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ASSESSMENT OF THE PASSENGER SECURITY SCREENING PROCESS USING A VIRTUAL REALITY SIMULATOR

Summary. Passenger security screening is a necessary process carried out at the airport that affects the safety and capacity of the airport. Every person entering the restricted airport area must undergo a security check. The security control operator conducts training to detect prohibited items appropriately. Currently, training of security control operators is carried out in various ways, e.g., using electronic support systems. The author's proposal concerns using an innovative passenger security control simulator built using virtual reality technology. The author researched the effectiveness of passenger security screening at the airport. Indicators have been used in the VR simulator to assess the passenger screening process. The article aims to present an assessment of the security control process using an innovative VR simulator.
Keywords: virtual reality, passenger screening, airport screening operator training, security operational experience

1. INTRODUCTION

The dynamic development of civil aviation poses a serious challenge to the aviation sector in the context of the increasing number of passengers. One effective way to increase aviation's competitiveness is to increase the quality and safety of the services provided. Changes in

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technology force the adaptation of emerging opportunities to air transport, which leads to an increase in the quality of airport operations. At a time of rapid and difficult changes, the concept of sustainable development is of particular importance, understood not only concerning ecology but also in the broad sense of the word sustainability, interpreted as, for example, the use of conditions created by the environment in air operations. The subject of sustainable development of air transport is related to increasing the capacity of the infrastructure of existing airports, ensuring conditions for the effective development of aviation at airports, and ensuring environmentally sustainable development of the aviation market. Achieving these goals involves using innovative technological solutions and virtual reality in training processes.

Airport processes must be carried out in a way that ensures security but also increases airport capacity. Passenger screening is a necessary process carried out at the airport. Every passenger and person entering the security-restricted area of the airport must undergo security screening.

Screening of passengers and cabin baggage shall take place in accordance with regulations. The screener shall have the right to deny a passenger access to the security-restricted area if he/she finds the passenger carrying prohibited articles. In this case, the passenger shall be screened again until the operator is satisfied that the screening requirements have been met. Metal items in travelers' possession cause the alarm signal's appearance. Numerous restrictions on the ability to bring certain items on board the aircraft determine the level of security of the flight operations performed. The screening operator undergoes training to ensure an adequate detection level of prohibited items. Currently, screening operators are trained in different ways. This paper proposes using an innovative screening simulator made with virtual reality technology. Such an approach allows the monitoring and cyclical checking of a properly executed passenger screening procedure.

Additionally, using such a tool, instructors can increase the difficulty level and analyze the security operator's behavior depending on the level of the passenger's recalcitrance. Security screeners who are better trained should be better able to deal with difficult passengers. In addition, repeated and refresher training should result in better compliance with existing procedures and rules than those with less training.

Evaluating the effectiveness of operator training with different knowledge-testing techniques is not meaningful. In general, when analyzing the training processes of the various groups working at the airport, it can be concluded that the subjective feeling of the assessor plays a key role, which makes the use of fuzzy sets justified when evaluating the training process [20]. Using a defined evaluation system will allow an unambiguous assessment of the level of passenger screening and the preparation of operators for this role.

The first part of this article presents an innovative passenger screening simulator developed using virtual reality technology. The capabilities and functions of the screening operator are described. The possibility of the instructor monitoring the progress of the screening process is also presented, as well as the parameters for evaluating screening.

The second part of the article is a quantitative analysis based on the research conducted. The evaluation parameters of passenger screening that can be adapted and monitored in a five-level process to evaluate the training process of passenger screening operators are presented. The main objective of the article is to present a way to evaluate the training process of a passenger screening operator. Based on the security operator's achieved level of training, it is possible to increase the intensity of training for those elements in which the trainee performs less well, while decreasing it for those in which the level of training is satisfactory.

The training evaluation system also considers passenger behavior and introduces a parameter called “recalcitrance”. The VR passenger screening simulator considers hazardous materials, a list of which can be dissected.

This paper aims to present and apply virtual reality technology in training security screeners as a cost-effective method of training and improving staff competencies, as well as to assess the training of security screeners and identify areas in which the training of security screeners should be improved.

2. A LITERATURE REVIEW

2.1. Virtual reality

Virtual reality (VR) is a technology that is playing an increasing role in the aviation industry and can be used for various educational and training purposes [18]. VR allows the simulation of realistic experiences under controlled conditions, which can have critical applications in pilot training, aircraft operations [23], mission planning, and developing new aviation technologies.

Today, the possibilities of using VR are very wide, and the concept of VR itself was formulated in the 1960s. The first commercial VR tools appeared in the late 1980s [2]. The first working and patented device, which resembles the most currently used devices, was patented by Ivan Sutherland, who then constructed a device for virtual world observation and interaction [21]. Aircraft simulators and cockpit mock-ups have been in use since around the 1920s, mainly to familiarize flying personnel with the equipment and to practice procedures without risking damage to the aircraft or endangering health in the early stages of military training. Training in classical simulators based on a computer environment with different mapping stages yields positive results, especially when practicing emergencies [14]. VR can be used to simulate realistic combat scenarios, train pilots in difficult weather conditions, and test new aviation technologies. Using VR, military pilots can hone their skills in safe conditions and be better prepared for real-world missions [7].

