during the training but also in their daily activities.

5. Metrics and evaluation of effectiveness – to ensure security education is effective, its outcomes must be systematically evaluated. This can be achieved through:

- Tests and assessments: Upon completing training, it is possible to test the acquired knowledge via online tests or practical tasks.
- Ongoing performance monitoring: Observing user behaviour such as the use of strong passwords, ability to detect phishing attempts, and maintaining secure online conduct.
- Feedback collection: Gathering participant feedback on the quality, relevance, and usefulness of the training contributes to continuous improvement of educational programs.

Technological progress significantly affects the field of security education. A key aspect of modernisation is the integration of virtual reality (VR), simulations, and other digital tools into training processes. These technologies serve as interfaces between the user and a computer-generated environment, characterized by their ability to create immersive, visual, and interactive simulations (Halúsková, Mošková). Virtual reality offers digitally modelled

environment that users can immerse themselves in to experience various security-related scenarios (Spiegel, 2018). These scenarios allow individuals to develop and test their responses and skills in a controlled and safe settings, without the need for physical dummies, extensive simulation laboratories, or additional costly equipment. Communication between the user and the synthetic environment takes place within a three-dimensional space through interactive devices that both transmit and receive information. These interactions influence the ongoing simulation, enabling the replication of real-world security scenarios. The primary objective is to create a highly realistic visual experience using stereoscopic devices (VR glasses, projection systems, specialized monitors). Sensory input can be further enhanced through stimulating touch (gloves), hearing (advanced audio systems, headphones, spatial sound speakers), motion perception (specialised suits, etc.). Head-mounted displays (HMDs) are commonly used, allowing users to fully immerse themselves in the virtual world by visually isolating them from the real one. More sophisticated systems include haptic gloves, suits, omnidirectional treadmills, or other hardware that significantly enhance the realism of the simulation. Virtual reality thus enables individuals to perceive artificial environments through visual, auditory, and tactile stimuli, which can be processed by the brain as realistic experiences (Mitašová, Košútová, Cidlinová, 2022). This makes it a powerful tool in security education, where realistic experience is essential for learning effective responses to potential threats. A practical example can be found in several EU countries, where VR-based safety training has been introduced for professionals in public health. These programs simulate the response to infectious disease outbreaks, significantly improving the participants' readiness and ability to respond swiftly and effectively in real-world crisis situations.

Effective security education programs must be tailored to diverse target groups, adapt to constantly evolving threats, and foster a culture where security is recognized as a shared responsibility.

## **2 EMERGENCE, PRESENT, AND FUTURE OF VIRTUAL REALITY**

Virtual reality is a technology that allows users to immerse themselves in simulated environments, which may either faithfully replicate the real world or present entirely different, imagined settings. The history of VR dates back to the 1950s and 1960s, when the first concepts of "artificial reality" emerged and first experimental systems were developed.

### **2.1 EARLY HISTORY OF VIRTUAL REALITY**

One of the first significant milestones in the history of VR was the Sensorama system, developed by Morton Heilig in 1962. This system combined visual, audio, wind and olfactory effects to create an immersive experience (Heilig, 1962). Another key figure was Ivan Sutherland, who introduced the concept of "Ultimate Display" in 1965, aimed at creating a virtual world that would be virtually indistinguishable from reality (Sutherland, 1965). In 1968, Sutherland and his student Bob Sproull developed the first headset for virtual reality, known as "The Sword of Damocles" (Sutherland & Sproull, 1968).

In the 1970s, VR began to develop within academic and military environment. Myron Krueger developed the technology VIDEOPLACE, which enabled users to interact with computer-generated environments (Krueger, 1977). In the 1980s, VR gained popularity thanks to Jaron Lanier, who founded the company VPL Research and popularized the term "virtual reality".

### **2.2 CURRENT STATE OF VIRTUAL REALITY**

Currently, VR is widely used in various fields, such as the gaming industry, education, healthcare, and business. Modern VR technology offers sophisticated headsets that enable users to experience realistic simulations and interact with virtual objects. Education is one of the fields where VR is revolutionizing

learning, as it allows students to experience immersive learning environments, enhancing retention and understanding of complex concepts (Cipresso et al., 2018).

In 2025, further advances in VR are expected, including innovations in hardware and development of new applications. For example, Meta Quest 3S is anticipated to be a key product influencing the direction of VR development in the coming years (Scopelliti, 2025). Additionally, progress in mixed reality is expected, which will integrate VR and AR elements to provide users with even more realistic interactions with virtual objects.

### **2.3 FUTURE OF VIRTUAL REALITY**

In the future, VR is expected to be increasingly integrated with artificial intelligence (AI) in order to create personalized and adaptive virtual environments. It is also anticipated that VR will play a key role in the development of hyperrealist experiences that will be nearly indistinguishable from reality. The social aspect of VR will continue to evolve, with platforms enabling users to interact in virtual communities and participate in virtual events (Cipresso, Giglioli, Raya, Riva, 2018).

The global VR market is expected to grow to tens of billions of dollars by 2030, which indicates the increasing importance of this technology across various industries (Scopelliti, 2025). The future of VR thus appears very promising, and it can be expected to have a significant influence on many areas of human life:

- Role of virtual reality in education – Education is one of the sectors most significantly transformed by VR. Virtual reality enables students to engage in immersive learning experiences, enhancing retention and understanding of complex concepts. Studies show that 7 out of 10 teachers wish to use VR to simulate experiences relevant to the subjects they teach (Cipresso, Giglioli, Raya, Riva, 2018). VR allows students to explore historical eras, visit distant planets, or examine complex scientific phenomena in an interactive and engaging way. In Germany, the "BeVR-Ready"

implemented VR simulations in the training of emergency response personnel for coordinating activities during large-scale natural disasters. Various educational platforms, such as Engage or VRChat, allow users to create their own educational modules. Engage, for example, is used to simulate diplomatic meetings and negotiations, providing a realistic environment for training.

- Environmental education – Virtual reality also offers unique perspectives on environmental issues, helping raise awareness and promote effective solutions. For example, simulations of climate change or ecosystem damage can serve as powerful educational tools for both professionals and the general public. The Stanford Virtual Human Interaction Lab developed a simulation that illustrates the effects of deforestation in the Amazon, thereby educating people on the consequences of environmental change.
- VR also offers new opportunities for students with specific learning needs. For example, autistic students or students with ADHD can benefit from VR as a tool that helps them focus and better process information. Moreover, VR is used in medical education for simulating surgical procedures, enabling students to gain hands-on experience in a safe environment (Ustun, Yilmaz, Karaoglan Yilmaz, 2020).
- Role of virtual reality in healthcare – In healthcare, VR is used to treat patients suffering from anxiety and depression by creating relaxing environments that reduce stress and improve mental well-being. It also enables the simulation of surgical procedures, which is particularly useful for training surgeons, and preparing them for complex operations. In addition, VR is applied in the rehabilitation of patients recovering from injuries or surgeries (Garcia-Palacios et al., 2002).
- Humanitarian aid – VR supports the creation of realistic training environments for response scenarios during humanitarian crises such as earthquakes, floods, or migration emergencies. Rescue teams can train in

advance for coordination and intervention under conditions that would otherwise be very difficult, expensive, or dangerous to simulate. The International Federation of Red Cross and Red Crescent Societies uses VR to train volunteers for mass-casualty situations, thus increasing the effectiveness of their interventions.

- Role of virtual reality in business – In business, VR is used for various purposes, including product prototyping, employee training, and interaction with customers. Companies are increasingly using VR to drive process innovation and enhance customer experience. As costs decrease and availability increases, VR is becoming a regular part of business operations. For example, the automotive industry uses VR to simulate test drives and design vehicles, which helps reduce costs and accelerate the development of new models.
- Intercultural communication – VR allows users to simulate interactions in international contexts, which is particularly beneficial for training diplomats, international negotiators, and NGO workers who must navigate complex cultural differences. Programs like Google Earth VR enable diplomatic staff to explore geographical and cultural environment, contributing to better preparation for foreign missions.
- Social aspect of virtual reality – Social interaction in VR is becoming increasingly important, with platforms allowing users to host events, attend virtual concerts, or participate in multiplayer games in virtual environments. These platforms promote inclusivity and transform VR from a solitary activity into a shared social experience. Social VR platforms, such as Meta Horizon and VRChat, continue to develop avatars, interactions, and integrated AI companions to deliver richer and more engaging experiences.

## **Possibilities for implementing virtual reality in practice:**

Virtual reality is a rapidly evolving technology that is gaining popularity in the field of education. It provides an interactive and engaging environment that enables students and professionals not only to acquire information passively but also to practically experience various scenarios in a safe and controlled setting. Below are several examples of how VR can be implemented in educational practice.

### 1. Simulation and training for professional fields

- **Medicine:** VR is utilized to create realistic simulations of surgical procedures and diagnostic processes. Medical students can perform surgeries on virtual patients, allowing them to develop practical skills without any risk to patients in clinical practice. These simulations include laparoscopic surgery, resuscitation procedures, as well as simulated childbirth and related complications.
- **Aviation industry:** Flight schools employ VR to simulate flight conditions. Training with VR simulators enables pilots to experience a variety of flight scenarios and emergency situations, thereby enhancing their preparedness for real-world dangers.
- **Industrial and safety training:** Workers involved in high-risk activities (construction works, handling hazardous materials) can be trained for dangerous situations through VR simulations. This allows them to practice procedures without exposing themselves to actual risk.

### 2. Virtual excursions and geographical education

- **Historical reconstructions:** VR offers history students the opportunity to “travel back in time” and explore historical sites, such as Ancient Rome or the pyramids in Egypt. This immersive experience allows students to gain a deeper understanding of historical events through direct exploration of these locations.

- Geographical and environmental education: VR enables students to visit diverse ecosystems, such as the Amazon rainforest or coral reefs, providing an immersive way to study these environments without the need for physical travel.

### 3. Language education

- Interactive language learning: VR creates an immersive environment where students can engage with the cultures and languages they are studying. For example, virtual trips to countries where the target language is spoken provide students with the opportunity to not only learn vocabulary and phrases but also experience the cultural contexts and situations in which these linguistic skills are applied.
- Conversation practice: VR can facilitate real-world interaction simulations, where students engage in conversations with machines, chatbots, or other users. This provides a valuable opportunity for students to practice their language skills in interactive, contextually rich scenarios.

### 4. Visual and artistic education

- Creation and interaction with art: VR allows students to create and interact with 3-D models, sculptures, and paintings in a virtual environment. This offers artists the ability to experiment with new forms of expression and gain experience in techniques that might be difficult or unsafe to replicate in the physical world.
- History of art: VR can be used to create virtual galleries or museums, where students can explore the works of world-renowned artists and gain insights into the history and evolution of arts.

### 5. Virtual learning environments

- Fully virtual classrooms and training: Educational institutions can establish entirely virtual classrooms, enabling students and teachers to engage in real-time interaction in a 3D virtual space. This approach

facilitates interactions between teachers and students, even in cases where they are physically distant.

- Collaborative online education: Educational VR platforms support collaborative project work and facilitate discussions in 3D environments, where students can use virtual boards and notes for shared learning experiences.

#### 6. Healthcare and rehabilitation

- Patient rehabilitation: VR has proven effective in the rehabilitation of patients recovering from surgery, offering them the opportunity to perform exercises and physical therapy in a simulated environment. These environments are often specifically designed to motivate patients and provide them with constructive feedback during their recovery.
- Psychological therapy: VR is increasingly employed in the treatment of various psychological disorders, including phobias, Post-Traumatic Stress Disorder (PTSD), and anxiety. Through controlled simulations, patients can confront their fears in a safe and manageable environment, thereby aiding in therapeutic interventions.

#### 7. Remote and safe testing

- Simulated testing and assessment: Educational institutions can design testing environments within VR, allowing students to perform tasks in simulated scenarios. For example, students can be tested on their driving skills under various conditions or assessed for their reactions to hazardous work environments, providing a safe and controlled platform for evaluation.

