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An Analysis of the Cabin Baggage Security Screening Process Incorporating Automation Elements

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ABSTRACT

The existing regulations impose the obligation to perform random cabin baggage security screening for the presence of traces of explosives (explosive trace detection, ETD) at airports. As a result, a problem arises in relation to the proper organization of security screening checkpoints and the provision of telematic devices used to facilitate the process. The study considered three options a) a dedicated ETD checkpoint, b) ETD screening in all security checkpoints, c) equipping all checkpoints with an explosive detection system (EDS). The purpose of the paper is to propose a mathematical model and conduct a practical evaluation of options concerning security checkpoint modernization in terms of the following criteria: capacity, cost, and efficiency of detecting prohibited substances. An independent evaluation was conducted on the basis of the criteria, considering the analysis of the actual inflow of baggage in individual security checkpoints and the annual costs of equipment and staff, while the efficiency of screening was subjectively evaluated by experts. The proposed mathematical model and the established calculation tool were used to evaluate the options of security checkpoint organization at Katowice Airport. As a result of the conducted analysis, option c) was recommended. This solution showed the best results in terms of capacity and efficiency and generated medium costs.

KEYWORDS: airport management, security screening, air transport safety and security, explosive detection system, explosive trace detection

1. Introduction

Airport operators are obliged to ensure the necessary terminal infrastructure and proper work organization of all airport services in order to enable a timely start of all airport operations. This is becoming more and more difficult in the era of the constant surge in air traffic. It is therefore imperative that airport operators and individual services are aided by different telematic systems.

One of the preparatory stages in air transport, where the use of telematic solutions is especially important, is the mandatory screening of passengers and baggage. Its purpose is to detect and eliminate objects which may be used to commit broadly defined acts of unlawful interference [4]. The procedure is performed by screeners certified by the Civil Aviation Authority. Their activities are conducted with the use of methods specified in legal acts on civil aviation security [2].

The subject of this paper is cabin baggage security screening [6]. Regulations impose the obligation to perform random cabin baggage security screening for the presence of traces of explosives (explosive trace detection, ETD). These activities concern a small number of passengers but are relatively lengthy and, in addition, ETD equipment is rather expensive. As a result, a problem arises in relation to the proper organization of security screening checkpoints and the provision of telematic devices used to facilitate the process on site, which will lead to achieving the required efficiency and maintaining the appropriate capacity of the passenger service system.

The problem is vital, considering that usually the dynamics of increasing air traffic necessitate quick responses. For example, in 2017 Polish airports observed an increase of 18% in the number of checked-in passengers as compared to 2016 [1]. Still, all investments are scheduled considering airport development plans which are ongoing or forecast for the next several years. Although unexpected for the airport operator, the need to adjust the current hardware and terminal infrastructure to current needs makes it necessary to apply ad hoc measures, such as opening additional security screening checkpoints or providing them with modern screening technology.

2. Cabin baggage security screening

2.1 Types and scope of screening

Security screening is performed both in the case of persons and baggage carried by passengers [3]. Considerable attention is given to cabin baggage screening, as it may be used to hide prohibited items and substances. The procedure is extremely significant, because passengers have direct access to their cabin baggage on board a plane.

Several different methods of cabin baggage screening have been devised, each characterized by different operating rules and distribution of tasks between humans and automatic support systems. The methods evolve in time, along with legal requirements on their application and technology of the employed equipment. The most popular screening methods include:

- hand search – direct search of baggage contents;
- explosive detection dogs;
- X-ray equipment, which enables scanning baggage contents remotely – the image is transmitted to the screener's station for examination;
- explosive detection systems (EDS), which usually automatically recognizes the image of baggage contents and assigns baggage to a security class;
- explosive trace detection (ETD) equipment, which conducts a chemical analysis of samples to detect particles characteristic for explosives.

Not all the above methods are used at the same time. Cabin baggage screening usually involves X-ray equipment and a hand search. Additionally, since 2015, randomly selected items of baggage are screened using ETD equipment [2].

