Safety & Defense 8(2) (2022)
DOI: https://doi.org/10.37105/sd.190

The capacity and effectiveness of screening people and baggage with the use of new technologies – standard C2

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Received: 09 September 2022 | Revised: 25 November 2022
Accepted: 28 November 2022 | Available online: 15 December 2022

Abstract

One of the basic elements inseparably connected with air communication is the security control of persons and luggage which is performed by certified OKBs entered on the list of the President of the Polish CAA. An area of interest is the security check of hand baggage passengers take with them on board the aircraft. This control is carried out based on current legal regulations in the field of civil aviation security and is designed to detect prohibited and dangerous items hidden in the passenger's luggage specified in these legal acts. Due to the fact that the catalogue of these items is not included in an enumerative way, the security control operator assesses the possibility of using any item other than that specified in the document in terms of the possibility of making an act of unlawful interference. However, the skills of the security control operator are only one of the elements affecting the effectiveness of the security check being performed. The technical background and degree of technical sophistication are no less important in the control process.

This paper aims to indicate possible organizational solutions to be applied in practice, which have a measurable impact not only on the effectiveness of the security control performed but also on the throughput at the security checkpoint, which in turn determines the operational readiness of the entire airport. The authors, through empirical studies carried out at airport security checkpoints equipped with different technical and technological solutions, quantitatively indicate the benefits of using new technologies and the possibility of choosing the organization of work at the security checkpoint, depending on the needs arising from the nature and number of flight operations.

Keywords: airport, baggage security and control, capacity, effectiveness, safety

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1. Introduction

Airports operate on the basis of principles arising from commercial law, and their purpose is to achieve a specific financial result. For this reason, investment activities are planned by considering current and forecasted airport development plans over the next few years. On the one hand, this reduces expenses that are not justified by the number of flight operations and thus eliminates the risk of incurring the costs of maintaining the infrastructure loss of financial liquidity of the airport incurring the costs of maintaining the infrastructure resulting from the revaluation of needs. However, on the other hand, such an airport reacts very poorly to all kinds of soaring traffic on the aviation market. Polish airports set another record in 2019, handling a total of nearly 49 million passengers, seven percent more than a year earlier. This situation forces the airport manager to adapt current equipment and terminal infrastructure to new needs unexpectedly. This aspect is particularly problematic in the area of security control of persons and luggage. Due to financial and cubature limitations, it is not always possible here to adapt the tasks carried out by airport security services to increased needs by, for example, opening additional security checkpoints. This significantly extends the time necessary for such an inspection. Existing security checkpoints must, in fact, check a much larger number of departing passengers at the same time. The increased number of luggage that security control operators must check in a given time period causes them to work under the influence of time pressure, which may negatively impact airport security and the efficiency of detecting hazardous materials.

In this case, the alternative is using new, certified technological solutions that can significantly speed up the security control process. This option can be envisaged for hand baggage checks. X-ray viewers are used to control this baggage at airports, which allow the operator to analyze the x-ray image of the baggage in detail. The technological development of these devices allows the use of one or two viewers, which undoubtedly positively affects the detection of prohibited items. In addition, if doubts arise concerning the contents of baggage, the ASO performs a manual baggage check to eliminate the risk of transferring an object or prohibited substances to the aircraft. The effectiveness of the control depends on the skills of these employees. Experience relevant training and even the employees' attitude to work are very important here. In addition to analyzing x-ray images and manual control, ASO must also carry out so-called control for contents of trace amounts of explosives in luggage (ETD -explosive trace detection). For this purpose, either an additional specialized device is used or these activities are carried out based on the EDS (explosive detection system) equipped with appropriate software for detecting explosives. Both of these methods differ significantly both in terms of technological advancement and the methodology of security control.