## **2.4 FUTURE TRENDS IN VIRTUAL REALITY**

Significant advancements are anticipated in 2025 in the areas of hyper-realistic virtual reality, social VR platforms, and AI-powered personalization. Standalone VR devices with built-in processors and enhanced battery capacity are

expected to dominate the market, allowing users to access high-quality, immersive environments without the need for connection to a computer or gaming console. Additionally, the ongoing development of technologies such as haptic feedback is expected to further enhance the realism of interactions with virtual objects.

Virtual reality is anticipated to expand its use across various sectors, including tourism. Tourists will have the opportunity to explore their destinations virtually before visiting, allowing them to access detailed information about specific locations. This will not only enhance their travel experience but also contribute to more sustainable tourism by promoting lesser-known destinations.

The economic impact of VR will become increasingly significant. As its availability grows and costs decrease, VR will become an attractive technology even for small and medium-sized enterprises, which will adopt it for purposes such as enhancing customer experience and innovating business processes. It is projected that the global VR market will reach tens of billions of dollars by 2030, which proves its growing relevance across various sectors (Scopelliti, 2025). An important issue is also the environmental impact of VR. While VR can help reduce the carbon footprint by replacing physical travel with virtual meetings and tours, the production of VR devices and equipment requires substantial energy and raw materials, underscoring the need for sustainable procedures and practices in their manufacturing and disposal.

Further development of VR is associated with the need to address ethical issues. The virtual environment can influence human behaviour and emotions, which has sparked debates about the ethical acceptability of certain simulations. Particular attention should be paid to virtual experiences that may trigger strong emotional responses or influence users' decision making.

Besides these aspects, VR will play a significant role in arts and entertainment. Virtual galleries and museums will enable visitors to explore exhibitions from around the world without the need to travel. At the same time,

VR is becoming an important tool for social change by enabling users to better understand diverse perspectives and experiences.

Another crucial area is the application of VR in therapy and healthcare in general. Virtual reality has proven to be an effective tool in the treatment of phobias, post-traumatic stress disorder (PTSD), and other mental health conditions. Owing to its ability to simulate realistic environments, patients can undergo therapeutic scenarios in a safe and controlled settings.

Since its emergence in the 1960s, virtual reality has undergone extensive development and currently influences many aspects of human life. Its future is closely linked to ongoing innovations and emerging applications that may profoundly transform the way people work, communicate, and spend their leisure time. However, ensuring sustainability and addressing ethical concerns will be essential in order to maximise benefits while minimising potential risks.

### **3 IMPORTANCE OF MODERN TECHNOLOGY IN CIVIL PROTECTION EDUCATION**

Modern technologies have significantly transformed the field of civil protection education. Digitalization has enhanced the efficiency of information transfer, supported interactive processing of information, and made content more accessible to the general public. Key digital tools include e-learning platforms, crisis situation simulators, and educational mobile applications. These technologies contribute not only to theoretical instruction but also to hands-on training, particularly through the use of virtual or augmented reality.

E-learning platforms such as Moodle and Blackboard offer specialized courses focused on crisis management, first aid, and the handling of emergency situations. Interactive teaching modules support the acquisition of theoretical knowledge while facilitating its application in simulated environments. These tools also provide immediate feedback, which contributes to more effective learning outcomes.

Virtual and augmented reality represent a revolutionary shift in teaching civil protection procedures. VR allows users to engage with crisis situations in a safe, controlled environment and to practice appropriate responses in various situations, such as fire evacuations or the provision of first aid. In contrast, AR enhances real-world settings by adding interactive elements – for instance, displaying resuscitation procedure steps directly on simulation dummies or on the screens of smart devices. A major advantage of these technologies lies in their capacity to replicate realistic training environments without requiring actual field interventions. This approach significantly improves the preparedness of both individuals and professional emergency services for extraordinary events.

Artificial intelligence is increasingly applied in civil protection education, particularly in the areas of data analysis and crisis prediction. AI systems can process large volumes of data, identify patterns, and anticipate potential risk

scenarios, thus contributing to improved preparedness and more effective planning. In the field of education, AI also supports personalized learning by adjusting the content to match individual learners' needs and progress.

For instance, chatbots can offer instant responses to queries related to crisis management, while adaptive learning platforms support self-paced study and provide targeted feedback based on student performance.

Mobile applications play an increasingly important role in civil protection education addressing the needs of both the general public and emergency professionals. Apps such as Záchranka or 112 Where ARE U provide users with clear guidance on appropriate actions during emergencies and critical crisis situations, facilitate rapid contact with emergency services, and include interactive educational materials. Some of these applications also incorporate elements of gamification, allowing users to simulate crisis scenarios through game-like features and earn rewards for correct responses. This engaging format promotes user involvement and supports more effective retention of essential knowledge.

Social platforms and online communities serve as valuable tools for disseminating information and raising awareness in the field of civil protection. Platforms such as Facebook, Twitter, and YouTube are commonly used not only to share official warnings and recommendations but also to support educational initiatives. Security-focused organizations regularly publish videos, articles, and interactive quizzes designed to increase public awareness of appropriate responses during emergencies. Online communities further support this effort by allowing individuals to exchange experience and practical advice, thus strengthening collective readiness for crisis situations. For instance, groups dedicated to civil protection or disaster response bring together both professionals and members of the general public, who share valuable insights and offer mutual support.

Cloud technologies facilitate access to educational materials and enable effective knowledge sharing among various institutions and experts. Thanks to cloud solutions, educational institutions, emergency services, and humanitarian organizations can share up-to-date information, training programs, and crisis response plans in real time. Cloud platforms also support international cooperation. For example, the European Union utilizes cloud-based databases to exchange information on security threats and crisis management methodologies among member states. This enables the harmonization of educational approaches and helps establish a unified standard for preparing citizens to respond to emergency situations.

Although modern technologies offer numerous advantages, their integration into the educational process faces several challenges. Key obstacles include the need to ensure adequate technological infrastructure, maintain cybersecurity, and provide equal access to educational tools for all groups of citizens. In the future, further development of AI, VR, and AR is expected in the field of civil protection education. Additionally, the use of blockchain technology is likely to increase in securing educational data and digital certificates, thereby enhancing the credibility and transparency of the educational system.

In conclusion, modern technologies play a vital role in civil protection education, and their continued advancement will contribute to greater preparedness of citizens for emergency situations. The integration of these technologies into the educational processes should be a priority for both institutions and public authorities, as it directly supports the protection of lives and property.

## **4 VIRTUAL REALITY AND CYBERSECURITY**

One of the most important areas where VR can offer a valuable contribution is cybersecurity. VR-based simulations enable cybersecurity professionals to train in the detection and mitigation of cyberattacks within realistic, controlled environments. These simulations may involve scenarios such as responding to phishing, identifying malware, or coordinating incident response teams during a cyber crisis. Cybersecurity plays a crucial role in safeguarding information and digital systems in today's technology-driven world. The rapid evolution of digital technologies is matched by a rise in related security threats and challenges. Virtual reality, which is becoming increasingly popular in the areas of entertainment, education, and workplace applications, also introduces new risks that may impact the security of users and systems.

Cybersecurity involves the protection of computer systems, networks, and data from attacks, damage, or unauthorised access. In an era where digital tools are used by nearly every organisation and individual, effective protection against cyber threats is essential. These threats encompass hacking, phishing, malware, ransomware, spyware, adware, and other malicious activities aimed at disrupting operations or gaining access to sensitive data. Education and awareness are critical components of cybersecurity. Research shows that up to 90% of security incidents stem from human error, highlighting the need for comprehensive training and proactive risk management strategies.

### **Cybersecurity threats in virtual reality**

With the growing utilization of VR, the number of security problems and incidents that may pose risk to users grows as well. Some of the most significant threats include the following:

- **Device attacks:** Cybercriminals may gain unauthorized access to VR devices and manipulate their functionality. Such intrusions can disrupt the

user's experience and, in extreme cases, lead even to physical harm.

- Personal data breaches: VR platforms can collect sensitive data about users, including biometric data and personal preferences. Without adequate protection, this data is vulnerable to misuse, posing significant privacy concerns.
- Physical safety risks: Users may suffer physical injuries when moving within real-world space while immersed in virtual environments. Cyberattacks that disable built-in safety features can further increase the likelihood of accidents.
- Simulated threats and fraud: Within some VR platforms, fraudulent virtual environments can be created, exposing users to scams, identity theft, and various forms of cyber fraud.

### **Protecting against cyber threats in virtual reality**

To minimize the cyber threats associated with the utilization of virtual reality, several measures should be implemented:

- Encrypt communications: Encrypting data transmitted between VR devices and servers is essential to safeguard users' personal information.
- Security updates and patching: regularly updating VR devices and applications is crucial to ensure that known vulnerabilities are promptly addressed.
- Authentication and access control: Enforcing strong authentication mechanisms and effective access rights management helps prevent unauthorised access.
- User education: VR users should be informed about potential threats and educated in best security practices, such as recognising phishing and fraudulent activities within VR environments. For instance, CyberGym in Israel offers VR-based training programs enabling teams to rehearse responses to various cyberattacks, including ransomware and DDoS attacks.

## **5 VIRTUAL REALITY AS A TOOL FOR CIVIL PROTECTION EDUCATION**

Virtual reality is emerging as a key tool in civil protection education. Its primary advantage lies in the ability to simulate crisis situations in realistic environments, which enables participants to experience and practise their responses in various scenarios without being exposed to actual danger. This instructional approach provides an effective means of preparing both professionals and the general public for emergency situations, including natural disasters, industrial accidents, or terrorist attacks (Smith, Ragan, 2005).

One of the major benefits of virtual reality is its ability to provide practical experience. In traditional instructional models, students typically acquire theoretical knowledge first and then apply it in real-life practice. While this is generally an effective approach, it may present certain limitations, particularly in crisis situations that require immediate response, leaving no room for hesitation or extended reflection. Virtual reality offers a unique opportunity to rehearse concrete actions such as evacuation of individuals, administering first aid, or managing crisis communication. All these steps can be practised in a safe and controlled environment that delivers immediate feedback and allows for repeated training sessions (Anderson, Dill, 2000).

A specific example of the use of VR in civil protection education is the simulation of evacuation scenarios in the case of a fire or earthquake. Participants are placed in a virtual environment where they are exposed to realistic conditions such as smoke, reduced visibility, and loud noises, which replicate those encountered during actual crisis situation. Participants must then decide how to respond appropriately and how to evacuate themselves and others in the most effective manner. This form of training not only enhances practical skills but also helps to overcome psychological barrier that may arise in real-life emergencies (Sousa, Costa, 2018).

Moreover, virtual reality can play a significant role in training for crisis management and the coordination of integrated emergency system units. In this context, VR enables training that simulates complex scenarios requiring cooperation between multiple emergency services (police, firefighters, emergency medical services, etc.). Such training may also incorporate tactical and logistical coordination, as well as the development of communication skills, all of which are essential for the effective management of crisis situations (Smith, Ragan, 2005).

In addition, virtual reality is increasingly being used in public training initiatives. For example, when preparing the general public for providing first aid or responding to accidents or natural disasters, VR can simulate situations that are difficult for laypeople to imagine. This allows them to experience first-hand the principles of first aid and safety procedures, such as how to react in the event of a traffic accident or in the case of hazardous material leakage (Anderson, Dill, 2000).

An important factor in the use of VR in civil protection education is its ability to simulate various scenarios at minimal costs for material or human resources. Unlike conventional training, which requires actual equipment, objects, or premises, VR-based training can be repeated without the need to purchase costly equipment or address logistical challenges. This fact is particularly beneficial for organizations that would otherwise not have the funds for regular training or for ensuring realistic simulations of crisis situations (Sousa, Costa, 2018).