2.2 Telematic security screening support

Airport security screening system is a complex anthropotechnical system aimed at preventing acts of unlawful interference at airports and during flight. This objective may be achieved upon the implementation of numerous tasks, such as access control, baggage contents analysis, and control of persons entering or leaving the security restricted area. The key tasks are carried out by screeners, who are usually under time pressure, as they strive to maintain timeliness of airport operations despite a large number or passengers who require service.

Apart from screeners' knowledge and skills, the process relies on telematic screening support systems. The systems include a large range of equipment interconnected by secure transmission networks and using advanced IT solutions. Usually, the systems provide support for screeners in the following aspects:

- access control within the security restricted area where security screening of persons and baggage takes place; boarding pass scanners with integrated databases are used to verify a person's authorization to remain in the restricted area,
- verification of cabin and hold baggage; scanners on different levels of technological development are used to enable viewing baggage contents on the screener's display,
- automatic recognition of objects prohibited in passenger baggage; the main feature of such systems is their smart software sourcing data from a baggage image received from a scanner,
- detecting prohibited items on passengers; WTMD (walk-through metal detecting) equipment and scanners which use non-ionizing radiation and can detect metallic and non-metallic objects are used,
- verifying authorisations of airport staff; ID card scanners and databases are used to verify an employee's authorization to remain in an area and perform operations,
- providing training; advanced simulators enable screeners to raise their qualifications in conditions as like the reality as possible.

2.3 Research problem

As indicated above, there is a need to adjust the existing airport infrastructure to legal requirements which impose security screening of cabin baggage and passengers using ETD equipment. Because of the extended screening time resulting from its use as well as the cost of the devices, an analysis of consequences following the implementation of infrastructural solutions is required, especially as regards the capacity of the entire cabin baggage screening system and the costs and efficiency of screening.

Laws on screening performed with the use of ETD equipment define the percentage of passengers who must undergo such a procedure. Alternatively, they allow the use of EDS equipment, consisting of an X-ray scanner and dedicated software which enables remote detection of hazardous substances. The software uses advanced image recognition algorithms and automates the process, thus to a large extent eliminating the human factor.

The research problem investigated in this paper is the evaluation of the available options of infrastructure organization as regards cabin baggage screening checkpoints. The following options should be taken into consideration:

1. Defining a dedicated security screening checkpoint to which passengers carrying cabin baggage subject to ETD screening are directed. This requires pre-selecting passengers for additional security screening of cabin baggage by a drawing system. At such a security screening checkpoint, all passenger baggage pieces

undergo an additional security screening procedure for the presence of traces of explosives.

2. Screening using ETD equipment is performed in all security screening lines. The configuration involves independent selection for additional screening in each security screening checkpoint. This solution requires an appropriate number of ETD devices and personnel to ensure the performance of the above activities.
3. Cabin baggage security screening checkpoints are equipped with an X-ray scanner and an automatic remote image recognition explosive detection system (EDS). They are used interchangeably with ETD equipment, depending on the compliance with the so-called C2 standard, specified in classified regulations on civil aviation. They enable the detection of explosives hidden, for example, inside widely accessible electronic devices, such as laptops or cameras. This function is considered crucial because such electronic devices may be transported in cabin baggage, while detecting an explosive device hidden in such complex systems is extremely difficult.

3. Security screening checkpoint evaluation method

A security screening checkpoint should be evaluated in terms of at least three criteria – capacity, cost and screening efficiency. At this stage of research, we will present a detailed capacity analysis, with the remaining two criteria specified as estimates only. Additionally, each of the criteria will be analyzed separately. A joint, multi-criteria analysis involving a more accurate specification of costs and efficiency is planned at a future stage. We will consider three work organization and screening checkpoint equipment options defined in section 2.3. We assume that traffic is so intense that passengers are constantly approaching the security screening checkpoint. Under such conditions, a capacity analysis will comprise the following stages:

- empirically defining the time of performing individual screening procedures (standard, using ETD and using EDS) and the number of baggage pieces to be screened,
- specifying the number of baggage pieces screened using different methods,
- calculating the expected time of a screening procedure at a screening checkpoint,
- determining the average capacity of a screening checkpoint.