There are three major trends in the research regarding the passenger security control that is used at airport terminals. The first one is related to the scope of control and the perception of the process by the passenger. The second one analyses the capacity of the security checkpoint, or from a wider point of view - the passenger boarding system as a whole, depending on the organization of the security control process. The third one covers the security policy and management of the security control process organization. The actions related to security control are perceived by most passengers as unpleasant and are considered as a sort of nuisance. This sometimes leads to tensions, conflicts and even aggression between the passenger and the SCP (security checkpoint) operator. Gkritza has analyzed the impact of the type and intensity of the taken control actions on the subjective satisfaction of the passenger (Gkritza, K., Niemeier, D., Mannering, F., 2006). Similar studies have been performed by Alards-Tomalin (Alards-Tomalin, D., Ansons, T.L., Reich, T.C., Sakamoto, Y, Davie, R, Leboe-McGowan, J.P., Leboe-McGowan, L.C., 2014). Their study has shown that the type of actions taken at the SCP considerably impacts the subjective sense of security in aviation. It also depends on the level of awareness of hazards present in aviation as well as on cultural or religious background (Rusiłowicz, K. 2011). In general, the results of studies in this field indicate the quite obvious fact that the higher the level of control effectiveness we wish to obtain, the lower the resulting passenger comfort and satisfaction. The results of this study bring the analysis to a higher level. They allow for the selection of such passenger security control system configuration parameters, which will allow for minimizing the nuisance experienced by passengers, therefore, maximizing their satisfaction level while maintaining the assumed security level.

The study, conducted at an international airport, took into account the varying degree of technological sophistication of security screening equipment. In the course of the authors' re-search, the sensitivity in terms of technical changes and technology of work at the security checkpoint to passenger handling time and, consequently, throughput at the checkpoint for passengers and their luggage was examined. The subject of the ba-study was the work of security checkpoint operators at checkpoints equipped with dedicated screening equipment. These stations, however, differed from each other in the type of devices and their number. The checkpoints equipped with newer technology X-ray machines had the ability to analyze the contents of scanned baggage for the presence of explosives. Stations with less technologically advanced X-ray equipment had to be additionally equipped with another device for testing traces of explosives. These solutions impact the number of checked passengers in a given time interval, which largely determines the capacity of the entire airport. The results of the research presented in this paper show in a quantitative way these dependencies, which can consequently influence informed decisions in the area of planned investments at the airport.

The capacity analysis trend is the most developed one and usually applies to registered baggage control (Butler, V., Poole, R.W., 2002), (Leone. K., Liu, R., 2005) and (Leone, K., Liu, R., 2011) or cabin baggage control (Perboli, G., Musso, S., Perfetti, F., Trapani, P.,