VR is increasingly used in civil aviation training. Training in the aviation industry is crucial due to the need to achieve a high level of safety. Areas in which VR can be applied include pilots' in-flight behavior, operations during maintenance, aircraft ground handling, and passenger screening at the airport terminal. Each of the aforementioned professional groups is subject to training, and through regular training, aviation personnel can improve their skills, learn new procedures, and respond quickly and effectively to emergencies [3].

In recent years, most of the scientific research in the area of VR applications has focused precisely on the training aspect and the reduction of training costs. Research shows a correlation between learning effectiveness and cognitive ability when using VR-based learning [4]. One of the guiding applications is the transfer of training from traditional flight simulators to the VR environment, which has positive cost effects compared to expensive equipment. The manufacturer of the first EASA-certified helicopter simulators, Loft Dynamics, claims that the VR-based FNPT Flight and Navigation Procedures Trainer simulators are 1/20th the cost of a full-size simulator while taking up significantly less space than traditional designs of this kind [24].

In addition to solutions that transfer the tasks of traditional simulators, one other solution is to use the Head Mounted Device HMD to track the eyes of the examinee when testing the examinee's ability to observe situations and make decisions [5]. This device was designed by a company called Cineon Training, called TACET Training Air Crew Competency using Eye Tracking. A study on the effectiveness of this type of behavioral control of behavioral patterns and observation of given areas showed a correlation between the observation patterns of more experienced pilots in environments with a high accumulation of tasks. In less experienced pilots, significantly more searches of areas suitable for a response and less consistent behavior were observed than for experienced personnel. Hence, such devices can significantly change the approach to flight crew training and highlight problem areas to instructors [11].

Another frequently suggested perspective of use is to move some of the training modules, both theoretical and practical, into virtual spaces. One airline that has announced the introduction of such modifications to its training programs is KLM. According to the company's announcement, the technology will be introduced into training for a given aircraft type (Type Rating) [12]. In addition to the positives related to the cost and effectiveness of training, frequently cited advantages include the possibility of adapting simulation environments more quickly to, for example, other aircraft configurations or making modifications to the simulation environment more immersive and easier [16]. Regarding cabin crew training, only the carriers Lufthansa, Emirates, Qatar, and ANA are currently running projects using VR technology [15].

In 2017, IATA launched a pilot project called RampVR to enhance the safety of ground handlers [7]. It aimed to increase training effectiveness and compliance with ground handling procedures and instructions. It incorporates modules such as:

- pre-flight inspections,
- aircraft guidance,
- operations using the passenger bridge,
- pushback process operations.

The benefits of using virtual reality in flight training include:

- Increased safety - through virtual reality simulation, trainees can train in various emergencies and learn how to respond to them without risking their own lives and health or endangering others.
- Time and cost savings - virtual reality training allows knowledge and piloting skills to be acquired more quickly and efficiently, saving time and costs associated with traditional training methods.
- Accessibility of training - thanks to VR, flight training can be accessible to more people, regardless of location or access to actual flight simulators.
- Personalization of training - with VR, instructors can personalize training, monitor progress, and tailor training to the individual needs and skills of the trainees.
- Improved learning experience - VR allows the creation of highly realistic and engaging flight simulations that can provide a more effective and exciting learning experience for trainers.

By using VR in flight training, staff can be better prepared for various situations, resulting in increased air traffic safety and reduced risk of incidents. It is an extremely important tool in improving aviation personnel's skills and raising air transport safety standards.

It is worth noting that, despite its many benefits, VR does not replace traditional aviation training methods but can be a valuable complement and enrichment to the training process. With VR technology, trainers can gain more practical skills and experience that will be useful in real-world operations.

Conclusions from the literature review indicate that virtual reality has great potential in the civilian and military aviation industry. With this technology, the quality of flight training can be improved, flight safety can be enhanced, and the development of new aviation technologies can be accelerated. Consequently, there is a growing interest in the use of VR in aviation, and researchers and technology companies are doing a lot of work to develop this technology so that it can be used as widely as possible in the aviation industry. A review of the literature also indicates that there is no transparent system for evaluating the training process; therefore, a system for evaluating the passenger screening process is presented in this paper, including options for adapting the training process to the security operator's performance. The VR passenger screening simulator can also be used for security operator candidates to learn about the specifics of working with passengers and to indicate suitability for the position.

2.2. Security training

The passenger screening process and security training have been topics widely considered in the literature. The authors [9] performed a review of European airports, analyzing the impact of security training on security. The conclusions drawn indicated that the training process results in attaining certain habits and security decision-making, based on the operator's experience and identifying emerging threats. In the article [8], the authors investigated how to consider the decision-making and performance of security control operators when assessing vulnerability to a terrorist attack at an airport security checkpoint. An agent-based model (passenger, attacker) was designed, in which the performance of security operators was modeled using a functional state model, while decision-making was modeled using decision field theory.

The simulation results indicated that the most skilled operators outperformed their least skilled counterparts in analyzing X-rays, but performed less well in both bag searches and passenger searches. In addition, the results showed that a high emphasis on speed by security operators reduces the number of bag searches and thus increases vulnerability. Analyzing the field of airport security, there is a conviction that the training of security screeners directly impacts the actual behavior of these individuals in accordance with the rules in force, thus ensuring an optimal level of security. This area is very complex in organizational terms but also in social terms, given that there is a perception that a not inconsiderable percentage of security personnel, including controllers, guards, and ground staff, do not apply the rules and procedures in force, which calls into question the effectiveness of training [10].

