

## UTILIZATION OF SIMULATION AND VIRTUAL REALITY TOOLS IN EDUCATION OF FIRE AND RESCUE SERVICES

## VYUŽITIE SIMULAČNÝCH NÁSTROJOV A VIRTUÁLNEJ REALITY PRE VZDELÁVANIE HASIČSKÝCH A ZÁCHRANNÝCH ZLOŽIEK

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### ABSTRACT:

*The authors of the paper deal with the possibilities of implementing modern simulation technologies in the educational process. They present a part of the results of the institutional grant project, which was implemented thanks to the support of the Department of Fire Engineering, Faculty of Security Engineering, University of Žilina. The aim of this project was to create a study with the analysis of current simulation solutions worldwide and to choose suitable possibilities of applying these technologies and simulation tools to the needs of the Fire and Rescue Services in the Slovak Republic. This analytical study also includes a questionnaire survey. The main objective of this preliminary questionnaire survey was to determine the methods of possible introduction of simulation technologies and virtual reality tools into the education and training of firefighters and rescue teams and to map current needs of future users. The results presented in the paper confirmed a growing interest in simulation and virtual reality tools. It has also been confirmed by the academic and field experts.*

**KEYWORDS:** Simulation tool, virtual reality, fire and rescue services, education, questionnaire survey

### INTRODUCTION

The Fire and Rescue Services must conduct their activities in accordance with valid legislation [1]. One of these activities is to perform tasks in the field of education, learning, and training in the field of fire protection and preventative educational activities. The corps must also participate in the tasks of scientific and technological development in the field of fire protection. The area of training and education is addressed and developed in the training of all members and units of Fire and Rescue Corps. In the education and training in the field of fire protection, training simulators [2], polygons, and practical exercises are used to simulate real interventions. Firefighters can practice different cases, improve their intervention and rescue operations. However, a real crisis situation or a difficult intervention is not really practicable. In a tactical training, we cannot influence the firefighter's way of thinking in a way he would believe that "it is not real, that is just exercise."

A more demanding task is faced by intervention commanders, who often have to make decisions according to the current situation at the place of intervention, regarding the procedure, order, and execution of individual rescue work and related activities. The commander of the intervention must decide how to save endangered human lives, animals, property or environmental compartments, and must also decide not to compromise the safety of the members of Fire and Rescue Corps. For the purpose of protecting the life and health of fire brigade members, the commander of the intervention assesses the hazard information at the scene of the interference, divides the site into the intervention areas with a distinctive hazard, and determines the corresponding work regime as well as the security and protection of individual firefighters.

In all activities, it is necessary to consider the safety of health and safety at work. The problem with the education and training of the members of fire units is that no form of training

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or exercise will give firefighters the direct contact with reality and will not guarantee that they will not become injured during the training or exercise. The solution could be the application of simulation tools based on the virtual reality that offers users a great deal of versatility. Their gradual introduction into the process of education, preparation and training of fire and rescue personnel could have a significant and, in particular, positive impact on improving the overall fire safety of firefighters.

## 1. SIMULATION AND VIRTUAL REALITY TOOLS

For the needs of Fire and Rescue Services, various simulation tools have been developed [3]. They mostly focus on decision-making skills of an individual, which in fact affect all the rescue team. The aim is to improve the preparedness for future crises and emergencies and they might be found useful not only by firefighters but also crisis managers, army and police forces, medical doctors and paramedics. Due to stress or pressure resulting from the crisis situation, an individual is likely to make a mistake. The virtual environment cannot fully replace real conditions but it can approximate them to prevent mistakes in real-life incidents. Experimenting with a real system is costly, often inconvenient and in some fields completely impossible (e.g. structural fire protection) and dangerous.