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2014) and (Sterchi, Y., Schwaninger, A., 2015). In Hainen's work, the factors influencing the time of the passengers' presence at the SCP were analyzed (Hainen, A.M., Remias, S.M., Bullock, D.M., Mannering, F.L., 2013). Another view of the problem is presented by (Kirschenbaum, A., 2013), who analyzed the individual characteristics of the passenger influencing the capacity of SCP. The obtained results are also important in the first field - the perception of the control system by the passenger. The statistical study of the waiting time at the security checkpoint is presented in (Barros, A.G., Tomber, D.D., 2007), while the model analysis can be found in (Boekhold, J., Faghri, A., Li, M., 2014). The work by Yu (Yu, M.-M., 2010) analyses the effectiveness of the operation of an airport, taking into consideration the processes involving passengers performed in the terminal part of an airport. These processes also include passenger security control. The relationship between how flight safety and aviation security are organized in civil aviation was zanalyzed by Pettersen (Pettersen, K. A., Bjørnskau, T., 2015). Questions related to the proper organization without infrastructure development have been analyzed in (Narciso, M.E., Piera, M.A., 2014). In my study, we assume that in the future, it will be required to jointly analyze the questions of capacity and effectiveness of security control as a multiple-criteria issue. This work is an attempt to provide methods to assess the effectiveness of security controls in the context of ensuring adequate SCP capacity. The subject of the effectiveness of security controls was described in a great degree of detail in (Skorupski, J. and Uchroński, P., 2015) and (Skorupski, J. and Uchroński, P., 2018).When combined with current knowledge about capacity, this opens the route to future multiple-criteria analyses considering the fact that the capacity evaluation may be expressed using numerical (objective) methods while the control system effectiveness evaluation has a linguistic (subjective) character, the analysis methods allowing for the aggregation of both types of evaluation may become useful (Skorupski, J., 2014). The analysis of literature related to managing the security control organization at an airport indicates that there are no useful, practical methods and systems to support airport managers. Attempts are made to develop alternative solutions integrating all types of control to which the passenger and the baggage are subjected (Yildiz, Y.O., Abraham, D.Q., Panetta, K., Agaian, S., 2008). The review of new methods can be found in (Leone K., Liu R., 2005) and (Leone K., Liu R., 2011). An interesting method involves dynamically assigning a threat level to a passenger (Nie, X., Parab, G., Batta, R., Lin, L., 2012) and (Nikolaev, A.G., Lee, A.J., Jacobson, S.H., 2012). Another problem is finding a balance between profiling and screening (Bagchi, A., Paul, J.A., 2014. Optimal Allocation of Resources in Airport Security: Profiling vs. Screening. Operations Research 62, 2013). In the work (Yoo, K.E., Choi, Y.C., 2006), an evaluation of the relative importance of the various factors influencing the effectiveness of passenger control at an airport is presented. The layers in a hierarchical security system will not always combine as straightforwardly as our intuition would suggest, making the evaluation of a layered security effort difficult (Jackson, B.A., LaTourrette, T., 2015). Many authors claim that the human factor is the most important (Skorupski, J. and Uchroński, P., 2016). This research confirms the importance of this factor. However, expanding research with studies of quantitative evaluation of the impact of various criteria on the effectiveness of passenger security control, taking into consideration the other decision variables, has shown that the importance of other factors, such as the frequency of manual controls, is equally important. (Wienenke, M., Koch, W. 2009) suggest a method involving automatic tracking and classification of moving passengers using numerous chemical sensors. This method allows for localizing threats and quickly informing the security control operators. Gerstenfeld and Berger in their paper) suggest a method for selecting the number and type of devices used at a security checkpoint (Gerstenfeld, A. & Berger, P.D., 2011. However Adler, Liebert, and Yazhemsky, in there article (Adler, N, et al. 2013) suggested a method for the evaluation of airports regarding the management methods, which includes, to a certain degree, the effectiveness of security controls but focuses on the generated costs and obtained profits. Security cost analysis is often undertaken in articles in recent years (Gillen, D., Morrison, W.G., 2015) and (Stewart, M.G., Mueller, J., 2014).

Among other research areas directly related to the subject of this study, the computer support offered by electronic systems is also worth mentioning (Michel, Mendes, de Ruiter, Koomen, Schwaninger, 2014). As a result of the increasingly important role of computer systems, it is becoming increasingly important to raise questions regarding their resistance to external, unlawful interference with their structure. This matter has been discussed in the work (Wolf, Minzlaff, Moser, 2014), which indicates the need to intensify the work to better protect modern aircraft against cyber-attacks. In general, the problem of rusting the applied support equipment is analyzed in greater detail in (Kirschenbaum, Mariani, Van Gulijk, Rapaport, Lubasz, 2012). In the study, this problem applies to the evaluation of WTMD effectiveness. The literature review indicates the need to develop a new method for evaluating the effectiveness of passenger security control at an airport. Currently, there is no analysis covering the quantitative relation between the parameters of this process and the ability to effectively detect an attempt to bring a prohibited item onboard an aircraft. The most important factors in such analysis would include the effectiveness of the WTMD, the quality of operator work and the number of manual controls. In each of these fields the human factor plays a considerable role which means that many evaluations cannot be expressed precisely as they have subjective character. The security of civil aviation can be analyzed with the standard risk assessment methods (Tamasi, Demichela, 2011) and (Wong, Brooks, 2015). However, the probabilities are difficult to assess quantitatively, so these considerations are usually conducted at a high level of generality. This was the reasoning behind the proposal to use the hierarchical fuzzy inference mechanism. We refrain from defining the probabilities of the benefit of assessing the efficiency of screening devices using expert judgements. An analysis of this type is not found in the literature, and at the same

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time, it is required as it allows for the rational allocation of equipment and personnel to the tasks by the entity managing an airport. It also allows for specifying the parameters of the existing security control system.