The authors [11] investigated screening operator behavior and adherence to or disregard for rules, dividing employees into three groups to determine the dependence of these groups on adherence to procedures and rules. These groups were combined with the job duties performed and the types of airport employees: “adaptive”, “socially interactive”, and “compliant bureaucrat”. The research carried out indicated that the “adaptive” group of employees is prone to not complying with existing rules.” Socially interactive” relies primarily on group decision-making, while “compliant bureaucrat” is attached to administrative and safety regulations. The results can be used to define candidates for screening operators in the recruitment process.

A lot of attention has been given in the literature to analyzing the screening of hand luggage. The introduction of automation that provides alerts, alarms, or warnings allows security operators to be supported by drawing attention to display areas that may contain a target. The authors [0] tested security screeners who were supported by explosive detection systems for cabin baggage screening (EDSCB). Used as low-level automation during baggage screening at airports, EDSCBs support operators by pinpointing areas on X-rays that may contain explosives. The study was performed using measures of automation reliability (accuracy, positive predictive value). The results of the study, conducted with operators at the X-ray screening of hand luggage, confirm and extend the results of previous studies on low-level automation. The analyses conclude that when device performance is high, operator confidence is high, and automation provides only low benefits; when device performance is lower, operator confidence is lower, and automation provides high benefits.

The safety control process has been analyzed in terms of human factors. The authors [17] studied the prevalence of errors and human factors in the screening process and their impact on security. The authors assessed the potential errors and human factors that affect the performance of passenger security checkpoints using the example of airports in Brazil. For this purpose, 10 out of 60 items of a self-observation questionnaire, based on the Generic Error-Modeling System (GEMS) theory and the human factors framework recommended by the International Civil Aviation Organization (ICAO), were analyzed. The exploratory analysis focused on items directly related to safety culture and organizational environment. The results indicated the presence of essential elements for creating an appropriate safety culture among professionals. On the other hand, the data indicated the presence of human factors related to a safety culture that may have a negative impact on passenger screening performance.

The training process was the subject of a study by the authors [1], during which, using data from a random sample of 145 airline passengers, hypotheses were tested to examine the predictive relationships of screening procedures, security staff training, security staff professionalism, and screening systems on passengers' perceived biases. Multiple regression analysis was used to test the hypotheses. The results indicate that security staff professionalism is negatively and significantly related to passenger-perceived biases. In addition, security staff training and screening procedures are positively and significantly related to security professionalism.

The issues of coping with safety hazards in the workplace and the analysis of employees' awareness of safety procedures were investigated by the authors [19], who conducted analyses to explore the relationship between three dimensions of employees' safety awareness. A questionnaire measured the relationship between employees' knowledge of safety procedures and policies, attitudes toward safety, and self-reported safety behavior. Secondly, a case study was conducted to investigate the impact of training sessions on employees' security awareness. By providing awareness training, its impact on employees' knowledge, attitude, and behavior was measured. While the first study found a significant relationship between workers' knowledge and attitude and their self-reported behavior, the second study showed that the training session positively impacted workers' safety awareness levels.

The authors in [13] identified and quantified the relationships and trade-offs between the effectiveness of illegal item detection and the average queuing time at airport security checkpoints. These relationships and trade-offs were analyzed through simulations using a cognitive agent model of operations at airport security checkpoints. As a result of the simulation analysis, a performance curve of security checkpoints with three different regions was identified. Furthermore, the importance of focusing on accuracy for the security checkpoint operator was demonstrated. The simulation study results were related to empirical studies at an existing regional airport.

The authors [22] proposed several models to evaluate the effectiveness of safety training. The study aimed to indicate how employee safety performance may improve after a safety training intervention. The impact on safety performance was investigated in two units of the study company based on a questionnaire and selected indicators. A descriptive analysis was carried out on the basis of the collected data. Based on the questionnaire, some improvements in safety knowledge, attitudes, behavior, and safety performance can be found.

2.3. Work concept

The literature review of the application of VR and the evaluation of the passenger screening training process indicates that this area needs in-depth analysis and research. The minimum requirements for the job are known in the training process, but there is a lack of effective methods to determine skill levels at the training stage. In addition, consideration must be given to emerging threats and hazardous materials that the security operator must recognize. Emerging threats necessitate refresher training, which can be done considering the proposed VR simulator.

The article is organized as follows. Chapter 2 presents the theoretical background of the application of virtual reality and the airport passenger screening process. Chapter 3 deals with the presentation of the VR simulator and its application in the passenger screening process. Chapter 4 contains the results of the research conducted. Chapter 5 provides a summary and conclusions.

3. PASSENGER SECURITY SCREENING SIMULATOR IN VR TECHNOLOGY

3.1. Implementation of the training process and functionality of the VR simulator

The VR simulator on display is equipped with goggles and two motion controllers for each hand, allowing the selection of the relevant functions and manual control of the passenger. The VR simulator can implement the passenger screening process by operators visualizing the process and the ability for the instructor to monitor the training process.