The cost evaluation of the proposed solutions will be conducted by estimating the expenditures necessary to provide the required equipment and screeners to all security screening checkpoints. The cost will be expressed as an annual amount, assuming that the equipment is in operation for five years on average. The presented calculations concern only the comparable part of costs, excluding, for example, the cost of training, electricity consumption or routine maintenance.

The efficiency analysis will be based on an expert knowledge. A study involving experts – employees who perform security screening of persons and baggage or supervise this area of airport operation – was conducted for this purpose. The employees were asked to evaluate the efficiency of the implemented solutions by subjectively determining the usefulness of a given option in ensuring security as regards the detection of explosives hidden in baggage. The assumption is that the ETD and EDS equipment is 100% effective.

The proposed model and a calculation tool will be used to evaluate the organization of security screening checkpoints in Katowice Airport. We will examine the frequency of selection for screening using ETD in each solution. This value is classified. For this reason, four different percentages of baggage selection were assumed.

3.1 Option 1 – a dedicated ETD screening checkpoint

The first option concerns situations with a screening checkpoint dedicated to screening passengers and baggage selected for ETD screening. Under this option, the selection of baggage for ETD screening must be performed in a place where the stream of passengers is divided into separate checkpoints.

The following symbols are used:

τ_d – the average time of security screening using ETD equipment,

τ_g – the average time of standard security screening using an X-ray scanner,

n – the number of open security checkpoints,

λ – the average number of passengers to be screened within an hour,

w – the average number of baggage pieces per passenger,

η – the percentage of baggage screened using ETD,

The maximum number of baggage pieces to be handled at the dedicated ETD screening checkpoint is expressed as

$$c_d=(\tau_d+\tau_g)^{-1}\cdot 3600 \quad (1)$$

The actual inflow of baggage to a designated checkpoint equals

$$b_d=\lambda\cdot w\cdot\eta \quad (2)$$

Similarly, the maximum number of baggage pieces to be handled at each of the remaining screening checkpoints operating in the standard mode is

$$c_g=\tau_g^{-1}\cdot 3600 \quad (3)$$

while the actual average inflow of baggage at these checkpoints equals

$$b_g=\frac{\lambda\times w\times(1-\eta)}{n-1} \quad (4)$$

The capacity analysis of this option consists in testing the following conditions

$$b_d\le c_d \quad (5)$$

$$b_g\le c_g \quad (6)$$

As regards the cost, the following symbols are used:

p_g – the estimated price of an X-ray scanner,

p_d – the estimated price of an ETD device,

p_s – the estimated price of a C2 compliant EDS device,

p_w – hourly cost of a screener,

l_g – the number of screeners employed at standard screening checkpoints equipped with X-ray scanners,

l_d – the number of screeners employed at ETD screening checkpoints,

l_s – the number of screeners employed at screening checkpoints equipped with an EDS device.

Option 1 requires only one ETD device and traditional X-ray scanners. Assuming that the airport is open for 16 hours a day, the estimated annual cost of this option is

$$P_{W1}=1/5\ (n \cdot p_g+p_d)+(n \cdot l_g+l_d) \cdot 16 \cdot 365 \cdot p_w \quad \textbf{(7)}$$

The evaluation of explosive detection efficiency is conducted by experts, is subjective in nature and concerns conditions observed at an airport. Therefore we do not present general formulas for Option 1, but instead describe evaluation results for Katowice Airport in section 4.2.

3.2 Option 2 – ETD screening in each line

Under Option 2, all screening checkpoints are equipped with ETD devices. In this case, all checkpoints are functionally the same and perform both screening procedures. We will call them versatile screening checkpoints. The selection of passengers and cabin baggage for ETD screening may be carried out when a passenger is passing through WTMD equipment.