The relationship between gate evaluation and its sensitivity in metal detection, the number of detection areas, the number of visualization areas and the existence of the manual control support system belongs to a category of issues impossible to be objectively assessed in quantity. However, there is a possibility to describe the relationships in a subjective, approximate and qualitative way. Those statements were the basis for using the fuzzy inference systems to solve problems which arose in this work (Siler, Buckley, 2005).

2. Functional solutions for baggage security

The application of a specific solution has consequences in the form of work organization, effectiveness of controls and time necessary to perform the control of a single piece of luggage. In the case of using controls using an additional ETD (Explosive Trace Detection), it is necessary, for example, to dedicate one security control operator to perform this activity. Otherwise, an employee performing security checks on persons and baggage is forced to stop the security check point for the duration of the ETD check. This is important for the liquidity performed at the occupational safety control point and, thus, for the capacity of this security control point. Additionally, such work organization may adversely affect the effectiveness of controls due to an increased number of possible errors made by a security control operator distracted while performing additional activities.

By following the models of solutions used in this field at individual airports, we can distinguish the following configurations of hand luggage security control organization:

1. A dedicated security checkpoint to which passengers selected by a randomizing system for additional baggage screening are directed. At such a security checkpoint, passengers' baggage directed to this GDP undergo an additional checking procedure for the presence of trace amounts of explosives in the baggage.
2. The ETD device check is carried out on each passenger and carry-on baggage screening line. In this configuration, the baggage selection is carried out separately at each security checkpoint. This solution requires the provision of an adequate number of ETD devices and personnel to carry out the above-mentioned activities.
3. Hand baggage security checkpoints are equipped with a device that meets the requirements of the so-called C2 standard parameterized in detail in classified civil aviation security regulations. Such an X-ray is equipped with EDS that meets the above-mentioned C2 standard. Its possession means that the device, without the security control operator's participation can detect hidden explosives hidden, e.g. in generally available electronic equipment such as a portable computer or camera. This is an important function that such electronic devices can be transported in a passenger's hand luggage, and detecting an explosive in such a complex apparatus is extremely difficult. Not without significance for the operation of the airport is also the fact that the C2 standard significantly reduces the need to use an additional device to control trace amounts of explosives. This standard significantly affects the organization of the entire area dedicated to checking hand luggage. This specialized software implemented in x-ray devices indicates to the security control operator potentially suspicious areas and marks them graphically on the monitor screen. This is a great convenience for the operator of the security check. He can then focus all his attention on the suspicious object or substance and take specific verification actions in relation to the item of baggage.

3. Results of the research

When analyzing the configurations mentioned above of hand baggage control solutions, consideration should also be given to assessment criteria such as check time, effectiveness, throughput or financial factor. The effectiveness of security checks will be considered here in the context of both the quality of tasks performed by ASO (Airport security operator) but also the sensitivity of changing the frequency of hand luggage being subjected to additional ETD control. The frequency of baggage typing for additional security checks is classified information, so data in this area is not available to the public. This solution aims to increase the likelihood of detecting the presence of explosives in luggage, thus increasing the safety of flight operations. Therefore, for the purposes of this work, we assumed four different percentages of the luggage typing frequency. Based on tests carried out at the Katowice International Airport at the security checkpoints of persons and baggage, it was found that, on average, about two pieces of luggage (two containers) per passenger, while the average hourly throughput at one security checkpoint is about 100 passengers per hour which gives a total result of 240 pieces of hand luggage that are subject to control in the standard mode, i.e. without additional activities related to control by means of ETD devices. These assumptions were also adopted for the purposes of analyzing the security checkpoint configuration, taking into account the need to carry out additional checks on hand luggage for detection of trace amounts of explosives. To this end, MPL Katowice carried out tests with the participation of ASO, during which the average time necessary for the operator to carry out baggage security checks were calculated, both in the standard mode and

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in the additional ETD mode. The tests were carried out in real conditions during the control carried out by the security control operators with full control point occupancy. As a result of the research, it was determined that the time of checking hand luggage in standard mode is, on average, about 15 seconds, which reflects the accepted number of checked luggage in one hour in the amount of 240 pieces of luggage per hour. On the other hand, the time needed to check the safety of hand luggage with the use of additional devices for testing trace amounts of explosives is approximately 30 seconds. At the same time, these activities resulting from the legal obligation necessitate the use of such a configuration of controls at security passes, which on the one hand, takes into account the requirement of additional ETD control, and on the other hand, ensures that activities are carried out in this area smoothly.