The passenger screening process is designed to check the passenger for prohibited substances, objects, and risks to other passengers. The first screening stage is the moment before passing through the security gate. From the point of view of the security control operator, the operation begins with selecting the appropriate function. At this stage, the security operator may require the passenger to do the following (Fig. 1):

- "clothing" instructs the passenger to take off the clothing,
- "accessories" instructs the passenger to remove jewelry and exterior accessories,
- "footwear" requires the removal of shoes,
- "turn around" instructs the passenger to turn around,
- "in the container" instructs the passenger to put away potential,
- "pass" allows the passenger to be checked further, which begins after passing through security.

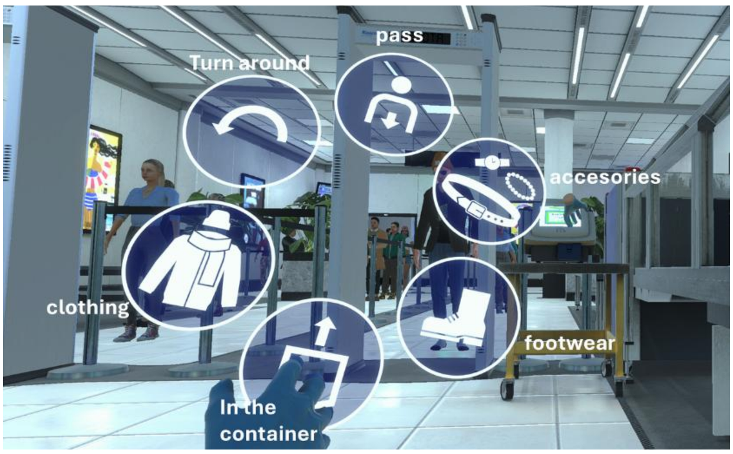

Fig. 1. Scheme of function in simulator VR

Fig. 2. Scheme of using a laser

As an alternative to the predefined functions, the passenger can indicate the item of clothing he or she must remove by a point indicator (Fig. 2).

The second screening stage occurs after the passenger passes through the security gate. More possibilities for passenger control characterize this stage, and these are the following example functions (Fig. 3):

- “turn” tells the passenger to turn. You should be sure that you do not carry anything prohibited in your back pockets or under your clothing.
- “hand over” transfers the passenger to a personal inspection performed by the second guard. This option is required when we want to personally inspect a passenger, but he is of the opposite sex. At the start of each session, we can choose our gender. It is strictly forbidden for men to carry out personal inspections of women, and vice versa. After ordering a personal inspection, the guard next to us decides whether the passenger can proceed or not.
- the “guard” transfers the passenger to the border guard services.
- “return” requires the passenger to return to the gate. It should be used when the gate lights up red while passing through.
- “pockets”, similarly to the previous stage, we can ask the passenger to empty his pockets. If it turns out that the passenger has taken an item out of his pocket, we can take the further steps shown in Fig. 4.
- “manual check” performed only on passengers of the same gender as the one we specified when starting the session. The check requires us to approach the passenger and, using traffic controllers, check the pockets, hands, and torso of the person being searched to exclude the possibility of the passenger carrying prohibited items.
- “to the container” requires the passenger to place all items that can be detected by the security gate- liquids, electrical devices, and other items specified in the regulations- into the container. This takes you back to the security gate again.
- “ETD” is a passenger screening to detect dangerous substances, such as explosives. To carry out the inspection, after selecting this action from the activity wheel, we will receive a special piece of paper with which we should wipe our hands and the passenger's clothing (Fig. 5) and then put the sample into a special computer located next to the security gate (Fig. 6). After waiting a few seconds, we receive the result of whether a given passenger has had contact with explosives or drugs. If so, it should be handed over to the border guard services.

- "finish" if we are sure that the passenger does not pose a threat, we allow him to leave the security check.

Fig. 3. Scheme of function in the second stage of security

Fig. 4. Function to empty pockets

Fig. 5. Function of ETD

Fig. 6. ETD testing device

The passenger security screening process ends after selecting the function ending the session, or the session may end after screening a defined number of passengers.

3.2. Monitoring the passenger security screening process from the instructor's point of view

The instructor monitors the passenger security screening process performed by the security operator. In the first stage, the gender of the security operator is selected. A defined operator can conduct the training process at five training levels, characterized by increasingly higher difficulty levels. In the program, you can set a user's profile and parameters specific to a given training session.

Each level is characterized by default parameters, which can be changed and adapted to the instructor's requirements. The groups of parameters that have been proposed concern the characteristics (fig. 7):

- surroundings – ability to assign small, medium, or large surroundings and crowd size,
- passenger – determining the number of passengers during the training session, passenger recalcitrance and its severity, and gender compatibility,
- items – defining the degree of allowed and prohibited items for passengers,
- clothes – percentage of outerwear among passengers,
- gates – number of gate control excitation and identification of ETD traces.