An important aspect to consider when implementing VR in educational programs is the adaptation and training of instructors and trainers. Although the technology offers a wide range of possibilities, it is essential that VR training is used effectively, not only in terms of the technology itself, but also in terms of methodological guidance. Instructors must be trained in the proper use of VR

platforms and in how to interpret the results of training to ensure maximum educational benefit (Smith, Ragan, 2005).

Virtual reality represents a revolutionary approach to modernizing civil protection education. The application of this technology opens up new possibilities for the effective transfer of theoretical knowledge into practice, which is crucial for providing appropriate and prompt responses in crisis situations. This ability to transform abstract theoretical concepts into specific, interactive experiences offers participants the opportunity to engage with crisis situations in a safe, controlled environment, with no risk to their health or safety. Experiencing crises—whether floods, fires, or other emergencies—enables both individuals and organizations to improve their responses under realistic conditions, which is of critical importance for ensuring the effective protection of citizens.

This technology proves invaluable for the professional units of integrated emergency services (IES), such as firefighters, paramedics, and police as well as for the general public, who can use VR simulation to learn how to respond to crisis situations and perform basic rescue operations, such as first aid or evacuation. The emphasis on practical training in an environment that most accurately simulates real-life crisis situations enables participants to better understand the dynamics and complexity of these situations, thus improving their preparedness. This type of training is indispensable for all those involved in civil protection, whether professionals dealing with actual crises or civilians preparing for potentially dangerous situations that could impact their everyday lives.

Moreover, it should be emphasized that each advancement and development in VR technologies opens up new opportunities for creating complex and highly realistic scenarios that were previously unattainable. For example, simulations of large-scale disasters, such as earthquakes or terrorist attacks, are expected to become significantly more realistic in the future, incorporating more interactive elements that will enable participants to adapt to the evolving

dynamics of the situation. With the advancement of technology, it will become possible to integrate additional parameters into training scenarios, such as crowd behaviour, changes in weather, or unpredictable complications, further enhancing preparation for unknown and difficult-to-predict situations.

As VR technology constantly evolves, it is expected that its application will expand into other areas. In the future, VR could be integrated into educational programs at all levels, from school curricula to corporate training, enabling the general public to familiarize themselves with crisis scenarios and prepare for them. This technology could also be applied in areas where specific risk factors are present, such as preparation for epidemics, managing the psychological consequences of crisis situations, or training for cyberattacks. Virtual reality is thus not limited to physical crisis situations but can also be an effective tool for a wide range of scenarios involving threats to the protection of citizens.

When focusing on specific examples of integrating VR into civil protection in the Czech Republic, it is evident that there are already projects actively using this technology. For example, firefighters use VR simulations for training exercises aimed at firefighting or evacuations, which enhances their understanding of the complexity of crisis situations that may arise in real life. Additionally, VR is also used for public awareness campaigns, where simulations of crisis situations improve the general public's understanding of the need for prompt response and appropriate behaviour in crisis conditions. These simulations not only help to prepare for specific situations but also motivate preventive measures and foster a sense of responsibility for one's own safety and the safety of others.

An important factor in the development of virtual reality in civil protection is its availability. With advancements in technology and the decreasing cost of VR devices, it is expected that in the future, these technologies will be available to a broader public. This could result in VR not only being part of professional training but integrated into the common educational process in primary and

secondary schools, enhancing awareness of crisis situations and preparedness for them from an early age. The integration of VR into educational programs in schools could involve, for example, simulations of natural disasters, teaching first aid, or ensuring proper responses during terrorist attacks, which could, in the long term, lead to improved awareness and preparedness among citizens. For instance, in the Ostrava region, several schools were supported through the Integrated Regional Operational Programme to equip classrooms with VR systems.

With the growing availability and performance of virtual reality, new challenges may arise. One of these challenges is the need for continuous development of content applications that will accurately simulate crisis situations and be tailored to the specific needs of individual users. Another challenge will be the integration of VR into existing training programs and ensuring adequate training for instructors who will work with these technologies. However, as the advance in the field of modern technologies, it is only a matter of time before these issues are addressed, and VR will become a common tool not only in professional preparation but also in everyday practice in civil protection.

As virtual reality technology continues to evolve, it can be expected that it will become an indispensable tool for training both professionals and those in the field of civil protection. The ultimate goal of these efforts is to increase preparedness for emergency situations, thereby minimizing their negative impacts on human lives, property, and infrastructure. As evidenced by current developments, virtual reality will continue to play a key role in this field and will be increasingly integrated into education and training processes, contributing to enhanced protection and security of citizens in crisis situations.

## **6 DEVELOPMENT AND PERSPECTIVES OF MODERN TECHNOLOGIES IN CIVIL PROTECTION EDUCATION – VIRTUAL REALITY APPLICATION IN THE CZECH REPUBLIC**

### **6.1 APPLICATION OF VIRTUAL REALITY IN THE CZECH REPUBLIC**

The utilization of virtual reality in the Czech Republic has evolved gradually, driven by advances in technology, growing interest in innovative teaching methods, and improvements in technological capacities. Initially, virtual reality in the Czech Republic was primarily used in the entertainment industry but later expanded into other sectors, including education and security.

The first steps in the field of VR in the Czech Republic can be traced back to the late 1990s, when experimental applications of VR were part of academic and research projects. At that time, the technology was quite costly and available only to a limited extent, primarily to scientific institutions or large companies. The use of VR in educational institutions was largely theoretical, focusing on research in the field of computer simulations and visualizations.

In the first decade of the 21<sup>st</sup> century, there was a significant advancement in the development of hardware and software for VR. With the growing availability of computers and graphics cards, the first commercially available VR systems started to be developed. In the Czech Republic, VR was initially used for developing video games and in the field of simulations and training. Its first applications in civil protection were limited and somewhat exceptional, focusing on emergency services, firefighters, and the police, who experimented with VR for training in crisis situations.

Since 2010, there have been further technological advances and cost reductions in VR technology, leading to its broader adoption. Interest in virtual reality in education and vocational and professional training has grown significantly. VR started to be used more frequently not only in public safety and

security, but also in medicine, transport, and the military. In the Czech Republic, specific projects have been launched, focusing on the use of VR for simulating crisis situations, such as training units of the Integrated Rescue System (IRS), as well as for educating the general public on emergency procedures. This trend was supported by European funds, which financed projects aimed at innovations in public safety and security.

With the advent of 4K resolution, improved virtual reality headset, and features of devices such as Oculus Rift or HTC Vive, VR in the Czech Republic has started to gain momentum. Thanks to advancements in software development, high-quality simulations and training programs started to emerge that can be applied in the field of public safety. These technologies have begun to be implemented not only in crisis management and security institutions, but also in schools, where students are acquiring the skills and knowledge necessary to respond effectively to crisis situations, without being exposed to real danger.

Currently, the use of virtual reality is becoming increasingly popular in public protection education in the Czech Republic. Universities and vocational schools are developing new courses focused on simulating crisis situations using VR technologies. The emphasis is placed not only on building theoretical knowledge but also on developing practical skills through simulated scenarios, such as evacuations, first aid, or responses to natural disasters.

Important projects in the Czech Republic include systems designed for training Integrated Rescue System (IRS) units using VR to prepare responders and other professionals for crisis situations. These simulations enable realistic training in which participants must deal with complex scenarios such as fires, floods, or terrorist attacks. A key advantage is that the training occurs in a safe and controlled environment, minimizing the risks associated with real-life exercises. In addition, public-facing applications are emerging that use VR to educate citizens about emergency situations, including first aid training and fire

evacuation drills. These projects aim to raise public awareness and enhance citizens' preparedness for crisis events.

In the coming years, VR technologies are expected to play a crucial role in preparing not only emergency professionals but also the general public to respond effectively to emergencies. As the technology continues to advance, it is anticipated that VR will become a standard tool for training and public education in the Czech Republic. The growing interest in virtual reality, combined with its increasing accessibility and improvements in simulation software, will likely support its broader adoption. Altogether, this will contribute to more effective education and improved societal preparedness for crisis situations.

## **6.2 CURRENT PROJECTS AND APPLICATIONS OF VR IN CRISIS MANAGEMENT IN THE CZECH REPUBLIC**

The number of projects focused on the use of virtual reality in crisis management in the Czech Republic remains limited, as this is a relatively new and specialized field that continues to evolve. Many initiatives are currently in the pilot phase or are being implemented through collaborations between various stakeholders, which further constraints their number.

In practice, there are approximately 15–20 projects in the Czech Republic that are either publicly known or actively involved in the development of virtual reality technologies for crisis management. This number depends on the availability of information about currently ongoing projects and their public presentation. Many of these projects are still in the development phase, undergoing pilot testing, or being implemented internally within specific units of the integrated rescue system.

Currently, several projects involving the use of virtual reality in crisis management and civil protection are underway in the Czech Republic. These initiatives aim to enhance the preparedness and efficiency of the Integrated

Rescue System, as well as to educate the general public on how to behave in emergency situations. Below is a list of key projects and initiatives:

1. VR Group – Simulators for the Czech Army (since 1998)

VR Group develops training simulators for the Czech Army, including systems for the CV90 infantry fighting vehicle and AH-1 Cobra helicopters. These technologies enable soldiers to train under realistic battlefield conditions in a virtual environment.

2. VR tools for risk activities (2004–2007)

Funded by the Ministry of Industry and Trade, this project explored the use of VR in high-risk sectors such as industry and energy.

3. Operational and tactical command system of the Czech Armed Forces (2007–2008)

This Ministry of Defence initiative used VR technologies to support the development of operational and tactical command and control systems.

4. Virtual pilot for the tactical air force (2011–2013)

This project of the Ministry of Defence developed an autonomous virtual pilot system to support air force training through advanced VR simulation.

5. XVR – Training of Integrated Rescue System (since 2011)

The Fire Brigade of the CR and other IRS units use XVR software to simulate emergencies such as fires, traffic accidents, or chemical accidents. The software enables scenario personalization and training at tactical, operational, and strategic levels.

6. Training simulator for typical activities (2015–2020)

Run by the Centre for a Safe State, this project aimed to enhance preparedness and coordination among emergency response units through a simulation environment that enabled the modelling of various crisis scenarios.

7. AR Safebook (2019–2021)

Also led by the Centre for a Safe State, this project focused on public education using AR and VR technologies to raise awareness of emergency procedures and motivate citizens to take an active role in crisis prevention and response.

8. Czech Firefighters VR (2019–2021)

The VR4Fire project offered immersive training for firefighters and emergency responders. Scenarios included firefighting in confined spaces, navigating through smoke, and operating at high altitudes.

9. PwC – Crisis exercises in VR (2020)

PwC developed a VR-based crisis simulation for the Czech branch of a multinational bank. The scenario involved a simulated terrorist attack, evacuation procedures, and chaos management. The project helped identify weaknesses in crisis protocols and improve management preparedness.

10. VR for first aid and emergency services (2020–2022)

Virtual Lab's VR CPR application focuses on training in cardiopulmonary resuscitation and basic first aid through immersive simulations.

11. Emotionally challenging situations (2021)

This project by the Czech Police uses VR to train officers in communication during emotionally sensitive situations, such as informing relatives of a death or assisting victims of crime.

12. Virtual ICU – Virtual LAB (2021)

South Bohemian company Virtual Lab created a VR training module for medical staff in intensive care units. It enables healthcare professionals to practice critical interventions and crisis response in an interactive, simulated environments connected with physical simulators.

13. Virtual reality in OHS – Výzkumný ústav bezpečnosti práce (2021)

This project uses VR for employee training in workplace safety, simulating crisis events such as chemical spills or fires.

14. Vitalis – Education for autokinesiotherapy (2022–2024)

Supported by the Technology Agency of the Czech Republic, this project develops a VR application for patients with neurodegenerative diseases. The app combines game elements with rehabilitative exercises.

15. IDRIS – Occupational health and safety monitoring system (2023–2025)

Výzkumný ústav bezpečnosti práce (The Occupational Safety Research Institute) developed the IDRIS application for workplace risk analysis using VR. It includes interactive simulations designed to prevent workplace accidents and improve safety awareness.