1. Variant

The first variant concerns a situation where we have a dedicated security checkpoint for checking passengers and baggage selected and selected for ETD checking.

Table 1. Performance analysis of the security control point dedicated to ETD control

Variant for 240 items of baggage / h – one passenger has, on average, two items of luggage					
No.	**Measured factor**	**Measurement results**	**Measurement results**	**Measurement results**	**Measurement results**
1.	Percentage of baggage selection for ETD control	5.00	10.00	15.00	20.00
2.	Number of items of baggage selected for ETD inspection	12	24	36	48
3.	Time [sec] of inspections of baggage selected for inspection	1800	3600	5400	7200
4.	Effectiveness / probability of selecting a person with suspicious baggage [b/h]	10.00	15.00	25.00	30.00
5.	Checking time [sec] per item of baggage / average /	30			
6.	Baggage inspection time [min]	30	60	90	120
7.	Capacity / baggage flow SCP from ETD [b/h]	120			

Source: Authors' own study.

This configuration requires that this security checkpoint is equipped with at least one ETD device. Passengers whose luggage has been selected for additional control are directed to the marked point, while the remaining passengers go to the standard security check at subsequent positions. This option requires, in addition to completed standard activities, providing an additional person for ETD control. For the purposes of analyzing the time of baggage inspection with the use of the ETD device at a dedicated security checkpoint, four percent values were adopted to determine the frequency of baggage sampling for this check. These are 5%, 10%, 15% and 20% of the total number of luggage items that go through the RTG device in the standard control mode (240 items). Obviously, the more luggage drawn, the more time this control will take. An interesting observation, however, is that in such a system, after security control, a dedicated control station's capacity is exhausted only after reaching 120 pieces of luggage per hour. This value can be reached if 10% of baggage is checked.

It can also be seen that compared to standard hand luggage control, ETD control is twice as slow. The question then arises as to how the presented system affects the overall throughput of security checks at all security checkpoints in the terminal. Terminal A at MPL Katowice is equipped with six security control points, one of which is dedicated to ETD control. Based on the earlier assumptions, it should be stated that within one hour, this terminal is able to inspect a total of about 1320 pieces of luggage. This result is influenced by the fact that five security control stations work in the standard mode, reaching a throughput of 240 bags per hour, and only one ETD station reaches a throughput of 120 bags per hour. Not without significance for a particular configuration of a security checkpoint is also its impact on the assessment of the effectiveness of tasks carried out by security check operators. To this end, research was carried out with the participation of employee experts dealing with the daily security and supervision of persons and luggage. The employees had to assess the effectiveness of the adopted solution, taking into account the effectiveness of the device itself and the likelihood of detecting explosives hidden by the passenger in the luggage. The results of the tests are presented in Table 1. As you can see, the assessment of the effectiveness of the detection of explosives at a random selection of checked baggage is quite high. This is due to the fact that although the vast majority of luggage is sent for standard inspection

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where the luggage is not verified for the content of trace amounts of explosives, they are thoroughly analyzed by experienced and properly trained security control operators. Operators are required to perform inspections to detect hazardous materials and substances, and their qualifications in this area are confirmed by an official certificate issued by the Civil Aviation Office. However, one should bear in mind the very large impact of the human factor, which in the presented model significantly determines the level of effectiveness of performed security control. This factor was taken into account when assessing the effectiveness of the work of the security control operator in the article (Skorupski, Uchroński, 2015).