Examples of the utilization of simulation and virtual reality tools include:

- firefighting - extensive forest fires, indoor fires, fires in confined space, open-space fires, training of firefighting activities, evacuation, extinguishing tactics, extinguishing fire outbreaks,
- rescue works - in case of technological accidents, natural disasters (e.g. floods, landslides, etc.), environmental protection,
- fire brigade management and training of cooperation among fire brigades and units - cooperation among the members of a fire unit, among fire corps, among units of the Integrated Rescue System, possibly among several countries,
- coordination of rescue activities - in case of accidents with a mass collective disability, premedical first aid assistance, removal and evacuation of the wounded, behaviour of the crowds,
- activities related to rescue works - evacuation management, removal of barriers and roadblocks, rescuing people,

- elimination of fire outbreaks, monitoring of intervention,
- the release of hazardous substances, detection of chemical substances, contamination and decontamination,
- others - e.g. explosion, detection of fire outbreaks by thermal imaging cameras, detection of hazardous substances, bomb systems, terrorist attack.

The advantages of the utilization of simulation and virtual reality tools include:

- lifelike representation/display of a real incident with the added virtual scenario,
- two-dimensional 2D plan to 3D three-dimensional object or dynamic work environment,
- interactive communication with a "picture in a picture" system and connectivity with all members of the Fire Corps during the intervention,
- review and improvement of the usability of products and processes whilst their development and design are still in progress - this enables to avoid errors in development and the need for subsequent modifications,
- systematic and empirical review of design solutions for the human-system interfaces and their influence upon human behaviour - this reduces the need for physical modifications to machinery, and for extensive field studies,
- safety test of potentially hazardous products, processes and safety concepts [4] - this avoids actual hazards during the study of human-system interaction,
- identification of cause-effect relationships [5] based on accidents and involving products - this saves material, personnel, time and financial outlay associated with in-situ testing,
- specification of the accuracy of data acquired through thought processes and verification of the software-evaluated level of protection,
- VR-simulated real workplaces for life safety, object and property security [6] or occupational safety and health purposes of firefighters and also of citizens,
- instruction manual and operating instructions for education,
- guidebook for motivating education - e.g. Museum of Firefighting, Firefighting Technics, Principles of Structures Fire Protection, Explosion Suppression Prevention.

The utilization of simulation tools based on virtual reality applications and devices enables

to simulate close to real life conditions and prepare Fire and Rescue Services for scenarios based on real events. We see great potential in the 3D environment of various emergencies, natural disasters and accidents that happened in the past and their application in virtual reality. The existing scenarios can be further shared by other Rescue Services and in this way, they can prepare for situations that have already occurred in a different place [7]. We assume that in the near future virtual reality devices will be introduced into training, not only of firefighting brigades but also other rescue services. The objective of introduction of virtual reality solutions into preparation and training of Fire and Rescue Services should be the improvement of their emergency preparedness and work safety.

## 2. METHODOLOGY

In Slovakia, simulation technologies based on virtual reality, software applications and additional equipment are not used for education and training needs of the members of Fire and Rescue Services. Based on current trends in the modern education, including the use of virtual reality tools, we have decided to explore their possible application to firefighters

and rescuers. In the framework of an institutional grant project at the Department of Fire Engineering FBI UNIZA, a pilot questionnaire was conducted. The purpose of this preliminary questionnaire survey was to find out the views on the possible introduction of simulation technologies and virtual reality tools into the education and training of firefighters and rescue teams and to map the current needs of future users.

The questionnaire was distributed electronically via the form (see Figure 1) to a representative sample of selected representative groups in the Slovak Republic:

- Fire and Rescue Services - Ministry of Interior, Presidium of Fire and Rescue Corps, Fire Appraisal Institute, Regional Directorates of Fire and Rescue Services,
- training institutes - Secondary School of Fire Protection of the Ministry of Interior in Žilina, Rescue Brigades, Training Centre of the Ministry of Interior in Lešť,
- universities - the University of Žilina, the Technical University in Zvolen, VŠB - Technical University of Ostrava, the University of Defence in Brno, CTU - Czech Technical University in Prague,
- commercial sector - experts in IT, fire equipment, science and education.