The capacity of a versatile screening checkpoint is

$$c_v=[\eta \cdot (\tau_d+\tau_g)+(1-\eta) \cdot \tau_g]^{-1} \cdot 3600 \quad \textbf{(8)}$$

The actual inflow of passengers at a single screening checkpoint in Option 2 equals

$$b_v = \frac{\lambda \cdot w}{n} \quad \textbf{(9)}$$

Similarly to the previous case, the capacity condition is expressed as

$$b_v \leq c_v \quad \textbf{(10)}$$

As regards the cost, Option 2 requires ETD devices and traditional scanners, and employees at each screening checkpoint. Therefore, the estimated annual cost of this option is

$$P_{W2}=1/5n(p_g+p_d)+n(l_g+l_d) \cdot 16 \cdot 365 \cdot p_w \quad \textbf{(11)}$$

The results of the expert efficiency evaluation under this option are presented in section 4.3.

3.3 Option 3 – automatic ETD screening

Option 3 features X-ray scanners equipped with EDS software which enables automatic, smart detection of explosives in baggage. This solution provides fully remote screening and limits screeners' activity to responding to alerts generated by the system upon the detection of a suspicious substance. We will refer to such checkpoints as automatic screening checkpoints.

When EDS classifies baggage as free from explosives, the screening time is quite short and is limited to the time of the baggage passing through the scanner. However, if an alarm indicating a possible presence of explosives is generated, the system identified areas which require the screener's special attention in the baggage image. In such a case, the empirically measured average screening time is longer – the screener analyses the image thoroughly and sometimes performs a hand search.

Usually, the above actions allow the screener to eliminate any doubts as to baggage safety. Still, there is a percentage of situations where a sample must be taken and analyzed using ETD equipment.

The following symbols are employed, in addition to those used in previous sections:

- the percentage of baggage marked as safe by EDS,
- the average automatic screening time of baggage marked as safe,
- the average screening time of baggage for which EDS triggered an alert and identified areas to be checked,
- the percentage of baggage selected by EDS for additional checking by the screener, where the standard screening procedure was insufficient, and samples must be taken for an ETD analysis.

The capacity of an automatic screening checkpoint is

$$c_a=[\vartheta \cdot \tau_0+(1-\vartheta) \cdot (\tau_a+\gamma \cdot \tau_e)]^{-1} \cdot 3600 \quad \textbf{(12)}$$

The actual inflow of passengers at a single automatic screening checkpoint in Option 3 equals

$$b_a = \frac{\lambda \cdot w}{n} \quad \textbf{(13)}$$

therefore, the capacity evaluation will be based on testing the following condition

$$b_a \leq c_a \quad \textbf{(14)}$$

As regards the cost criterion, Option 3 requires as many EDS scanners as there are screening checkpoints, i.e. , and one ETD device, so screeners have to be employed at each screening checkpoint, while employees are necessary to operate ETD equipment. Therefore, the estimated annual cost of this option is

$$P_{W3}=1/5(n \cdot p_s+p_d)+(n \cdot l_s+l_d) \cdot 16 \cdot 365 \cdot p_w \quad \textbf{(15)}$$

The results of expert efficiency evaluation under this option are presented in section 4.4.

4. Application of the method at Katowice Airport

4.1 Empirical establishment of system operation parameters

Measurement campaigns were performed in June and July 2018 at security checkpoints at Katowice Airport. The measured values included the time necessary for a screener to screen baggage in the standard mode and with additional ETD screening. The study was conducted under actual operating conditions, during screening performed by screeners at full traffic rate.

The measurement campaign results indicated that one passenger carries more than two pieces of baggage on average, and more specifically uses 2.4 containers with cabin baggage and small items worn on the body or carried in pockets, such as keys, watches, belts. The average screening time of one container in the standard mode, excluding additional ETD screening activities, is 15 seconds. The average screening time of cabin baggage when additional ETD equipment is used is also about 15 seconds. In the case of EDS screening used in Option 3, about 75% of baggage is classified by the system as safe (free from explosives). In such cases, the screening time is very short and equals about 6 seconds. Nonetheless, 25% of baggage triggers an EDS alert indicating the need for an additional check. In such cases, the screener deactivates the alert by analyzing the image or performing a hand search. This phase takes about 40 seconds on average.