16. Únikovka 112 (2024)

The Ministry of the Interior of the CR financed project “Únikovka 112 (Escape Game)”, developed by the Centre of Safe State. The project combines virtual reality and escape room principles. The simulates emergency scenarios such as fires or chemical accidents to educate users on proper emergency response procedures.

17. VR Drive Sim Pro – Police Edition (2024–2025)

VR|SPACE developed this advanced driving simulator to train police officers. It includes scenarios such as emergency driving, car chases, and accident response, with built-in feedback for improving driving skills.

18. Back to the future – Ústí nad Labem region (2025)

An ambitious regional project aimed at modernizing schools introduces VR into crisis management education and mental health prevention programs for both students and teachers.

19. Modernization of education – Zlín region (2025)

Secondary schools in the Zlín Region are integrating VR into curricula to support training in nursing procedures, agricultural machinery operation, and science education.

This is an overview of key projects that have been implemented or are currently underway in the Czech Republic in the field of virtual reality. Each project targets a specific aspect of crisis management—ranging from the training of emergency services to public education. As VR technologies become increasingly accessible, it is likely that new initiatives will emerge in the future, expanding into even broader areas of crisis response and emergency preparedness.

### **6.3 COMPANIES INVOLVED IN VIRTUAL REALITY FOR CRISIS MANAGEMENT IN THE CZECH REPUBLIC**

Based on available information, it is possible to identify key companies and institutions in the CR that specialize in the development and implementation of virtual reality technologies for crisis management. These entities provide solutions for emergency service training, simulation of crisis scenarios, and support decision-making processes during emergency situations.

#### **1. VR Group**

- Description: VR Group is one of the leading suppliers of simulation technologies in the Czech Republic. The company specializes in the development of training systems for emergency services, the armed forces, and crisis management authorities.
- Key projects:
  - Mobile Crisis Management Training System (MCMTS): A system used, for example, in Brno to simulate fires, traffic accidents, and evacuations.
  - Simulators for the Czech Army: Training systems for CV90 infantry fighting vehicles and AH-1Z Viper helicopters.
- Web: [www.vrg.cz](http://www.vrg.cz)

## 2. Virtuplex

- Description: Virtuplex is known for its advanced VR platforms. The company specializes in simulations for emergency services, the police, and the armed forces.
- Key projects:
  - Emergency Fire & Medical Training: Training for firefighters, paramedics, and rescue teams.
  - SWAT Training: Simulation of tactical interventions in urban environments.
- Web: [www.virtuplex.cz](http://www.virtuplex.cz)

## 3. Virtual Lab

- Description: Virtual Lab develops applications for healthcare and crisis management. Their technologies include simulators for intensive care and first aid.
- Key projects:
  - Virtual ICU: Training for healthcare professionals during the COVID-19 pandemic.
  - Training of first aid in realistic scenarios.
- Web: [www.virtual-lab.cz](http://www.virtual-lab.cz)

## 4. Centrum pro bezpečný stát (Centre for Safe State)

- Description: Organization focused on supporting security education, using modern technologies, including VR, for crisis management.
- Key projects:
  - Simulations of evacuations: The project focuses on training both the general public and professionals for emergency situations such as fires or chemical accidents.
  - Development of interactive VR scenarios for crisis management training for municipalities.
- Web: [www.ochranaobyvatel.cz](http://www.ochranaobyvatel.cz)

## 5. Institut ochrany obyvatelstva

- Description: Institut ochrany obyvatelstva is part of the Ministry of the Interior of the CR – General Directorate of the Fire Rescue Service of the CR, focusing on research and implementation of VR/AR technologies for civil protection.
- Key project:
  - Study on the usability of VR/AR technologies for the Fire Rescue Service of the Czech Republic.
- Web: [www.ioolb.cz](http://www.ioolb.cz)

## 6. Výzkumný ústav bezpečnosti práce (VÚBP)

- Description: Czech research institute implementing VR technologies for risk analysis and training in occupational safety.
- Projects:
  - IDRIS: A system for workplace risk analysis using VR simulations.
  - Smart OHS workplace using VR.
- Web: [www.vubp.cz](http://www.vubp.cz)

## 7. Centre of simulation technologies (CESIT) at VŠB-TU Ostrava

- Description: An academic centre focused on the research and teaching of crisis management using VR simulations, such as XVR or SIMPROKIM.
- Projects:
  - Simulations of fires, floods, and industrial accidents for both students and professionals.
  - Training programs for IRS units.
- Web: [www.vsb.cz](http://www.vsb.cz)

## 8. ARCDATA Praha

- Description: A Czech company focused on geographical information systems (GIS) supporting crisis management. GIS data can be integrated into VR simulations.
- Web: [www.arcdata.cz](http://www.arcdata.cz)

## 9. Bohemia Interactive Simulations

- Description: Originally a Czech company now has a global reach. The company develops simulation systems for military and civil protection purposes.
- Projects:
  - VBS3 (Virtual Battlespace): The simulation platform is used by armed forces worldwide.
  - Applications for crisis management and emergency service training.
- Web: [www.bisimulations.com](http://www.bisimulations.com)

### Other major companies:

1. Ackee – specializes in the development of software, including VR-based applications ([www.ackee.cz](http://www.ackee.cz)).
2. Etnetera Motion – develops interactive VR applications, e.g., for Škoda Auto or Česká spořitelna ([www.etnetera.cz](http://www.etnetera.cz)).
3. GINA Software – Provides software for emergency services, compatible with VR technologies ([www.ginasoftware.com](http://www.ginasoftware.com)).
4. Holistic Management – Partner of Virtual Lab in the development of applications for healthcare training ([www.holistic-management.cz](http://www.holistic-management.cz)).
5. Kyb3r – A company specializing in cybersecurity. Its portfolio includes five VR applications, including the presentation of the Siemens Vectron Locomotive, museum exhibits, and the drawing application ARTO ([kyb3r.org](http://kyb3r.org)).

6. LOM PRAHA – Development of simulation centres for airbases of the Czech Army in cooperation with VR Group ([www.lompraha.cz](http://www.lompraha.cz)).
7. Virtubea – An innovative Czech company focusing on the development of applications and solutions in the field of virtual and augmented reality. Its products are used in various sectors, including education, healthcare, and industry ([virtubea.cz](http://virtubea.cz)).

The Czech Republic boasts a robust ecosystem of companies focused on utilizing virtual reality in crisis management. Companies such as VR Group, Virtuplex, and Virtual Lab offer innovative solutions that enhance the preparedness of both the Integrated Rescue System (IRS) and the public for emergencies. The involvement of academic institutions, such as the Czech Technical University (CTU) and VŠB-TU Ostrava, which support research and practical implementation of VR technologies, is also crucial.

#### **6.4 HIGHER EDUCATION INSTITUTIONS AND VIRTUAL REALITY IN CRISIS MANAGEMENT**

Virtual reality is becoming an increasingly important tool in education, particularly in the fields where practical training for crisis situations is crucial. In the context of civil protection and crisis management, VR enables the simulation of real-life scenarios that would otherwise be difficult or dangerous to perform. This chapter deals with analysing and comparing approaches of various Czech and Slovak educational institutions to the implementation of VR in teaching. It also identifies the major barriers and benefits influencing the broader integration of VR into educational programs. The comparison of individual educational institutions will provide a comprehensive insight into the current state of using VR in education in this field and offers recommendations for future development. The research was conducted in April 2024, and 15 universities in the Czech Republic, 5 in Slovakia, and 7 in Poland, all offering accredited study programs in the fields of security and crisis management, were contacted. The low return

rate of the questionnaires can largely be attributed to the non-use of virtual reality by many higher education institutions (HEIs). Based on the analysis of the questionnaire data, the responses from seven institutions, each with different approaches to integrating virtual reality in education related to public safety and crisis management, were evaluated. Below is a comparison of seven key aspects.

1. Frequency of VR usage

<i>Institution</i>	<i>Frequency of VR usage</i>
Armed Forces Academy of General M. R. Štefánik	Several times a year
CEVRO Institute	No use of VR
Technical University in Prague (ČVUT)	weekly
Police Academy of the CR in Prague	Several times a year
University of Defence	No use of VR
Tomas Bata University in Zlín	monthly
VSB-TU of Ostrava	weekly

Source: own research, 2024.

The most frequent use of VR (weekly) was recorded at VSB – Technical University of Ostrava and Czech Technical University (CTU), while the University of Defence and CEVRO Institute do not use virtual reality at all.

2. Effectiveness of VR usage

<i>Institution</i>	<i>Effectiveness evaluation</i>
Armed Forces Academy of General M. R. Štefánik	Very effective
CEVRO Institute	No use of VR
Technical University in Prague (ČVUT)	Effective
Police Academy of the CR in Prague	Effective
University of Defence	No use of VR
Tomas Bata University in Zlín	Effective
VSB-TU of Ostrava	Effective

Source: own research, 2024.

Most institutions rate the use of virtual reality as effective, highlighting concrete benefits such as enhanced retention of information, better interactivity, and more realistic simulations of situations compared to traditional teaching or training methods. For instance, VR enables the safe practice of complex or risky activities, improving user competence while also reducing the costs associated with physical equipment or training. The General M.R. Štefánik Armed Forces

Academy rated VR as very effective, indicating that, within its specific environment, the technology has provided even greater benefits. Naturally, institutions that do not use VR were unable to assess its effectiveness, as they have not had direct experience with its advantages or potential limitations.

### 3. Technical preparedness

<i>Institution</i>	<i>Technical preparedness</i>
Armed Forces Academy of General M. R. Štefánik	Very well prepared
CEVRO Institute	Less prepared
Technical University in Prague (ČVUT)	Well-prepared
Police Academy of the CR in Prague	Neutral
University of Defence	Not prepared
Tomas Bata University in Zlín	Neutral
VSB-TU of Ostrava	Prepared

Source: own research, 2024.

The institutions that are the best prepared technically are the Armed Forces Academy, VSB-TU Ostrava, and the Technical University in Prague (ČVUT), while the University of Defence and the CEVRO Institute show insufficient technical preparedness.

### 4. Available technical resources

<i>Institution</i>	<i>Available technical resources</i>
Armed Forces Academy of General M. R. Štefánik	Yes
CEVRO Institute	No
Technical University in Prague (ČVUT)	Yes
Police Academy of the CR in Prague	Yes
University of Defence	No
Tomas Bata University in Zlín	Yes
VSB-TU of Ostrava	Yes

Source: own research, 2024.

For most institutions, technical resources such as VR headsets and computers are available. The only exceptions are the University of Defence and the CEVRO Institute.

## 5. Preparedness of teachers

<i>Institution</i>	<i>Preparedness of teachers</i>
Armed Forces Academy of General M. R. Štefánik	Neutral
CEVRO Institute	Less prepared
Technical University in Prague (ČVUT)	Well-prepared
Police Academy of the CR in Prague	Neutral
University of Defence	Not prepared
Tomas Bata University in Zlín	Neutral
VSB-TU of Ostrava	Neutral

Source: own research, 2024.

The preparedness of teachers is generally rated as neutral, indicating the need for further training. Only the Technical University in Prague (ČVUT) reports full preparedness of its teachers.

## 6. Student satisfaction with the use of VR in instruction

<i>Institution</i>	<i>Student satisfaction</i>
Armed Forces Academy of General M. R. Štefánik	Very satisfied
CEVRO Institute	Satisfied
Technical University in Prague (ČVUT)	Satisfied
Police Academy of the CR in Prague	Not evaluated
University of Defence	Satisfied
Tomas Bata University in Zlín	Not evaluated
VSB-TU of Ostrava	Satisfied

Source: own research, 2024.

At most institutions, students report a high level of satisfaction with the use of VR in instruction, with the highest level of satisfaction observed among students at the Armed Forces Academy.

## 7. Barriers to implementation of VR

The most common barriers mentioned by the institutions include:

- Limited budget for purchasing and maintaining the technology.
- Lack of training for teachers.
- Limited availability of specific content and educational materials.