**Simulation tools for training Fire and Rescue Services**

The main objective of this survey is to identify needs and possibilities how simulation tools can support training of firefighters and rescuers. Your opinions are very important to us, and will be discussed with our team. Your valuable participation in the survey and all of your responses will be kept confidential. No personally identifiable information will be associated with your responses to any reports of these data.

We would really appreciate if you could take a couple of minutes to complete our survey that can be accessed via the link "Next" below. Thank you.

[Next](#)

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Figure 1 Questionnaire survey for an institutional grant project

The questionnaire contained a set of questions divided into five sections:

1. section contained basic information related to the questionnaire form, including a data protection disclaimer,
2. section (n = 6) focused on respondent identification data - we identified: the work area, number of years worked, job position, workload, the highest education achieved and the initial information whether the respondents encountered the use of simulation software-based technologies (e.g. virtual reality devices, serious games, mobile apps, etc.) in their work,
3. section focused on questions (n = 4) regarding simulation technologies and their applications - respondents could watch a video presenting the training of soldiers using modern simulation technologies and identify related claims - this section also included a verification question,
4. section also included a video showing the use of simulation technology specifically for firefighters and a set of questions (n = 5) by which we wanted to identify the interest of respondents in the real use of this technology for the needs of firefighters, as well as attitudes to the introduction of simulation technologies into the education and training of firefighters and rescuers,

and the respondents should react to functions and properties of the simulation tool for the needs of fire and rescue services,

5. section comprised the conclusion of a questionnaire survey, where respondents were provided a space for their opinions, comments and recommendations, and where they could type their email address if they are interested in the results of our survey.

### 3. RESULTS OF THE QUESTIONNAIRE SURVEY

The questionnaire was distributed to the interested groups or to specific people in the above-mentioned institutions (about 150). 101 respondents responded to the questionnaire. Thus, the return on the questionnaire was higher than we expected. The questionnaire was also probably disseminated among the respondents. The return rate of the questionnaire was 67%. Out of the 101 completed questionnaires, 98% (n = 99) were fully and correctly filled. This piece of information provided a verification question. All obtained results were statistically evaluated (see Table 1) and further analyzed.

Table 1 **Results of the questionnaire survey for an institutional grant project**

Number of respondents	Percentage expression	Meaning of response
50	49.5%	respondents selected the area of work - education (the most frequent jobs were a teacher, a researcher, a lecturer, an academic worker)
48	47.5%	respondents selected the area of work in the field - firemen and rescuers (the most frequent jobs were a firefighter, head of the department, independent professional inspector, a technician of fire prevention)
54	53.5%	respondents have been working in their field for more than 10 years
26	25.7%	respondents have been working in their field for 4 to 10 years
15	14.9%	respondents have been working in their field for 1-3 years
6	5.9%	respondents have been working in their field for less than 1 year
40	39.6%	respondents have completed the third level education
51	50.5%	respondents have completed the second level education
67	66.3%	respondents have already encountered the use of software-based simulation technologies (virtual reality devices) in their work
5	4.9%	respondents often use software-based simulation technologies based on virtual reality in their work
27	26.7%	respondents did not encounter software-based simulation technologies based on virtual reality in their work
60	59.4%	respondents selected the option "Simulation tools for firefighters based on virtual reality could help in the training and continuing education of the members of Fire and Rescue Services"
58	57.4%	respondents selected the option "Simulation tools for firefighters based on virtual reality could contribute to the periodical training"