4.2 Option 1

The calculation formulas described in section 3.1 were used to evaluate Option 1 of the solution to the issue of introducing random screening of cabin baggage for the presence of explosives. Calculations were based upon the following input:

- the average time of security screening using ETD equipment τ_d=15,
- the average time of standard security screening τ_g=15,
- the number of open security checkpoints *n*=6 (Terminal A, Katowice Airport),
- the average number of passengers to be screened within an hour λ=*500*,

As there is no possibility to publish the percentage of baggage screened using ETD equipment, our calculations included parameter *η=5%,10%,15%,20%*. The results are listed in Table 1.

Under this screening option, assuming the passenger inflow of λ=500 persons per hour, a dedicated ETD checkpoint is a bottleneck. The limit frequency of selecting baggage for ETD screening at which the option can continue to function is 10%. The standard security checkpoints maintain spare capacity both below as well as above this value.

Table 1. The capacity of the screening system under Option 1 [own work]

	η=5%	*η=10%*	*η=15%*	*η=20%*
ETD checkpoint capacity c_d	120			
Standard checkpoint capacity c_g	240			
Actual inflow at the ETD checkpoint b_d	60	120	180	240
Actual inflow at the standard checkpoint b_g	228	216	204	192

Fig. 1 shows the correlation between the number of passengers served by both types of checkpoints and the frequency of selection for ETD screening in more detail.

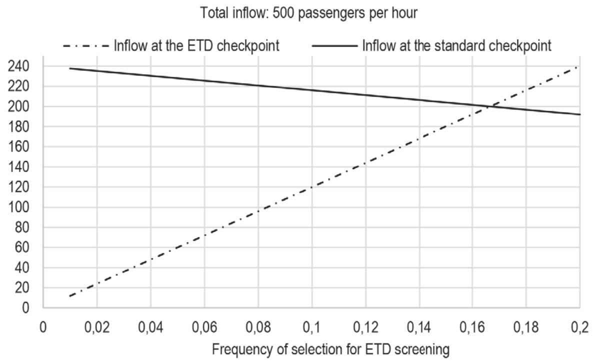

Fig. 1. The dependence of the number of bags handled at a security checkpoint and the frequency of ETD screening [own work]

At the same time, Fig. 2 illustrates the same correlation, taking into account a 20% increase in passenger inflow, corresponding to the approximate increase observed between 2016 and 2017. Fig. 2a presents the results for six security checkpoints, while Fig. 2b – for seven.

A 20% increase in traffic means that 600 passengers must be served in an hour. It may, therefore, be seen (Fig. 2a) that providing service to such a number of passengers is impossible with six security checkpoints. Owing to the capacity of the ETD security checkpoint, condition (5) defines the maximum frequency of screening of about 8.5%. On the other hand, due to the capacity of the standard security checkpoints, condition (6) defines the minimum frequency of screening at the level of about 17%. As can be observed, there is no possibility to handle the planned traffic at any ETD screening frequency.

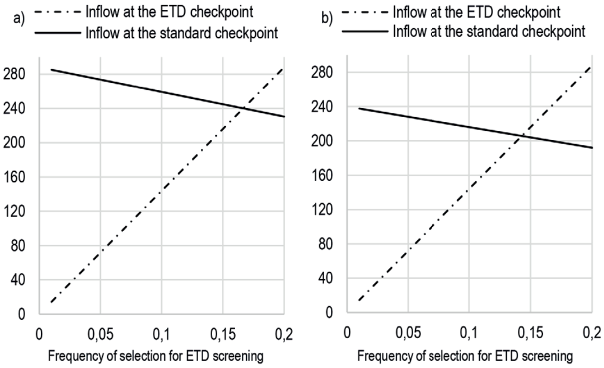

Fig. 2. The dependence of the number of bags handled by security checkpoints and the frequency of ETD screening during a 20% increase in traffic, a) 6 checkpoints, b) 7 checkpoints [own work]

Opening an additional security checkpoint solves the problem. As proved by the results illustrated in Fig. 2b, the screening system satisfied both capacity conditions (5) and (6) for screening frequency below 9%. Another issue is whether 9% is a sufficient frequency and whether another checkpoint can be opened, taking spatial conditions into consideration.