These barriers are common to most institutions and represent significant obstacles to the wider implementation of VR in education.

## Summary

Institutions (colleges and universities) differ in terms of frequency of use, technical preparedness, and student satisfaction with the use of VR:

- The top performers in this context are VSB-TU of Ostrava, Czech Technical University, and the Armed Forces Academy, which have the necessary technical infrastructure and regularly use VR.
- Other higher education institutions do not use VR due to a lack of technical resources and insufficient preparedness, as confirmed during the project workshop in České Budějovice in 2023, where only VSB-TU of Ostrava confirmed the use of VR.

It is recommended to focus on three key areas: enhancing teacher training to better prepare educators to effectively integrate VR into teaching, expanding the educational content available for VR, which would involve developing more applications and simulations covering diverse teaching areas, and providing funding for institutions with limited resources to acquire the necessary technology, ensuring equal access to these advanced educational tools.

## **6.5 SWOT ANALYSIS OF THE USE OF VIRTUAL REALITY IN THE CZECH REPUBLIC**

### Strengths:

- Advanced infrastructure and specialized centres: The Czech Republic boasts modern facilities such as the Centre for Simulation Technologies (CESIT) at the University of Mining and Technology in Ostrava. CESIT uses VR simulators (e.g., XVR) for realistic crisis management training, enhancing the level of training for both students and professionals.
- State support: The Ministry of the Interior and the Institut ochrany obyvatelstva (Institute of Population Protection) are implementing projects focused on the use of VR/AR technologies in civil protection. For example,

a study is being conducted on the applicability of VR/AR for the Fire Rescue Corps of the CR.

- Realistic simulations of crisis situations: VR enables training for interventions during fires, floods, chemical accidents, and traffic accidents within a safe and controlled environment.
- Repeatability and analysis: VR makes it possible to repeat, pause, and analyse simulations, allowing for detailed evaluation of procedures and improved coordination among components of the Integrated Rescue System.

#### Weaknesses:

- High acquisition cost: The implementation of VR technologies requires considerable investment in hardware, software, and user training.
- Technological complexity: The use of VR demands expert knowledge and regular maintenance of the equipment, which can pose a challenge, especially for smaller organizations or regional units of the Integrated Rescue System.
- Insufficient integration with practice: Although there are advanced centres such as CESIT, their capacity is limited, and not all components of the integrated rescue system have access to such technology.
- Psychological limitations: The simulation of high-stress situations can trigger adverse emotional responses or mental strain in some participants.

#### Opportunities:

- Strengthening international cooperation: The CR can leverage European funding and collaborate with other countries on the development of innovative VR applications in crisis management.
- Integration into educational programs: Expanding the use of VR in secondary and higher education could help improve the qualifications of future crisis management professionals.

- Broader application of VR: The technology can be used not only for training emergency services but also for raising public awareness about crisis response and for simulating environmental risks.
- Technological advances: Ongoing developments in artificial intelligence and haptic technologies can enhance the realism of simulations and allow them to be tailored to the specific needs of individual users.

Threats:

- Insufficient funding: Limited financial resources may slow down the implementation of VR technologies, particularly at the regional level.
- Cybersecurity risks: Simulations involving sensitive data must be adequately protected to prevent data breaches or cyber-attacks.
- Resistance to new technologies: Some users can be sceptical about the use of VR due to lack of experience or concerns about technological change.
- Overreliance on technology: Excessive dependence on virtual simulations could lead to the neglect of traditional physical training, which remains essential for comprehensive crisis preparedness.

The SWOT analysis indicates that the Czech Republic is well-positioned to use virtual reality effectively in crisis management, thanks to modern centres such as CESIT and the support of state institutions. VR offers new opportunities for training emergency services and preparing future professionals. However, challenges such as high costs, technological complexity, and limited access for certain institutions or individuals still need to be addressed.

## **7 DEVELOPMENT AND PERSPECTIVES OF MODERN TECHNOLOGIES IN CIVIL PROTECTION EDUCATION – APPLICATION OF VIRTUAL REALITY IN SLOVAKIA**

### **7.1 APPLICATION OF VIRTUAL REALITY IN SLOVAKIA**

Virtual reality is a rapidly evolving field in Slovakia, and in recent years, it has found applications across a wide range of sectors, from education and healthcare to architecture and industry. The history and current use of this technology in Slovakia illustrate how VR is gradually becoming part of everyday life, transforming the ways people work, learn, and communicate.

The use of virtual reality in Slovakia dates back to the 1990s, when the technology first appeared in academic settings. Universities such as Comenius University in Bratislava began experimenting with early simulators and visualization tools mainly in engineering and medicine. These tools were primarily used to support research and teaching in specialized fields. At that time, however, VR was still seen as a futuristic technology, with broader adoption limited by the high cost of hardware and lack of accessible software solutions.

However, the situation has changed dramatically in the last two decades. A major milestone was the emergence of Slovak startups focused on virtual reality applications. One of the pioneers in this field is the company Virtual Medicine, which has been developing the application Human Anatomy VR for teaching anatomy. This application enables students at medical universities and secondary medical schools to explore the human body interactively in a 3D environment. As a result, Slovakia has become one of the countries innovatively incorporating VR into education. Another noteworthy example is the company Virtuplex, a company that in 2022 opened the world's largest virtual reality hall – a 700 m<sup>2</sup> space located on the outskirts of Bratislava. The facility allows clients in architecture, development, and retail to walk through virtual building models at a

1:1 scale, greatly simplifying project planning and enabling early detection of design flaws before construction begins.

The current application of VR in Slovakia is multifaceted. In the healthcare sector, VR has become crucial tool, not only in the field of anatomical education but also in the training of medical personnel and the treatment of mental health conditions. VR-based simulators are employed to enable medical professionals to rehearse complex surgical procedures and manage crisis situations. Rehabilitation centers, for example, are increasingly utilizing VR to enhance patient motivation during physiotherapy and to address anxiety disorders by exposing patients to simulated stress-inducing scenarios.

In the context of education, VR is gaining popularity due to its capacity to deliver interactive and immersive learning experiences. Numerous Slovak secondary schools have already implemented virtual anatomy classrooms, providing students with the opportunity to explore the human body in detail and simulate various physiological processes. Furthermore, the Ministry of Education actively promotes the integration of digital technologies in education through initiatives such as the Viki platform, which includes VR-based educational content. This initiative forms part of a broader national strategy aimed at advancing the digitalization of education in Slovakia.

Virtual reality is also being increasingly applied in industry and transportation. For instance, Slovak Railways employs training simulators integrated with virtual environments, enabling train operators to practice their responses to unpredictable situations. These simulators combine hardware replicas of control panels with virtual environments, thereby enhancing the realism of the training and preparing employees for various crisis scenarios. In the context of production and maintenance, VR helps companies in optimizing processes and visualizing complex industrial projects. Technologies such as Infinity Mesh facilitate the presentation of solution proposals within a virtual

environment, thereby improving communication and collaboration between suppliers and clients.

While Slovakia has made significant progress in the adoption of virtual reality, it still faces several challenges. One of the primary issues is the uneven availability of the technology across several regions and schools. Some schools are equipped with modern classrooms featuring VR technologies, while others lack the financial resources to invest in such tools. Another obstacle is the integration of VR into common educational process, as implementation of new technologies requires both financial resources and teacher training and the development of suitable educational materials.

Nevertheless, the future of VR in Slovakia holds great promise. Companies like Virtuplex are planning to expand into international markets, bringing new innovations to both domestic and foreign customers. The startup Virtual Medicine has already attracted global interest in its products and has plans for further expansion, including into the United States and other European countries. Additionally, there is a growing interest in the use of VR in tourism; for instance, simulations of historical landmarks or cultural events could potentially draw more visitors to Slovak regions.

The history and current application of virtual reality in Slovakia underscore its increasing significance across various sectors. From education to healthcare and industry, VR offers new opportunities to enhance work, learning, and communication.

## **7.2 CURRENT PROJECTS AND APPLICATION OF VIRTUAL REALITY IN CRISIS MANAGEMENT IN SLOVAKIA**

Virtual reality is becoming a key tool in crisis management, and Slovakia is actively engaging in projects aimed at its integration.

At the Faculty of Safety Engineering at the University of Žilina, modern technologies, including virtual reality, are being progressively incorporated into

educational curricula (Sventeková, 2022). Students use Oculus quest 2 headsets, which allow them to engage in practical simulations across various domains. Within the course "Safety and Health Protection in Rescue and Fire Services," virtual reality plays an important role in familiarizing students with the general principles and specific safety protocols essential for rescue operations. The curriculum includes an overview of the legislative framework, state policies, the responsibilities of employers and employees, as well as emergency response measures. Students are introduced to the classification and documentation of occupational accidents, and the associated cooperation with labor inspectors. The course also covers the practical aspects of risk assessment in rescue operations, proposing preventive measures, and familiarizing students with personal protective equipment (PPE)—its classification, allocation, and correct usage. Additionally, students are trained to recognize the hazards inherent in rescue work, particularly in extreme conditions such as extreme temperatures, fatigue, and reduced visibility. The integration of VR into the curriculum allows students to gain not only theoretical knowledge but also valuable hands-on experience in selecting and correctly utilizing PPE. The integration of VR into the curriculum allows students to gain not only theoretical knowledge but also valuable hands-on experience in selecting and correctly utilizing PPE. Furthermore, students learn to differentiate between false fire alarms and life-threatening emergencies and practice activating alarm systems. Instruction can take place in two modes: training mode, where students are guided through the necessary information to complete a given scenario, and test mode, where students are required to independently perform the entire procedure correctly (Mitašová, Košútová, Cidlinová, 2022).

The education system in Slovakia offers opportunities for graduates to continue their professional development, expand their knowledge across various fields, and acquire additional competencies that enhance their employability in the labor market, even after completing high school or university. This continuous

development is particularly essential in the field of security, where the increasing and constantly evolving nature of security threats demands ongoing adaptation. It is crucial to enhance the quality and efficiency of various educational activities, including the integration of simulations and virtual reality, to better equip individuals for the challenges in the public and private security sectors. Furthermore, new opportunities for skill development should be sought to meet the demands of workers in these sectors.

A prerequisite for the effective execution of the necessary duties by professional workers in the field of security is the acquisition or extension of professional competencies, as well as the required professional preparation, all of which are facilitated by the continuing education system (Bílý, Kavan et al., 2013).

A seamless transition from university education to further education is facilitated through educational programs within the framework of lifelong learning. The University of Safety Management in Košice offers managerial professional education programs in the field of security as part of its professional and educational portfolio. The Institute of Lifelong Education, which is an integral part of the university's organizational structure, is engaged in pedagogical and scientific-research activities, with a focus on fulfilling society-wide roles in lifelong education and creating opportunities for acquiring professional education on an international scale. In 2014, the Ministry of Education, Science, Research and Sports of the SR granted accreditation to the university for two educational programs in the field of security, namely Security Science Management and Security Management in the Public and Private Sector. Graduates of the first aforementioned educational program acquire comprehensive knowledge of security services and relevant legislation, the organization of integrated rescue systems, planning and forecasting processes, security system design, and forensic engineering. They are also equipped with the knowledge in computer systems and experimental methods, labour laws, company security, and audit of management

systems. In addition to theoretical knowledge in key areas of security management, graduates develop practical management skills, enabling them to undertake roles such as security analysts, advisors, consultants, or managers.

The Armed Forces Academy in Liptovský Mikuláš provides, in addition to the foundational training for members of the Armed Forces of the Slovak Republic, supplementary military education that falls within the category of security training. This includes programs such as the Basic Command and Staff Course, Higher Command and Staff Course, Officer Course for University Graduates, International Course for Staff Officers, Entry Professional Officer Course, short-term professional courses, as well as the National Security Course, which represents the pinnacle of career education. The National Security Course serves as a symbolic cornerstone, forming the foundation of the entire educational structure across various contexts. The course is designed to foster the development of strategic, conceptual, and critical thinking among participants, enhancing their capabilities in managing both people and systems, with a focus on contemporary security challenges (Kováčová, Lošonczi, 2016).