Number of respondents	Percentage expression	Meaning of response
		of the capabilities and skills of all firefighters and rescuers "
36	35.6%	respondents selected the option "Simulation tools for firefighters based on virtual reality could help improve the decision-making skills of the intervention commander"
11	10.9%	respondents selected the option " "Simulation tools for firefighters based on virtual reality could contribute to the preparation of only young firefighters and rescuers"
72	71.3%	respondents positively responded to the video presenting a specific simulation technology based on virtual reality for the needs of firefighters and selected the option "I can imagine the real use of simulation technologies for the needs of firefighters"
14	13.9%	respondents negatively responded to the video presenting a specific simulation technology for the needs of firefighters and selected the option "I cannot imagine the real use of simulation technologies for the needs of firefighters"
87	86.1%	respondents would welcome the implementation of simulation technologies based on virtual reality into the training, preparation and higher education for firefighters and rescuers (see Figure 2)
91	90.1%	respondents would welcome the implementation of simulation technologies based on virtual reality into the process of university education for firefighters and rescuers
68	67.3%	respondents agreed with the statement that "the extension of training and the use of simulation technologies based on virtual reality can improve the level of preparedness of firefighters and rescuers"
65	64.4%	respondents selected the option "simulation technologies based on virtual reality can be an asset for the continuous education of the members of fire and rescue services"
60	59.4%	respondents confirmed the claim "simulation technologies based on virtual reality would be appropriate for implementation into the education process at universities"
57	56.4%	respondents selected the option that "the application of simulation technologies based on virtual reality can contribute to a better and safer work of members of fire units"

Would you welcome the introduction of simulation technologies into the firefighting training and education process?

101 answers

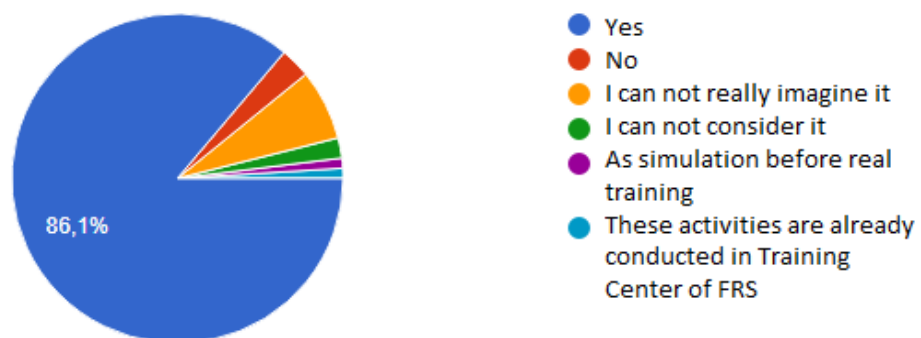


Figure 2 Question from the questionnaire survey including the results

Among the respondents, responding to the question "What is your job position" (in addition to the answers in Table 1), there were positions as a vice-dean for strategy and development, a head of department, a director of a district directorate of Fire and Rescue Services, a head of operational and technical department of a regional directorate of Fire and Rescue Services, a head of fire prevention department, a head of training, a team

commander of the fire unit, a leading technician specialist, operator of the operating center, technician engineer, ICT engineer or cop.

One of the questions of the questionnaire survey was "What features (properties) would you think a simulation tool for the needs of firefighters and rescuers should have?" The responses varied (see Figure 3).