Using formula (7) and taking into account the current equipment prices and the hourly cost of a screener at Katowice Airport, we can estimate that the annual cost of Option 1 is about EUR 450,000. The cost of equipment makes up about EUR 90,000 of this amount, while the cost of screeners – about EUR 360,00.

The results of the expert evaluation regarding the efficiency of detecting explosives under Option 1 are presented in Table 2.

Table 2. The efficiency of the screening system under Option 1 [own work]

	η=5%	*η=10%*	*η=15%*	*η=20%*
Subjectively defined usefulness of the option in ensuring safety [0,1]	0.45	0.55	0.65	0.75

The evaluation of the solution under Option 1 is not very favorable and depends on the percentage of baggage undergoing ETD screening. When expressed as a numerical value, it is obviously higher than the said percentage, as all bags are normally analyzed by trained screeners, also for the presence of explosives. However, the vast majority of baggage undergoes only standard screening, without any verification related to the detection of traces of explosives with the use of ETD equipment. This is the reason for the relatively low evaluation results. Such a method does not guarantee that explosives hidden, for example, in electronic devices will be detected. We should assume that a person attempting to commit a terrorist act knows how to use such weak points. Moreover, the option is to a large extend based on a human factor which determines the level of efficiency of the performed procedure. The factor was taken into account during the evaluation of screener efficiency in [5] and [7].

4.3 Option 2

The calculation formulas described in section 3.2 were used to evaluate Option 2 of the solution to the issue of introducing random screening of cabin baggage for the presence of explosives. The calculations were based on the same input as under Option 1. Similarly, our calculations included parameter $\eta=5\%,10\%,15\%,20\%$. The results are listed in Table 3.

Table 3. The capacity of the screening system under Option 2 [own work]

	$\eta=5\%$	$\eta=10\%$	$\eta=15\%$	$\eta=20\%$
Versatile checkpoint capacity c_v	229	218	209	200
Actual inflow at the versatile checkpoint b_v	200			
Actual inflow at the versatile checkpoint b_v with traffic increased by 20%	240			

As is clearly visible, it is much easier to conduct screening with passenger inflow reaching $\lambda=500$ persons per hour under Option 2. For any given frequency n of selection for ETD screening, capacity of the checkpoint is higher than passenger inflow. Unfortunately, as demonstrated in Option 1, when traffic increases by 20%, there is no possibility to serve all passengers, because regardless of parameter n the capacity of the checkpoint is smaller than the influx of passengers. Once again, the problem may be solved by opening an additional checkpoint.

Using formula (11) and taking into account the current equipment prices and the hourly cost of a screener at Katowice Airport we can estimate that the annual cost of Option 2 is about EUR 740,000. The cost of equipment makes up about EUR 130,000 of this amount, while the cost of screeners – about EUR 610,00.

The results of the expert evaluation regarding the efficiency of detecting explosives under Option 2 are presented in Table 4.

Table 4. The efficiency of the screening system under Option 2 [own work]

	$\eta=5\%$	$\eta=10\%$	$\eta=15\%$	$\eta=20\%$
Subjectively defined usefulness of the option in ensuring safety [0,1]	0.65	0.75	0.85	0.95

It appears that Option 2 was evaluated as more efficient that Option 1. Even though the number of bags selected for additional ETD screening is actually the same, the very fact that baggage is selected for screening at all checkpoints and that the procedure is conducted by different screeners gives rise to a higher feeling of security and efficiency of performed activities. This is due to a higher unpredictability rate of random selection for additional screening.