Civil protection is a system of tasks and measures aimed at safeguarding life, health, and property, primarily involving the analysis of potential threats, the implementation of risk-reducing measures, and the establishment of procedures and activities for mitigating the consequences of extraordinary events. The legal requirement for professional competence in civil protection was formalized by the amendment to Act NR SR No. 42/1994 Coll., as amended by Act No 395/2011 Coll. Completing tasks in the field of civil protection necessitates high-quality professional training or organizational leadership. In particular, during extraordinary situations, such as natural disasters (floods, landslides, earthquakes, windstorms, snowstorms), technological and ecological accidents (fires and explosions, hazardous substance leaks, damage to distribution networks), large-scale accidents (major air, railway, and road crashes, breaches of water management systems), or acts of terrorism—it is crucial to respond quickly and

appropriately. Education in civil protection aims to prepare both management and operational personnel for crisis prevention and intervention at all levels. It teaches them to assess potential risks, analyse conditions that could lead to crises, manage the development and progression of crises, and develop the ability to implement appropriate solutions that control the crisis and minimize losses (Kováčová, Lošonczi, 2016).

The current legislation of Slovakia regarding the education of volunteer firefighters provides only a basic framework, as outlined in Decree No. 611/2006 Coll., of the Ministry of the Interior of the Slovak Republic on fire brigades. A municipality that establishes a volunteer fire brigade is obliged to ensure training for applicants for membership. The training falls under the category of basic firefighter training, which may only be conducted by a legal entity or self-employed person who has been granted authorisation by the Ministry. The authorisation is time-limited, and renewal requires the training to be repeated. The purpose of the training is to equip participants with a defined level of knowledge, skills, physical fitness, and habits necessary for firefighting and rescue operations. The regulation outlines only the general scope and thematic areas of the basic training, which may be adapted by the trainer (Kováčová & Lošonczi, 2016).

Adequate preparation of students or employees for dangers and security threats is impossible in advance in many cases. In the field of education, virtual reality holds a significant potential, especially due to its ability to allow the exploration of various objects and phenomena in ways that would not be possible in real life (Ménová, 2020). The use of virtual technologies for training is particularly suitable in sectors where it is difficult to replicate identical scenarios and where it is necessary to simulate specific, unique, and unrepeatable situations (e.g., medicine, aviation, research, fire protection) (Mitašová, Košútová, Cidlinová, 2022). Virtual reality combines the advantages of e-learning and hands-on experience, while eliminating the constraints of each of them. The

technology can simulate all the subtleties of real-life training without the associated safety risks. It offers students practical experience within a repeatable and scalable training environment. With virtual reality, an entire team can be trained uniformly using a single course, repeated endlessly without incurring additional costs. Students learn specific procedures exactly as intended by the instructor and simultaneously test their mastery of certain skills during the training, increasing their level of engagement. Furthermore, traditional costs associated with live training sessions are eliminated (Mitašová, Košútová, Cidlinová, 2022).

Constructive simulations serve as an interface between humans and computer-generated virtual environment and its hardware and software tools. These simulations use computer programs to replicate specific phenomena in real or predefined time and conditions, providing trainees with the impression of a realistic situation to which they must respond appropriately. In the field of security sciences, students may work with simulation software such as VR-Forces, WASP, and others in specialized laboratories (Halúsková, 2022). Mixed reality technologies are also integrated into teaching through devices like Microsoft HoloLens 2. These glasses connect the physical and digital worlds using advanced sensing and imaging technology. Digital objects can be manipulated and, upon interaction, behave like real, tangible items (What is mixed reality?, 2022).

In 1997, simulation technology centres were established at the Military Academies in Liptovský Mikuláš and Košice with the aim of enhancing the effectiveness of security education. In 2010, a virtual air traffic control simulator (LETVIS) was launched to support the training of air traffic control personnel, including the simulation of unusual and highly stressful situations. In 2011, the system was upgraded to enable communication with other virtual simulators, further increasing the realism of training exercises. Additionally, a specialized laboratory for critical infrastructure protection (the virtual shooting range STING) and a laboratory for the verification and simulation of information and security

threats (LVSIBO) were established. The virtual shooting range offers the advantage of eliminating the need for expensive live or training ammunition, allowing trainees to fire significantly more rounds and improving their readiness exponentially. After each session, detailed results can be reviewed and evaluated over time, enabling the monitoring of individual progress and long-term development. A CQB (Close Quarters Battle) training facility is also available, designed for military and police units to practice operations in confined environments such as buildings and enclosed spaces.

The simulator of WASP constructive simulation serves as a fundamental component for computer-assisted training. It enables the visualization of the overall situation, the ability to influence its progression, and the interconnection of all participants involved. Importantly, it also enables the integration of virtual simulators (RVS, TLS) with constructive simulation elements into a single environment. It enables running pre-designed scenarios, thereby creating training conditions that closely resemble real-life situations. The system includes various entities and editors that allow users to configure specific parameters. These include assigning tasks with defined characteristics (e.g., fire, floods, artillery), using terrain tools, and setting environmental conditions such as rain, snow, wind, or darkness. Users can draw on the map using layers, lines, areas, and text annotations, and manage other processes such as issuing commands or adjusting the simulation time. The simulation operates in a semi-automated mode: the operator assigns a task to an entity or unit, which then either performs the task autonomously or responds to unfolding events. All participants in the exercise share a common synthetic environment, which enables mutual comparison and evaluation.

The Team Leader Simulator (TLS) is a dismounted infantry simulator primarily designed for military units to support the tactical training of commanders, individuals, and small groups. It offers the flexibility to configure various types of rescue units, police, and fire units for the purpose of practicing

crisis management tasks. The system provides a virtual environment that closely replicates real-world conditions, creating an effective foundation for subsequent live training. A realistic soundscape is naturally included to enhance immersion. TLS fosters coordination and communication, tactical thinking, as well as command and control capabilities, with particular emphasis on decision-making. It can be used for individual training or in combination with other simulation tools, such as the WASP constructive simulation system, thus contributing to collective training within a shared virtual environment. The simulator also supports interaction with vehicle simulators (RVS), allowing entities to enter and exit vehicles. This enables the simulation of personnel transport, including both military and civilian individuals, and supports the practice of coordination with transport units. TLS is primarily intended for the training of mechanized units in support of dismounted infantry operations.

The Reconfigurable Virtual Simulator (RVS) is designed for the tactical training of crews operating both combat and non-combat vehicles in military as well as non-military scenarios. It supports group training up to the company level. Unit commanders train their subordinates in crew and unit coordination through pre-defined scenarios that simulate realistic conditions as closely as possible. Each participant is equipped with a communication device enabling interaction via a simulated radio network, as well as internal communication through an intercom system within individual vehicles. The simulation centre in Liptovský Mikuláš operates 13 reconfigurable simulators, each offering three configurations of military vehicles and a helicopter, alongside five configurations of civilian vehicles designed for non-military training scenarios (e.g., police, ambulance, Medevac, bus, CAS 32 fire truck). All simulators can be integrated with the Team Leader Simulator, for instance, to provide fire support to dismounted infantry or to coordinate non-military operations such as the transportation of civilians, firefighting in collaboration with fire units, the provision of first aid by paramedics, and other joint tasks involving vehicles and dismounted personnel.

The Astra communication system provides local radio communication capabilities within virtual simulations for TLS and RVS, within constructive simulation for WASP trainees, and in combined training scenarios integrating these platforms. Its primary function is to facilitate communication between individual participants in a way that closely resembles real-world conditions. The system is not intended to replicate every technical detail of real communication devices but rather to ensure the functional communication necessary for the specific stage of the simulation, in accordance with the commander's instructions or the established communication plan.

For training military air traffic controllers in a synthetic environment, the APP radar simulator and the TWR tower simulator are used. These tools allow the configuration of all military airports in the Slovak Republic, as well as a virtual airport. The synthetic environment is ergonomically divided into two rooms, accommodating workstations for students, instructors, and pseudo pilots. For the same training purposes, the OAT/GCI radar simulator is also utilized, enabling the configuration of both real and virtual airspace.

As part of investigating safety education in Slovakia, attention will be paid to two companies involved in the production of simulators and the application of virtual reality in training processes.

Virtual Reality Media (VRM), headquartered in Trenčín, is a joint-stock company specializing in the design, development, and production of cutting-edge simulators and training systems. Founded in 1992 as a software and hardware integrator, the company adopted a proactive business strategy in 1995, focusing on research and development, production, and the sale of simulation technologies. This strategy led to its first major order from the Ministry of Defense of the Slovak Republic in 1995 for the delivery of a MiG-29 aircraft simulator. VRM is now recognized as a global leader in the development and implementation of virtual reality training simulators. The company currently offers simulators for civil

aviation (e.g., Boeing 737NG, Ilyushin IL-114), military aviation (e.g., Sikorsky UH-60 Black Hawk, Mi-171 helicopter, Albatros L-39), and ground forces (e.g., light armoured vehicle simulator, complex tank simulator). One of its newest product lines includes software-defined simulators (SDS), which offer modular solutions for synthetic training while requiring minimal hardware implementation. SDS is a specially developed unified platform that enables pilots to train for different aircraft types using a single simulator. It also allows real-time interconnection between simulators.

The company develops a range of applications and patented hardware components. These components primarily include electric motion platforms, fixed platforms, base modules, visual systems, panels, instruments, and other hardware. In terms of software applications, the company focuses on modular systems, matrix systems, tower systems, and training room systems. Additionally, it develops augmented reality systems, virtual mobile sensors, urban transport systems, and virtual reality tutorials. The company provides various advanced technologies, such as cyber-physical systems, modular solutions, visual systems, and tactical systems, alongside services including component testing, system repairs, installations, and software updates. In the field of training, it supports the implementation of military training centres, civilian training programs, as well as combat and tactical training.

Computer-Based Training System (CBTS) holds a distinctive position among ground forces simulators. It incorporates state-of-the-art technologies in line with current trends in education. This form of theoretical education provides comprehensive knowledge of aircraft structure, power units, systems, and their functions. It also covers the location and operation of aircraft controls and indicators, as well as various cockpit systems. The CBTS enables users to understand system malfunctions, their impact on aircraft performance, and to become familiar with standard, abnormal, and emergency procedures. A key component is the Classroom Software Application, which consists of a fully

equipped classroom designed for one instructor and ten trainees, with the option for remote training. The educational software and e-tutoring are highly flexible and can be easily reconfigured for different types of aircraft.

Anti-aircraft missile system simulators are built using original missile components integrated with simulation technologies. Their primary purpose is to train personnel in target detection and identification, monitoring of flight parameters, and missile launch procedures during target approach or departure.

The PSFO observation post is designed for operations at forward reconnaissance positions to support training in observation and fire control. It offers a high level of automation in reconnaissance activities by enabling the acquisition of measurement data, orientation using digital maps, and their manipulation for transfer to subordinate units.

Virtual Battlefield training platforms offer a broad spectrum of training objectives, including individual soldier training, small unit tactics, mission-specific exercises, and large-scale joint operations. These platforms are customizable and capable of replicating specific operational environments and scenarios, thereby enabling various training settings that support adaptability to mission-specific requirements. The technical solution is tailored and built on a powerful computing system with multiple LCD displays. VRM places emphasis on the delivery of comprehensive services, user training, and compliance with product warranty terms.

In October 2024, the company participated in the Global Defence Helicopter Conference in Warsaw – the largest European gathering of military helicopter and unmanned systems professionals – joining 800 experts from more than 50 countries. Military leaders, procurement professionals, and industry innovators convened to shape the future of defence aviation. With its broad portfolio of simulation technologies for rotary-wing aircraft, VRM introduced a solution designed to enhance training capabilities and support multi-role combat readiness of military pilots globally.