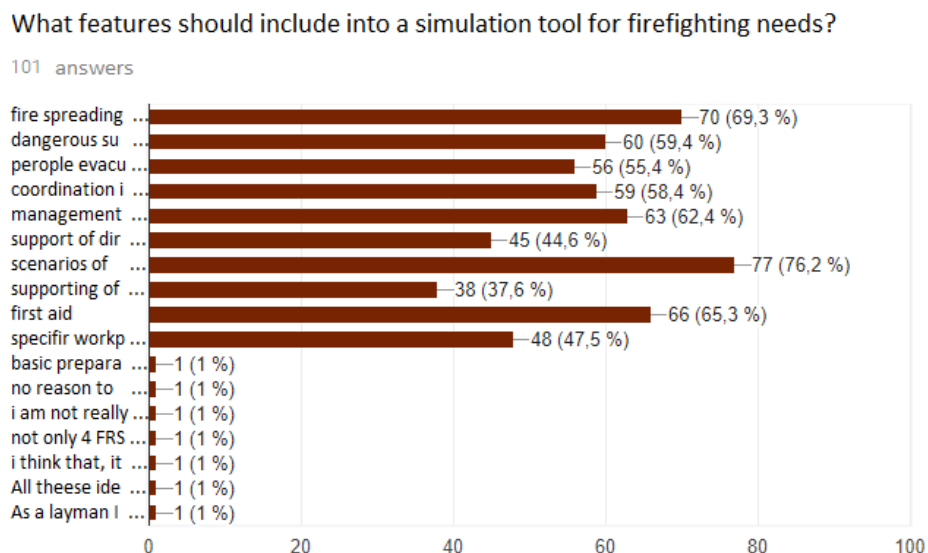


Figure 3 Question from the questionnaire survey including the results

The respondents have most frequently identified options such as: scenarios of various types of emergencies, fire and smoke spread, work in a specific environment (underground, building debris, bad meteorological conditions), decision making of the commander of the intervention, dissemination of dangerous toxic substance, coordination of several components of the Integrated Rescue System at the site of the intervention, evacuation of persons from the building, basic preparation of the firefighters-beginners, support for fire

brigade and fire units management and provision of premedical first aid assistance in a place with a mass collective disability of persons.

A space for opinions, comments, and recommendations from the respondents was created in the final part of the questionnaire. 20 respondents used this option. The table below (see Table 2) shows some interesting reactions.

Table 2 Responses from the questionnaire survey

The development of the simulation tool must include an accurate scenario and the individual steps should be consulted with a group of specialists from practice during its development.
Similar software is also used by soldiers in the Lešt Training Center and was tested in 2014, and since 2016 it has been regularly used for the training of command staff of the district directorate of Fire and Rescue Services.
An interesting incentive and a very good idea. Finally a good idea for the corps.
Simulation can be a great asset, but training and education also have to be applicable in real situations.
Any event simulation can be helpful in expanding knowledge and skills, but from my

point of view, each event is specific and cannot be fully prepared for, so we cannot avoid all the risks associated with it.
Simulation tools for training firefighters are a very interesting addition that can lead to improving the education and training of firefighters, especially in tactical tasks and decision-making. The disadvantage of these tools, however, is the fact that they cannot completely replace the physical training of firefighters in the conditions of a training fire with a real threat.
If this is done, it will be a significant shift forward.

## CONCLUSION

Available simulation tools and virtual reality solutions offer interesting applications for the needs of Fire and Rescue Services. We claim that with the help of modern technologies and the appropriate software solutions, we can contribute to more effective and safer work of firefighters. Currently, many different technologies are available. Simply select the most suitable training software for firefighters that would allow creating varied scenarios that cannot be simulated on a real polygon, which can be costly and inefficient. These scenarios can then be used to discuss the progress made, the decisions that have been taken, and the alternative ways of proceeding and managing in emergency situations. The aim is to extend previous firefighters' experience among less experienced firefighters and to expand the knowledge among university students.

The results of the questionnaire survey confirmed the interest in simulation tools for the needs of the Fire and Rescue Corps. It has been confirmed by the academic and professional experts. The information and results obtained from the project solution will serve as the basis for further project solutions of this issue. The application of modern and innovative trends in the process of education and training of rescue services can be the method of reduction of failure risk, thereby contributing to the increase of rescue workers' safety. Simulation technologies with a connection to virtual reality will help firefighters and rescuers train the necessary activities and skills in a safer way. At the same time, they can help improve the learning and teaching process at the Secondary School of Fire Protection of the Ministry of Interior of the Slovak Republic in Žilina or at the Department of Fire Engineering at the Faculty of Security Engineering of the Žilina University in Žilina.

## LITERATÚRA

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