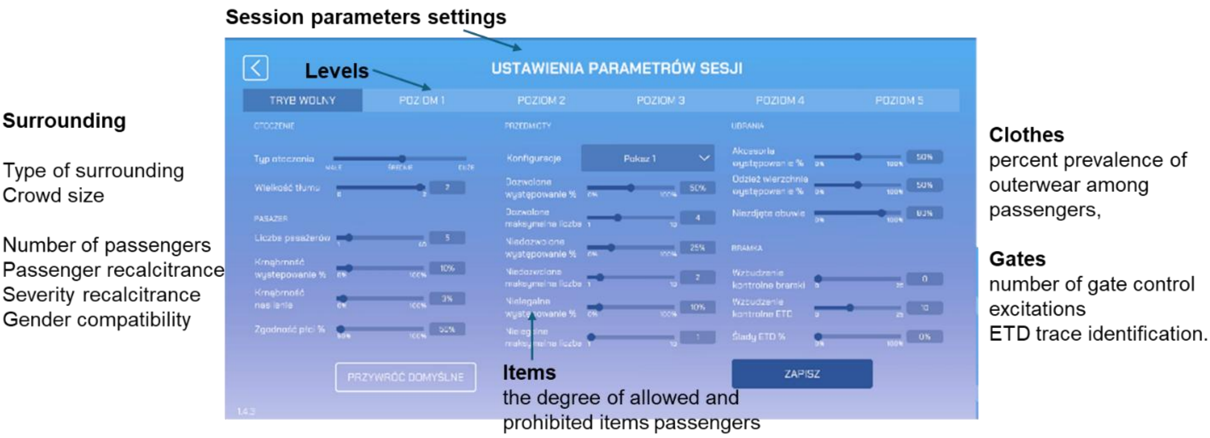

Fig. 7. Session parameter settings

The instructor monitors the training process and previews the inspection session to see what a given passenger brings to the airport. The instructor's view is presented in Figure 8, which shows the passenger's clothing items and what items the passenger has. Additionally, the implementation times of the passenger screening process are presented. The program assigns bonus or penalty points for activities performed. In the case of correctly performed activities, points are added and displayed in green; in incorrectly performed activities, points are subtracted and displayed in red. The proposed score for the activities performed constitutes the weight of the activities performed by the operator and can also be changed.

Inspection session

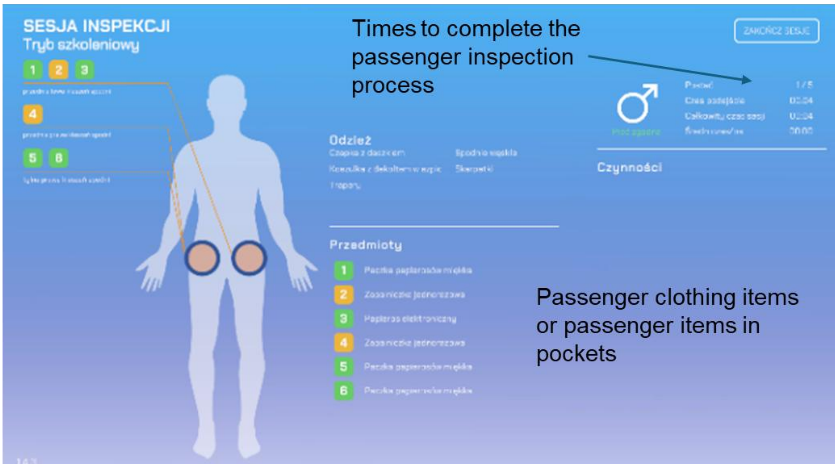

Fig. 8. Preview the instructor for an inspection session

After completing the session, the instructor has access to a summary that contains information on the points awarded, the time of the security check, the number of correctly performed security checks for passengers who had additional clothing items, the number of prohibited items found, and their identification. The program contains a list of prohibited items that can be expanded.

4. CONDUCTED RESEARCH

4.1. Study data

The research was conducted on 30 people who are or were involved in aviation activities. The respondents' aviation experience ranged from 0 months to 12 months. The total points obtained for correctly and incorrectly performed activities were recorded during the passenger security screening process examination. Errors are expressed as positive points for a correctly performed activity or negative points for an incorrect one. As mentioned earlier, these points constitute weights for individual activities and can be changed depending on the skills and need for training of selected activities. Therefore, the total points obtained may have a low evaluative value in the analyzed sample but may be extremely important for assessing progress during training. The following parameters recorded concerned the average time of passenger inspection and the percentage of passengers who passed through wearing outerwear, with an accessory, in shoes above the ankle, with a prohibited item, and with an illegal item. The research was carried out at three levels of passenger safety control, at which passenger recalcitrance was assumed to be 15%, 46%, and 60%, respectively. In practice, respondents were asked to conduct passenger safety checks in a VR simulator. An example of the measurements performed is presented in Table 1.

Tab. 1

A fragment of the measurements taken during the safety check of passengers in the VR simulator

No	Pts	n_pax_ch	av_t_pax [%]	p_out_c [%]	p_acc [%]	p_b [%]	p_proh [%]	p_ill [%]
1	0	20	120	0	0	0	0	0
2	0	20	70	0	5	0	0	0
3	0	20	87	0	0	0	0	0
4	10	20	66	0	5	0	0	0
5	0	20	67	0	0	0	0	0
6	20	20	50	0	0	0	0	0
7	80	45	133	0	17	0	0	0
8	-10	20	163	5	0	0	5	0
9	0	20	47	0	0	0	0	0
10	-20	20	44	10	5	0	10	5
11	10	20	53	0	0	0	0	0
12	0	20	68	0	0	0	0	0
13	-5	20	110	0	0	0	5	0
14	0	20	90	0	0	0	0	0
15	10	20	77	0	0	0	0	0

where:
No – number of security operator
Pts – points
n_pax_ch – number of passengers checked
av_t_pax [%] – average time per passenger
p_out_c [%] – passed in outer clothing [%]
p_acc [%] – passed with accessory [%]
p_b [%] – passed in ankle boots [%]
p_proh [%] – passed with prohibited item [%]
p_ill [%] – passed with an illegal item [%]