2. Variant

An alternative to the above-proposed configuration from the hand baggage security check is to equip all six seats with the option of hand baggage control using the ETD device. To make this possible, it is necessary to equip the security checkpoint station with appropriate hardware infrastructure. In this system, several solutions are practiced that significantly affect the throughput of a given control point. Due to the randomness of baggage control, the device may be designed to control randomly selected baggage at two security checkpoints. This solution significantly reduces the costs associated with the purchase of equipment, while if it is necessary to check luggage selected for screening at two security checkpoints at the same time, it will be necessary to suspend the work of one station. It is also possible to provide in the presented configuration the possibility of equipping each security checkpoint with a dedicated ETD device. This solution eliminates the problem described above but generates a significant cost in the form of additional devices. The research, based on the assumptions that, among others, the expected throughput of hand baggage security should be as close as possible to the one where the check is performed in standard mode, shows the high sensitivity of a single checkpoint to any changes in the frequency of baggage selection for additional check ETD. Detailed information in this regard is presented in Table 2.

Table 2. Performance analysis of security control points equipped with ETD devices

Variant for 6 SCP / 240 baggage / h					
No	**Measured factor**	**Measurement results**	**Measurement results**	**Measurement results**	**Measurement results**
1.	Percentage of baggage selection for ETD control	5.00	10.00	15.00	20.00
2.	Number of items of luggage selected for ETD inspection	12	24	36	48
3.	Checking time per item of baggage / average /	30			
4.	Time [sec] of inspections of baggage selected for inspection	360	720	1080	1440
5.	Effectiveness/probability of selecting a person with suspicious baggage [%]	50.00	70.00	80.00	70.00
6.	Total time of standard screening 240 items of baggage and ETD on one SCP [sec]	3780	3960	4140	4320
7.	Time to check 240 pcs of baggage with additional ETD check is [min]	63	66	69	72
8.	The capacity /SCP flow is [b /h]	228.5	218	208.6	200

Source: Authors' own study.

As you can see, the difference in the time needed to check hand baggage varies depending on the number of checked luggage items, with an additional check from 5% to 17% compared to the time of checking in standard mode. For 6 GDP, the number of all luggage checked using both ETD in what standard mode will be 1368 pieces and 1200 pieces of luggage, respectively.

Similarly to the first option, a study was also conducted to assess the effectiveness of security control carried out by ASO in such a configuration of GDP. As we can see in Table 2, this assessment is completely different from the one presented earlier. Although the amount of luggage subjected to additional control is identical, luggage selection takes place at all GDP and checks are carried out by different ASO, which increases the sense of security and efficiency of the tasks performed. At the same time, ASO respondents indicated that they feel there is a greater likelihood of detecting substances prohibited for transport in the case of the control points configuration described above. It is a solution based on selecting baggage for ETD control directly before each GDP, which also causes a sense of increased unpredictability of random baggage selection.

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3. Variant.

The next analyzed model is the control of hand baggage security using an X-ray equipped with dedicated software to detect the presence of explosives in luggage. This solution allows for limiting ASO activities to responding to alarms generated by the system in case of detection of suspicious substances. The operator is then required to explain and confirm the legitimacy of the alarm generated by the device. Notwithstanding the above, such an X-ray works in a continuous mode as a standard RTG device, which means that the duration of this control is the same as in the case of standard control, and the response time to the device alarm is comparable with the control using the ETD device. In this configuration, we are dealing with a situation where 100% of hand baggage is subjected. In addition to the analysis made by the operator, to automatic analysis for the presence of explosives in the luggage. Here you should pay attention to the number of alarms generated by this system. The research shows that as much as about 25% of all checked luggage within one hour is luggage marked by the system as suspicious and requiring analysis by the operator. It should be noted that the system means in the x-ray image only those places requiring special attention from the operator.

This is because many times, the permitted objects or substances carried by passengers resemble those prohibited for transport with their color, density and even shape. However, the research showed that although the system indicates as much as 25% of luggage for analysis by the operator, the vast majority of these alarms can be dealt with by analyzing the image made by the operator as part of the standard hand luggage assessment. In order to estimate the number of alarms generated and assess the impact of security controls implemented in such a configuration on the airport's operational capabilities, detailed tests were carried out, the result of which is presented in Table 3.