Virtuplex, a limited liability company headquartered in Bratislava, represents cutting-edge technologies and expertise in the field of virtual reality simulation. Since 2018, it has helped clients verify architectural and product concepts in early development stages, eliminate errors through spatial testing before physical implementation, and create educational applications for safe and effective knowledge acquisition. It operates a globally unique 600 m<sup>2</sup> laboratory – the world’s largest commercially available virtual reality hall – offering an authentic environment for training and virtual model presentation.

Through the Virtuplex OS platform, users can collaborate remotely and simultaneously in a shared virtual space with colleagues, business partners, clients, or suppliers. The technology enables simulation of future scenarios in business, production, or office layouts. It also supports employee training on any topic without the need for physical relocation. Virtual reality offers an engaging way to present products to clients interactively. A virtual encyclopaedia developed by the company enables the dissemination of educational and informative content in museums, public libraries, schools, and academic or professional libraries. It addresses current needs in information sharing in fields such as education, natural sciences, history, technology, and industry, allowing users to absorb information through experience. This experiential learning approach enables up to 75% retention, compared to just 5% for verbal transmission or 10% for reading.

### **7.3 SWOT ANALYSIS OF APPLICATION OF VIRTUAL REALITY IN SLOVAKIA**

Strengths:

- Realistic simulations of crisis situations: Virtual reality enables creating highly realistic scenarios, such as natural disasters, industrial accidents, or terrorist attacks, without exposing participants to any actual risk.

- Safe and repeatable environment: VR provides the possibility to train crisis management in a safe environment where it is possible to repeat scenarios and analyse errors, thus increasing the effectiveness of the training.
- Effective training of emergency services: The technology enables the simulation of complex operations such as triage, evacuation, or interventions in dangerous zones, thereby improving coordination and decision-making.
- Cost effectiveness: VR training is more cost-efficient than traditional physical training, as it eliminates the need for extensive material resources and infrastructure.

#### Weaknesses:

- High acquisition costs: Purchasing VR devices and developing specific scenarios is financially demanding, which limits the availability of the technology for smaller organizations.
- Technological complexity: The use of VR requires expert knowledge and user training, which may pose challenges in implementation.
- Limited integration into educational programs: At present, VR is not systematically integrated into school curricula or standard training plans for crisis management.
- Potential psychological impacts: Simulating stressful situations may trigger negative emotional responses or even trauma in some participants.

#### Opportunities:

- Technological advancement: Progress in the field of AI and haptic devices has the potential to enhance the realism of simulations and facilitate their customization to meet specific user needs.
- International cooperation: Slovakia can leverage EU funding to support the development of VR-based crisis management projects in cooperation with other countries.

- Broader application of VR: VR technology can be used not only in emergency service training but also in raising public awareness of crisis management and in simulating environmental threats.
- Digitalization of education: Integration of VR into curricula at secondary schools and higher education institutions could improve the competencies of future crisis management professionals.

#### Threats:

- Insufficient infrastructure: In certain regions of Slovakia, access to advanced technologies may be limited by underdeveloped IT infrastructure, finance, and inadequate high-speed internet connection.
- Resistance to technological innovation: Some users may exhibit scepticism towards the adoption of VR due to lack of prior experience or concerns about the implications of technological change.
- Cybersecurity risks: Simulations involving sensitive data must be adequately secured to prevent data breaches or cyberattacks.
- Overdependence on technology: An excessive reliance on VR may result in the underestimation of the importance of hands-on physical training, which remains essential for comprehensive crisis preparedness.

Virtual reality represents an innovative tool in the field of security education, significantly transforming the ways in which we prepare for both military and non-military security challenges. Despite the presence of various risks associated with its implementation, the advantages of this technology are indisputable. Continued research and development of VR is essential in order to fully harness its potential for the broader benefit of society. The application of virtual reality offers numerous opportunities to enhance education, healthcare, and work processes. However, its integration also entails addressing critical issues, such as cybersecurity risks, high financial demands, and ethical considerations. Successful implementation requires a balanced approach –

ensuring that the use of VR remains safe, efficient, and ethically responsible. In some countries, the deployment of virtual reality in education is hindered by financial constraints, with priority being given to addressing fundamental educational needs. Similarly, in Slovakia, limited funding hampers the integration of VR into teaching processes at both secondary schools and higher education institutions. Another limiting factor is the insufficiently developed and sustained cooperation with industry and companies engaged in the development of emerging technologies. Innovative educational approaches involving virtual reality represent a particular challenge for universities, where the demand for more dynamic and practice-oriented learning environments continues to grow.

## **8 DEVELOPMENT AND PERSPECTIVES OF MODERN TECHNOLOGIES IN CIVIL PROTECTION EDUCATION – THE APPLICATION OF VIRTUAL REALITY IN POLAND**

### **8.1 THE USE OF VR IN CIVIL PROTECTION EDUCATION IN POLAND**

With the increasing complexity of the contemporary threat environment, shaped by the coexistence of globalisation processes, natural disasters, and systemic socio-political and technological risks, there is a pressing need to redefine both the axiological and pragmatic foundations of civil protection education. In this context, immersive technologies and, in particular, virtual reality (VR) should not be regarded as an ephemeral component of enthusiasm with technology, but as a serious, epistemologically grounded and methodologically justified component of a modern set of didactic instruments. These technologies have the potential to co-create a space for learning under conditions of discontinuity, crisis, and risk (Scippo, Luzzi, Cuomo, Ranieri, 2024).

VR, as a dual-faceted environment encompassing both representation and simulation, facilitates the development of narrative-interactive models of action that, despite their lack of physical materiality, possess high performative capacity to influence procedural cognition, enhance decision-making competences, and strengthen affective-behavioural readiness to respond in extreme conditions. The application of VR-based solutions extends beyond the mere transfer of declarative knowledge; rather, it enters the level of a deeper transformation of cognitive consciousness, where experience, although simulated, generates authentic mechanisms of reflexive self-regulation and learning through action (Mazzoni, Cervelli, Leone, 2022).

On the domestic level, a gradual expansion of VR technology in areas of security education can be observed, the empirical evidence of which includes the results of a survey completed in 2024 among 50 respondents, mainly from

academia. The results shows not only the acceptance of immersive training methods (100% of respondents), but also a notable proportion of users with prior experience using VR (68%). Although the sample is limited, these results suggest the emergence of new technological-educational competences and the growing acceptance of immersive solutions within professional teaching practice.

In practical applications, VR primarily finds its use in simulating scenarios with a high degree of unpredictability and cognitive complexity, such as emergency response procedures (such as mass triage), evacuation of critical infrastructure facilities, the management of CBRN (chemical, biological, radiological, nuclear) incidents, as well as the development of multi-variant scenarios for emergency response services. The ability to iteratively recombine multiple scenarios, incorporate environmental variables, and adapt dynamically to the user's actions positions VR as a next-generation educational tool, which does not merely replicate reality, but transposes it into a form suitable for operational processing (De Lorenzis, Praticò, Cultrera, Migliorini, Lamberti, 2022).

From the perspective of social constructivism as well as situated learning theory, immersive VR education represents a qualitative leap in education, enabling profound integration of learning content with real-life contexts and decision-making challenges. Within a VR environment, educational content ceases to be merely transmitted information; it becomes an experience, an interaction that is both affective and cognitive, which significantly intensifies the effect of competence transfer to real-world environments, particularly in domains requiring rapid information processing, multitasking, and resilience to situational pressure (Correia, Água, Luzes, 2021).

Despite these advances, the domestic institutional and legislative framework remains fragmented and poorly coordinated. There is currently no unified certification system for educational modules delivered in immersive environments, nor are there formally defined quality benchmarks for educational

simulations. In addition, there is a lack of interoperability platforms to enable content transfer between academic centres, departmental structures and local government units. Most current efforts take the form of pilot projects, including the *VR4Safety* initiative carried out by the Gdansk University of Technology, the CBRN training provided by the Military University of Technology, and experimental decision-making platforms incorporating VR components developed by the School of Fire Service (ABW, or Internal Security Agency, <sup>2024</sup>).

Compared to the other Visegrad countries, Poland shows a significant, yet still underutilized development potential in the area of immersive technologies. In the Czech Republic, an integrated VR-Lab system has been established at the University of Defence in Brno, while in Slovakia, the VR-SAFETY project is underway in Banská Bystrica. This points to the need for a comprehensive national strategy aimed at integrating immersive environments in security education. Such a strategy should encompass legislative, institutional, technological, and methodological dimensions. Moreover, it should address the axiological foundations of education, particularly in the context of shaping civic responsibility, solidarity, and readiness to act to respond to shared threats (VRLab Academy, 2025).

The use of virtual reality in civil protection education should be considered an irreversible process and its further development as a necessary response to the dynamics of the contemporary world. However, for VR to become a genuine driver of qualitative transformation of teaching processes, it needs to be embedded in a sustainable institutional framework, scientifically grounded and anchored in the dialogue between pedagogy, technology, and public policy.

## **8.2 CURRENT PROJECTS AND APPLICATION OF VIRTUAL REALITY IN CRISIS MANAGEMENT IN POLAND**

In the landscape of Polish educational and training practices shaped at the intersection of reflections on collective security, the emergence of new

technologies, and the redefinition of pedagogical axioms, the use of immersive environments based on VR is a steadily expanding phenomenon. However, this development is unfolding in a regulatory context that lacks a clear formal and normative framework (Mystakidis, Lympouridis, 2023). This characteristic state of development, oscillating between pioneering vigour and systemic dispersion, is reflected in the form of a polycentric array of initiatives, often emerging locally, depending on the availability of funding for projects, grants, or institutional and municipal support. As a result, there is considerable heterogeneity in teaching models and both the infrastructural and curricular frameworks employed.

In the academic sector, several leading centres with a reference profile stand out, which, with full awareness of their scientific and research responsibilities, operate at the interface between immersive technologies and crisis teaching. These include the Warsaw University of Technology, the Military University of Technology, the Fire Service Academy (APoż) and the War Studies University (ASzWoj). These university centres implement complex immersive systems that integrate simulation graphics engines (Unity and Unreal Engine 5) with geospatial components (GIS), Newtonian and non-Newtonian physics models, artificial intelligence tools to support decision-making systems (AI-augmented DSS), and, in the most advanced solutions, biometric sensors and tools that monitor psychological and emotional responses (eye-tracking, EDA analysis, HRV) (Xing, Delinois, 2025).

Private sector actors, operating under public-private partnership (PPP) or business-to-institution (B2I) contract models, bring substantial innovations to the VR education ecosystem, often drawing on translational experiences from the defence, medical or industrial sectors. Some examples of these solutions include VR Heroes, offering firefighting training platforms equipped with dynamic fire simulation and temperature sensors; SIMPRO, focused on developing Mass Casualty Incident (MCI) management systems; Advisio Poland, which specialises in training modules for local government units in evacuation procedures and

emergency logistics; and VR TierOne, whose therapeutic and preventive environments are used in high-risk occupational settings.

Despite their structural differences, these projects share a high degree of architectural sophistication, both at the level of AI-driven branching logic and functionality for scaling the intensity of stressor exposure and ex-post behavioural analytics (Rudynets, Fedorchuk-Moroz, 2022). Additionally, experimental efforts are emerging in the field of distributed system architectures (decentralised immersive clusters), enabling synchronous multi-site training in real time while maintaining the coherence of training scenarios.

What is noteworthy is that cultural institutions, led by the Second World War Museum in Gdansk, are incorporating VR environments not only as display instruments, but also as tools for strategic and critical education. Interactive exhibits simulating the living conditions of civilians under wartime occupation during the WW2 not only provide a cognitive reconstruction of historical events, but also actively engage visitors in a critical deconstruction of behavioural patterns under conditions of resource scarcity, chaos and repression (Museum of the Second World War in Gdansk, <sup>2025</sup>).