4.2. Results

The dependence of the security check completion time on the passenger's recalcitrance is shown in Fig. 9. The obtained research shows that operators achieve proportional passenger security check times at three levels of training. However, when analyzing each operator's security separation, it can be seen that the most extended passenger security screening times were obtained for the highest level of passenger recalcitrance (level of 60%). The data obtained in this way may indicate the need to increase attention to dealing with an unyielding passenger but may also result from the need for the passenger to pass through the gate multiple times. Nevertheless, the security operator's decisiveness is essential here to shorten the time of passenger security checks. The passenger security screening time parameter is not the most important during operational activities, but it may be extremely important at the training level, indicating a candidate's progress for a security operator.

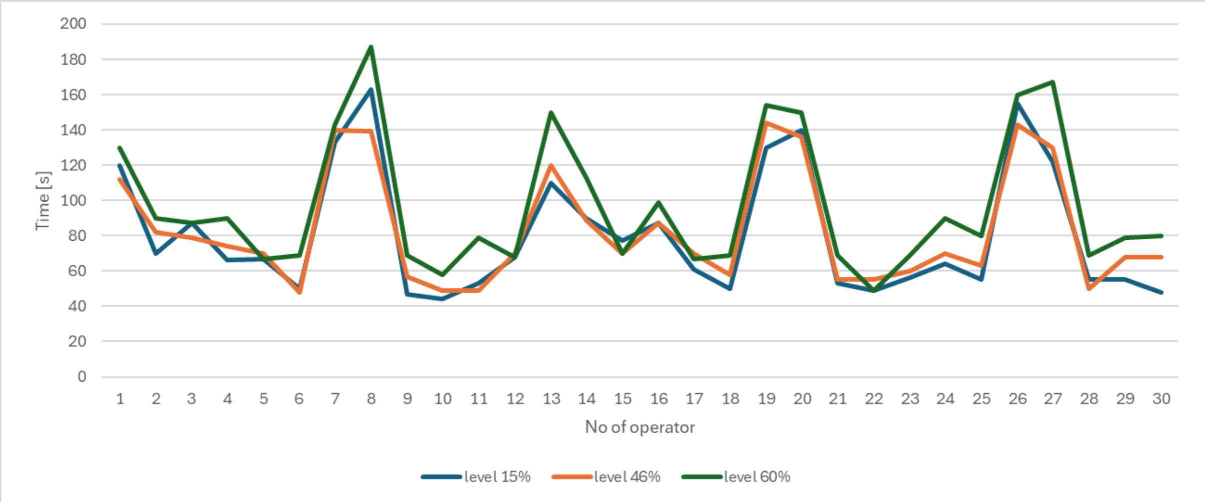

Fig. 9. Dependence of the time of the security check on the passenger's recalcitrance

When preparing for the security check, passengers must place all metal objects in containers on the X-ray machine's conveyor belt. When approaching the security check, passengers must remove the bag with packages containing liquids from their hand luggage and place it in a container with other items. Passengers are obliged to place outer clothing (jacket, jacket, coat) on the X-ray machine's conveyor belt. Passenger responsibilities are posted on the information board before the security check. However, passengers forget about the items they have or are simply too busy with other activities and enter the restricted area with prohibited or illegal items in their pockets or other places. The security check operator's job is to detect these items. The analysis of the security control process showed that 56.7% of the security operators achieved 100% effectiveness of security control, while 43.3% of operators allowed passengers to pass wearing outerwear, accessories, or prohibited or illegal items.

At the first level of testing the effectiveness of the training, the results presented in Figure 11 were obtained. Figure 10 shows the analysis of each security operator, and it can be seen that operator No. 18 achieved the highest levels of permeability, including 20% permeability with prohibited items. Such an analysis can help indicate which areas should be trained or which of them a given operator should practice to achieve higher efficiency.

Figure 11 shows the permeability of passenger security screening at the second level of screening for each security operator. Compared with the results in Figure 11, passenger safety control is seen to be more effective. Operators 3, 7, and 26 allowed passengers with accessories to pass. Operators 7, 17, 18, and 19 allowed passengers with illegal items to pass, and only one operator (number 4) allowed passengers with prohibited items to pass (5%).

Figure 12 contains the passenger pass-through results of security operators that were recorded in the third level of the knowledge check. The results obtained in Figure 13 indicate a better security control effectiveness than the first level but slightly worse compared to the second level. The third level of checking the effectiveness of security controls is characterized by a higher level of passenger recalcitrance (60%), which may affect the operator's actions. Operators No. 1 and 7 allowed passengers with outerwear (10% and 20%) to pass. Operators 7 and 26 allowed passengers with accessories to pass (6.7% and 13.3%). Operators 4, 12, 22, and

28 allowed passengers with prohibited items to pass (5% and as much as 13.7%). Operators no. 3, 12, 14, 19, and 24 let passengers pass with illegal items (5% and 10%).