Table 3. The results of the assessment of the implementation of Variant No. 3

3. Variant of checking 240 items of luggage using the EDS X-ray with the C2 standard					
No	**Measured factor**	**Measurement results**			
1.	Percentage of baggage subject to explosive detection analysis	100.00			
2.	Alarm percentage C2 / average	25.00			
3.	Baggage selected for verification by ASO (number of items)	60			
5.	Additional control using ETD (required number of items)	2			
6.	Time to verify the image of the x-rayed baggage [sec]	15			
7.	Time of additional control using ETD [sec]	30			
8.	Effectiveness / probability of selecting a person with suspicious baggage [%]	100.00	90.00	95.00	100.00
9.	Total control time on one SCP with the C2 standard [sec]	3630			
10.	Time to check 240 pcs of baggage with additional ETD check is [sec]	3650			
11.	The capacity / baggage flow is [b / h]	238			

Source: Authors' own study.

As we can see, unlike the previous solutions, there is no draw, typing luggage for additional control using the ETD device. The system automatically analyzes all overexposed luggage in terms of explosives. During the tests carried out among 25% of marked luggage for additional analysis by the operator, only two pieces of luggage out of 60 required the use of an external ETD device or manual control. This is due to the fact that ASO is able to perform a flawless verification of the luggage contents by analyzing the image of the x-rayed luggage. The EDS-C2 system reacts even to the smallest probability of the contents of luggage prohibited in transport.

The implementation of automation in the field of detection of explosives also positively affects the assessment of the effectiveness of the hand luggage control system. The security control operators highly rated the effectiveness of detecting a dangerous substance in the passenger's luggage. This is undoubtedly related to the fact that 100% of x-rayed luggage is analyzed for the content of explosives. You can also see the great trust of operators in implementing automated solutions based on new technologies. The analyzed configuration also showed that considering all aspects related to baggage security, including ETD control, as much as 1 428 pieces of luggage can be checked per 6 GDP per hour, which means that this value practically coincides with the time of the standard check.

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4. Conclusions

The presented proposals for solving the problems related to the implementation of new security standards to the existing terminal infrastructure, and thus to existing models of the organization of staff work, are universal and can be used at any selected airport. They take into account not only the restrictions resulting from the level of sophistication of the equipment dedicated to baggage security but also, equally important, the volume of passenger traffic. This means that these solutions can be implemented at airports with varying demands for a single GDP capacity and adapted to the airport's financial capabilities.

It should also be noted that there is high sensitivity in terms of assessing the effectiveness of baggage security checks depending on the chosen solution. This subjective feeling of higher efficiency of performed tasks is not always correlated with objective premises resulting even from statistical data. However, this work shows an interesting relationship between elements related to the human factor and the discipline of science, psychology. It turns out that the security check with the use of ETD performed in one dedicated place is assessed slightly less than the same check performed with the same frequency but carried out proportionally at all security checkpoints. An important element from the point of view of the effectiveness of the tasks carried out by ASO is also the fact that the automation of the process has a positive effect not only on the time of control but also allows you to maintain the required quality of tasks. In addition, the control options presented above show that a flexible approach to the organization of the work of security personnel is possible while taking into account objective premises resulting from the current financial capabilities of the airport or restrictions related to the infrastructure of the terminal. This relationship is also closely related to the varying needs of the airport for additional control equipment. The presented methods of work organization take into account this possibility. For example, the first option of screening your carry-on baggage is reasonable if you implement a maximum of 10% of additional checks for detecting traces of explosives in your luggage, and in addition, its implementation depends on the total number of security checkpoints. The research also shows the consequences of implementing a specific variant of the organization of security controls using ETD devices for a single GDP throughput. The simulation in this area was carried out for individual variants assuming that the security check using ETD devices is carried out with a frequency of a maximum of 10%. The hourly GDP throughput in this situation is as it was shown in Table 4.

Table 4. Results of SCP capacity depending on the variant of organization of security controls.

Measured factor	Variant 1	Variant 2	Variant 3
Capacity [b/h]	120	218	238

Source: own study.

An interesting observation is also the fact that the first option, which has the most restrictions related to the possibility of additional ETD controls, in summary, terms shows a similar capacity of security checkpoints to the fully automated option 3. This confirms a certain universality of the application of a particular control option at airports and, at the same time, provides the basis for adopting the assumption that the direction of the development of thematic and IT systems is right for use in the security control process at civil airports.

Declaration of interest – The authors declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article

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