4.4 Option 3

The calculation formulas described in section 3.3 were used to evaluate Option 3. In this case, there is no need to randomly select baggage for additional ETD screening. All scanned pieces of baggage are automatically analyzed for the presence of explosives.

All parameters concerning time and number of passengers approaching checkpoints per hour are the same as under Option 1. However, the study also revealed the following data:

- the percentage of baggage marked as safe by EDS $\vartheta=0.75$,
- the average automatic screening time of baggage marked as safe $\tau_0=6$,
- the average screening time of baggage for which EDS triggered an alert $\tau_a=40$,
- the percentage of baggage requiring ETD screening $\gamma=0.033$.

In light of our previous papers [8], one might notice that in the case of a C2 compliant EDS system installed in a cabin baggage security checkpoint the percentage of automatically accepted baggage is about 50% higher than in the case of an older generation of the system, installed in the hold baggage checkpoint.

Under Option 3, the capacity of each checkpoint equipped with a C2 compliant EDS device is 246 pieces of baggage per hour (formula 12). As can be easily observed, such capacity is sufficient for the current inflow of passengers (200 pieces of baggage per hour) as well as for traffic increased by 20% (240 pieces of baggage per hour).

Using formula (15) and taking into account the current equipment prices and the hourly cost of a screener at Katowice Airport, we can estimate that the annual cost of Option 3 is about EUR 550,000. The cost of equipment makes up about EUR 190,000 of this amount, while the cost of screeners – about EUR 360,00.

The implementation of explosive detection automation has a beneficial impact on the evaluation of the effectiveness of the cabin baggage screening system. The respondents valued the usefulness of Option 3 in ensuring security in the context of detecting explosives in passenger baggage, giving it the highest mark – 1. This is most definitely due to the fact that 100% of scanned baggage is analyzed for the presence of explosives. Another important issue is that experts show trust towards the implemented automatic solutions incorporating modern technologies.

5. Conclusion

The article analyzed three organization options of an airport baggage screening system. The analysis encompassed the provision of telematic systems which allow remote screening of baggage contents, automatic image recognition of objects inside a bag and analysis of chemical composition of samples at security checkpoints. Summarized results are shown in Table 5.

Table 5. Summarised analysis results [own work]

	η	Capacity [bags/h]	Cost [euro]	Efficiency [0,1]
Option 1	5%	1320	450.000	0.45
	10%			0.55
	15%			0.65
	20%			0.75
Option 2	5%	1374	740.000	0.65
	10%	1308		0.75
	15%	1254		0.85
	20%	1200		0.95
Option 3	100%	1476	550.000	1.0

The presented analyses prove that at the current rate of passenger inflow of persons per hour, i.e. 1200 pieces of baggage per hour, all options employing additional random ETD screening have the sufficient capacity, regardless of the adopted frequency of such additional screening. Still, assuming a hypothetical 20% increase in traffic, only Option 3 provides the necessary means to meet the demand on service. The remaining options require opening an additional security checkpoint. It is worth noting that a 20% increase is not an over-optimistic research scenario, as such an increase was observed between 2016 and 2017.

Option 1 is the most cost-effective. Nonetheless, the cost of Option 3 is only approximately 20% higher, and the cost of human labor is comparable in both cases. This issue is vital as regards the conditions on the job market. Option 2 appears unacceptable due to this criterion, especially since additional costs are generated mainly due to the work of screeners.

The evaluation of the efficiency of individual solutions is entirely subjective but was nonetheless provided by persons directly involved in the analyzed issues in their work. It does, therefore, have a certain practical value. The evaluation proved that the favored solution was Option 3, which won the respondents' full trust.

Summing up the results, we recommend Option 3 as the solution that best meets the capacity and efficiency criteria and is second best as regards costs, with only a small gap separating the second and first option in this criterion. One should also note that the recommended solution employs the highest level of automation and the most technologically advanced telematic solution among all the analyzed cases.

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