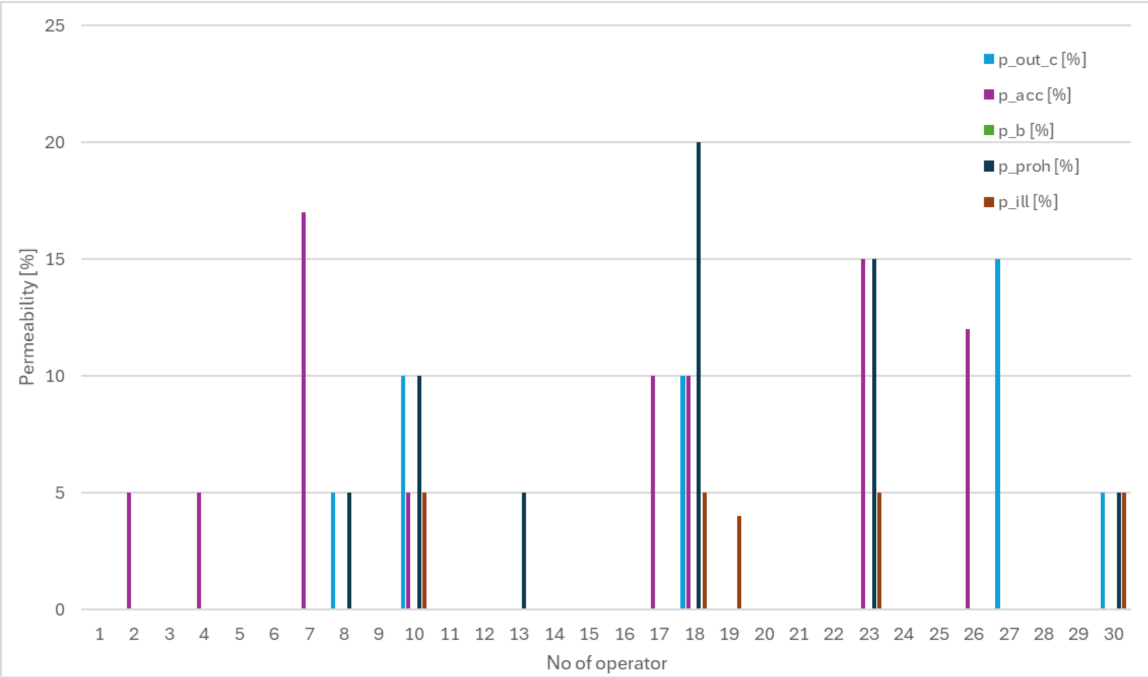

Fig. 10. Permeability at the first level of the operator's security knowledge check

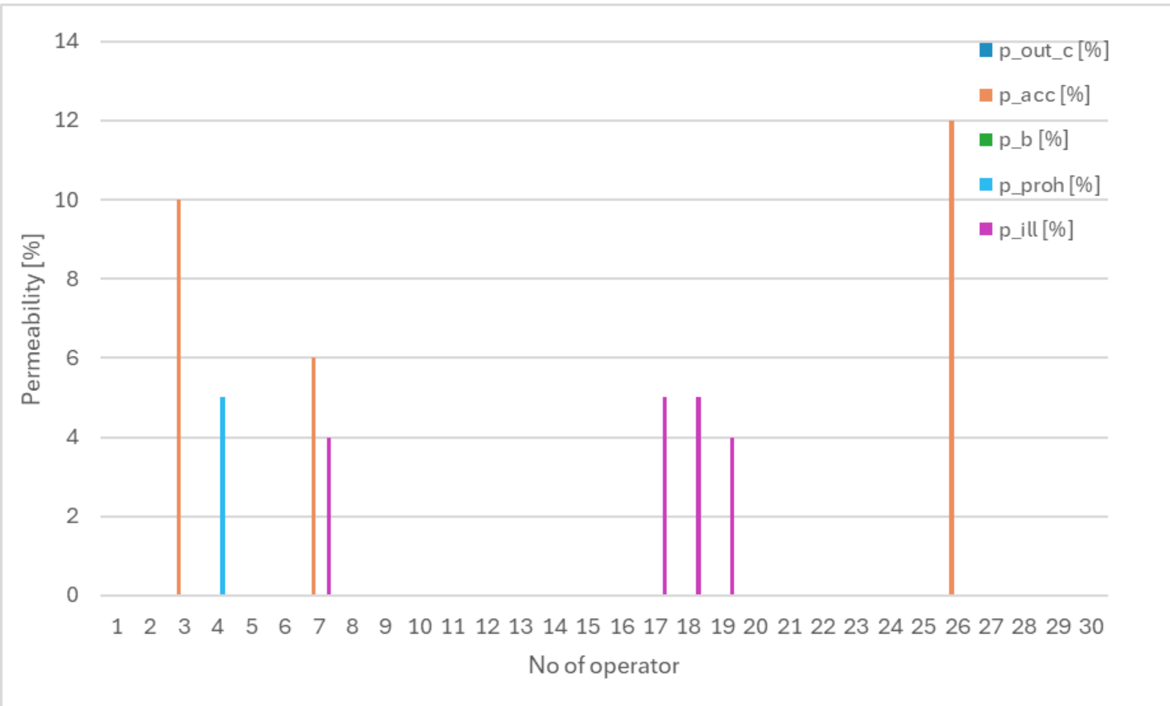

Fig. 11. Permeability at the second level of the operator's security knowledge check