In parallel, VR is also being implemented with increasing boldness by local government structures. For example, in cities like Lublin, Wrocław and Gdynia, immersive environments are used to train teachers, administrative staff, and support services in areas such as crisis communication, evacuation procedures, panic prevention, and the management of emergency assembly points. These applications are characterised by a high level of responsiveness and adaptability to local scenario adaptations.

Despite visible qualitative development and significant institutional diffusion, the Polish VR ecosystem in civil protection education still lacks formal standardisation. Teaching materials remain inconsistent, and interoperability between sectors is limited. This situation highlights the need to establish a central

repository of certified immersive modules, linked to an interdepartmental system for validating the teaching and operational effectiveness of these environments.

From a systemic perspective, VR projects in Poland currently function as experimental incubators of innovation, places where science, education, technology and security intersect to form the basis for a future immersive paradigm in public education. However, for these initiatives to evolve beyond the design phase and gain strategic dimension, it is necessary to adopt a holistic approach, incorporating both the legal architecture and the epistemic, cultural and civic dimensions in building social resilience through modern forms of education.

In completing the picture of the current ecosystem of VR deployments in the area of safety and civil protection education, it is important to acknowledge a range of initiatives that, although not always formally classified as components of public safety systems, contribute significantly to developing the skills needed for individuals and groups to operate under threat, uncertainty and situational stress. Noteworthy among these are projects combining immersive technologies with critical education, educational neuroscience, affective analysis, and AI-supported predictive mechanisms.

A particularly notable example is the VISUS VR project, developed by a Polish technology company. It is an advanced training platform embedded in a metaverse environment, focused on first aid, public health, and life emergency response education. The platform integrates three complementary immersive components: an interactive VR application, a 360° 3D spherical video, and a 180° 3D video. Designed for use in home, corporate, and institutional contexts, it demonstrates high level of scalability and strong social relevance (Meena, Mithesh, Panyam, Chowdary, Sadhu, Sheela, 2023). In the context of civil protection education, VISUS VR introduces a new quality of experiential teaching, allowing users to take the roles of bystander, emergency responder, or casualty, which promotes deep learning through affective and episodic memory channels.

ClassVR, a system developed to comprehensively support the educational process, exemplifies the integration of VR into formal education. Although primarily focused on subject-based instruction, it also offers potential for application in situational learning. This system consists of standalone VR headsets that operate independently of external peripherals, and an integrated management portal that allows teachers to distribute content and monitor student activity (Ramos, R. C., Borges, W. L. Jr., 2024). Another important feature is the system's compatibility with augmented reality (AR), which facilitates the creation of hybrid educational scenarios, like evacuation drills set in a real school environment, enhanced with real-time information and instructional components. As a methodological tool, ClassVR aligns with the principles of inclusive and personalised teaching, forming a bridge between traditional classroom teaching and digital reality.

A compelling example is the Empirius Virtual Laboratory platform, originally developed for chemistry instruction, which is now gaining relevance in the context of safety education. This system enables simulating chemical reactions, laboratory experiments, and hazardous substance handling exercises, eliminating the risk of biological or chemical exposure (Nowa Era,<sup>2025</sup>). In the context of crisis education, Empirius offers training in decontamination procedures, identification of toxic substances, and first contact protocols for hazardous materials. Moreover, this environment fosters the development of procedural and systems thinking, which is crucial in the management of large-scale contamination scenarios.

The Meta VR & AR for Education project, which is being carried out in international collaboration as part of the Meta Immersive Learning program, is also an example of the penetration of global solutions into the local education system (Meta Platforms, 2025). The project involves training teachers in the use of VR and AR technology in subjects such as history, biology and geography, but could potentially be adapted to scenarios for teaching civic competence, critical

thinking and strategic behaviour. Immersive environments created within the project allow for immersive reconstructions of historical events (e.g., the setting of WW2 occupation), explorations of disaster-prone geographic areas (e.g., earthquake zones, volcanoes, and deserts), and visualisations of biological processes like epidemics or mechanisms of herd immunity. In this way, the project becomes a platform for interdisciplinary education that links scientific cognition with affective experience and ethical reflection.

Finally, the eduLabVR platform developed by Learnetic demonstrates the potential of VR as a tool to integrate natural, environmental, and procedural content into coherent educational modules (Learnetic SA, 2025). This system, which includes 3D models, 360° videos, virtual experiences, and interactive exercises, can be effectively adapted to educate the public on environmental risk management, natural hazard recognition, and emergency response strategies. Particularly valuable are its simulations of geological and hydrological processes, which serve as training material for evacuation scenarios, decision-making exercises, and analyses of natural disaster impacts.

The projects discussed, diverse in terms of their scope, target groups, and technological background, demonstrate that the Polish environment of educational VR implementations is developing dynamically, demonstrating both adaptive and strategic potential. In light of mounting global challenges, from climate change to hybrid warfare threats, the systematic integration of immersive technologies into civil and prevention education appears not only desirable but also necessary for building societal resilience.

### 8.3 SWOT ANALYSIS OF USING VIRTUAL REALITY IN POLAND

#### Strengths:

- Government and institutional support: The Polish government actively invests in projects focused on the use of virtual reality in crisis management, particularly in the areas of historical education and security-related simulations. Initiatives such as the *Virtual Theatre of History* show the potential of VR to raise awareness and understanding of crisis situations.
- Well-developed technological infrastructure: Poland benefits from modern technology centres and a dynamic startup environment dedicated to developing VR applications, including those simulating terrorist attacks, natural disasters, or industrial accidents.
- Interactive and realistic simulations: VR enables the creation of highly detailed crisis scenarios that support improved decision-making and enhance coordination among components of the integrated rescue system.
- Emphasis on education: Polish secondary schools and universities are increasingly incorporating VR into the teaching of crisis management, thereby strengthening the qualifications and preparedness of future professionals in this field.

#### Weaknesses:

- High acquisition cost: The implementation of VR technologies demands substantial investment in hardware, software, and user training, which can limit the accessibility of this technology, particularly in smaller regions.
- Technological complexity: The use of VR requires specialized expertise as well as regular maintenance of equipment, which may pose an obstacle to broader implementation.
- Uneven accessibility: The availability of modern VR technologies varies across regions, leading to disparities in access and creating unequal conditions among individual institutions.

- Psychological limitations: The intensive simulation of crisis situations may induce stress or trigger negative emotional responses in some users.

#### Opportunities:

- International cooperation: Poland can leverage European funding and establish international partnerships in developing innovative VR applications focused on crisis management. Projects such as The EU-funded AUGGMED illustrate the possibilities of cross-border collaboration in this area.
- Raising public awareness: VR can be used not only for the training of emergency services but also for educating the general public on appropriate responses in crisis scenarios, such as natural disasters or terrorist attacks.
- Integration into educational programs: Broader implementation of VR technologies in secondary and higher education could enhance the qualifications and practical preparedness of future crisis management professionals.
- Technological advancements: Ongoing progress in artificial intelligence and haptic devices can further improve the realism of virtual simulations and enable their customization to meet the specific needs of different user groups.

#### Threats:

- Insufficient funding: Limited financial resources can slow down the broader implementation of VR technologies, particularly at the level of regions.
- Cybersecurity risks: Simulations that include sensitive data must be protected against potential data breaches and cyberattacks.
- Resistance to technological innovation: Certain users may be sceptical towards the adoption of VR technologies due to a lack of experience or concerns about technological change.

- **Overreliance on technology:** Excessive dependence on virtual simulations can lead to the underestimation of traditional physical methods, which is necessary for achieving comprehensive preparedness for real-life crisis scenarios.

The SWOT analysis indicates that, supported by government initiatives and a well-developed technological infrastructure, Poland is well-positioned to effectively implement virtual reality in the field of crisis management. This technology offers new opportunities for training emergency response teams and educating future professionals. However, it is necessary to overcome obstacles related to high costs, technological complexity, and unequal regional access. With continued technological advancement and strengthened international collaboration, Poland holds the potential to become a leader in the field of virtual reality applications for crisis management not only in Central Europe, but also on a global level.

## CONCLUSION

Modern technologies, particularly virtual reality, hold considerable potential for advancing education in the field of civil protection. This publication examines the current state of VR implementation in three Visegrad countries, namely the Czech Republic, Slovakia, and Poland, and formulates recommendations for their further development. The evolution of virtual reality in these countries show differing approaches, strengths, and challenges that need to be addressed, while each of these countries has to consider its own specific conditions and priorities.

In the area of virtual reality, the Czech Republic primarily focuses on crisis management and simulations for rescue teams. A notable example is the MCMTS system developed by the VR Group company, which provides effective training for firefighters and rescuers in handling critical situations. Another key project is the CESIT simulation centre at VSB-TU of Ostrava, which integrates virtual and physical reality to prepare crisis teams for various threat scenarios. These technologies enable not only realistic training but also an in-depth analysis of crisis response procedures. The Czech Republic has also established a strategic framework for digital transformation of the education system, which includes support for modern technologies such as VR. *Digitální strategie ČR na období 2020–2030* highlights the integration of such innovations into the educational process. Although VR applications in the field of civil protection are very effective, their expansion into mainstream education beyond specialized fields remains limited. In terms of widespread VR use in general education, there is still considerable room for development.

In Slovakia, the development of virtual reality is centred on projects related to the digitization of education and the development of IT infrastructure. The program *Informatizácie vzdelávania do roku 2030* emphasizes strengthening students' digital competences and equipping schools with modern technologies. As

a result, Slovakia is gradually creating the conditions for a broader implementation of VR in education and other sectors. Innovative initiatives include Virtuplex, a project that enables the visualization of architectural designs in a virtual environment, and WooW, which focuses on the use of VR in the real estate sector. These projects demonstrate the potential of virtual reality not only in education, but also in industry and services. Despite these developments, Slovakia faces several key challenges. One of the most pressing is the insufficient IT infrastructure in marginalized areas, which restricts access to modern technologies for all students regardless of their socioeconomic background. Another issue is the lack of systematic integration of VR into school curricula and the limited presence of practical applications of this technology in everyday teaching.

In the field of virtual reality, Poland focuses on historical education and international partnerships, which represents a unique approach to the use of this technology. The *Virtual Theatre of History* project uses VR to deliver interactive lessons on Polish history, which enables students to experience historical events through virtual simulations. This approach supports a deeper understanding of historical contexts while simultaneously enhancing the digital competences of young people. Another important initiative is *MedEd PolyTrauma VR*, implemented in cooperation with Lithuania and France, which focuses on training in emergency medicine using simulations through virtual simulations. The Polish government also supports teacher training in AR/VR technologies through partnerships with Meta and VR Heroes. While Poland is actively investing in modern technologies and their integration into the education system, unequal access to these innovations among students from different socioeconomic backgrounds remains a significant barrier. This inequality can limit the overall impact of VR in the Polish educational context.

Based on the analysis of the situation in these three countries, several recommendations can be made to support further development of virtual reality in the field of civil protection education. The Czech Republic should expand the use of VR simulations beyond specialized fields to include public safety, healthcare and other areas where this technology could play a key role in the preparation of professionals for crisis situations. Furthermore, the establishment of a national platform for sharing educational resources between universities and industrial partners would foster innovation and strengthen cooperation between academia and practice. Slovakia should prioritize investment in IT infrastructure of schools and build stronger links between schools and private sector partners to develop practical VR application across educational and professional fields. Furthermore, integrating VR into the updated national curriculum with a focus on its practical use across various subjects should be a priority. Poland should focus on the systematic integration of VR into curricula at all educational levels and ensure inclusive access to this technology for students from disadvantaged backgrounds.

V4 countries should take advantage of European Union funding to support inter-university projects focused on VR in education and establish common standards for evaluating the effectiveness of these tools across Central Europe. Synergies between public institutions and private sector can significantly boost innovation in the field of civil protection and beyond.

In conclusion, it can be stated that virtual reality holds great potential as a key tool in both crisis preparedness and everyday teaching across various disciplines. However, its full implementation requires consistent governmental support, innovative teaching approaches, and intensive international cooperation between academic institutions and industry partners.

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