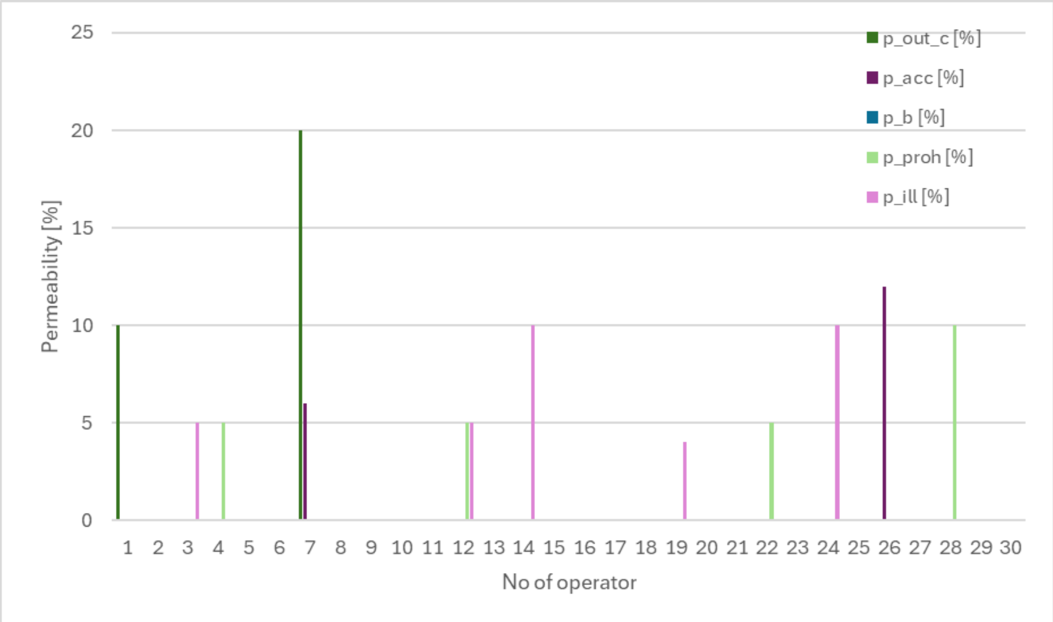

Fig. 12. Permeability at the third level of the operator's security knowledge check

The permeability percentage was determined by analyzing the results achieved at three levels of training difficulty (Fig. 13). No security operator allowed a passenger with shoes above the ankle to pass. Security operators allowed passengers in outerwear to pass during the first training (16.7%) and the third level (6.7%). Permeability with accessories was highest at the first level of training (26.7%). The permeability value with accessories was lower at subsequent training levels and amounted to 10% and 6.7%, respectively. Passengers were allowed to go through with prohibited items, and the rate ranged from 20% to 3.3%. The percentage of passengers allowed through with illegal items was 13.3% (training level 2) and 16.7% (training level 1 and 3). Security operators achieved better results during subsequent levels of training in terms of detecting accessories and allowing passengers to pass in outerwear. By analyzing the permeability of prohibited and illegal objects, the results indicated that operators should perform exercises to achieve better efficiency in detecting these objects.

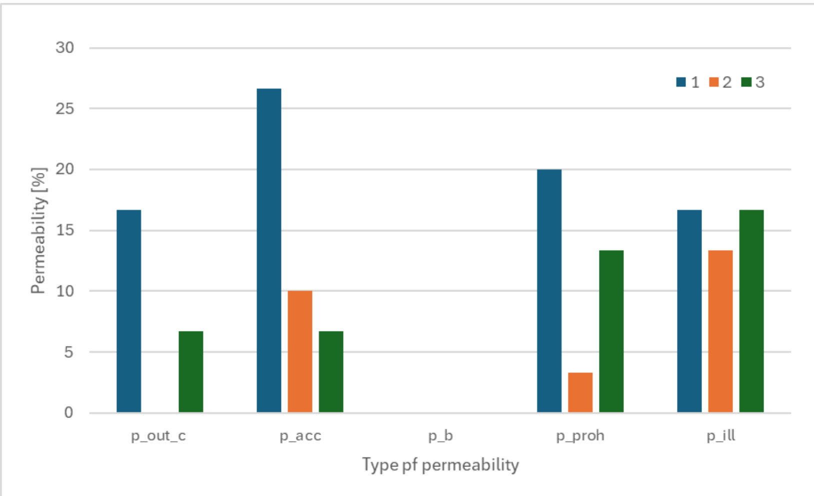

Fig. 13. The level of permeability, taking into account the type of permeability

5. SUMMARY AND CONCLUSIONS

The presented work presents a simulator of passenger security screening in VR technology and presents research on the security screening process. The research was conducted on a sample of 30 people who were assessed for passenger safety checks. The basic basis used for the analysis was measurements made during safety inspections in the VR simulator. The measurements recorded parameters related to the duration of passenger screening, as well as each correctly and incorrectly performed activity. The analysis was performed mainly in terms of the permeability of passengers in outerwear, over-the-ankle shoes, accessories, and prohibited and illegal items. The tests were carried out on three levels, which are characterized by an increasingly higher degree of difficulty and an increased level of passenger recalcitrance.

The described tool can be used to verify the effects after the training process, assess progress during training, and examine the behavior of security operators against threats. From the point of view of assessing the training process, parameters related to the time of security checks may be important, as well as the assessment of the permeability of objects with various passenger behaviors. The presented method of assessing the security of operators can be used in airports but also in other areas with a similar method of checking people entering restricted areas.

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