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Assessment of the impact of the restricted areas access control management on the airport security system

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Abstract. At present, airports are one of the few transport infrastructure facilities where we can see significant passenger comfort restrictions. In addition to several legal acts regulating precisely the rules of using this form of communication, we also deal with a continuous process of passenger flow management, broadly understood logistics and investment works, which significantly affect the airport's operational readiness. One of the essential elements related to air transport is the need to ensure air operations safety. The requirements and limitations associated with the transporting specific objects and substances and the tools for their detection are quite precisely defined in the applicable legal acts. These activities serve one purpose: to prevent acts of unlawful interference. However, the work indicates another element, perhaps less visible in the entire security control process, but equally crucial for the proper functioning of the security system. It is access control. The work shows the method of access control management in the context of an airport's functioning with many thousands of users. Bearing in mind the need to verify people moving around the airport and immediately react to all kinds of staff and structural rotations that directly affect people's rights to stay in specific airport zones, we can assess airport security level. Notably, the work shows the dependence of the entire airport's safety on managing its single link, which is the airport pass. This article also shows the impact of the automation of the access control management process on work efficiency and the effectiveness in achieving its primary goal, which is to protect the airport against unauthorized entry into the protected area.

Keywords: access control, airport, security

1. Introduction

When discussing the rigours related to ensuring air transport security, we usually think about security control activities performed by authorized certified security control operators. However, not everyone is aware that the current legal system precisely indicates access control as the first and essential step in verifying people trying to get to the airport's restricted area. According to point 10 of Regulation 300/2008, access control means applying measures that can prevent the entry of unauthorized persons or vehicles or both unauthorized

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persons and unauthorized vehicles.). Several human and technical resources are used for this purpose. Depending on the airport's size, the surveillance and access control models differ in terms of the technological advancement of the equipment used to manage the passes and organization and procedure. Nevertheless, airport operators' activities must meet the minimum standards described in European and national legal regulations on civil aviation security.

2. Access Control

Regulation 1998/2015 in point 1.2.2.2 indicates the documents that allow crossing the restricted security area. Under this legal act, to obtain permission to access restricted areas, a given person presents one of the following authorizations:

a) a valid boarding pass or equivalent; or
b) a valid crew member's identification card; or
c) a valid airport identification card; or
d) a valid national competent authority identification card; or
e) a valid regulatory authority identification card recognized by the competent national authority.

Besides, according to the same legal document, access to restricted security areas can only be allowed if there is a legitimate reason for people or vehicles being in that zone. A legitimate reason is considered to be a guided tour of the airport escorted by authorized persons.

Therefore, access control is the first step in verifying passengers and airport employees' rights before crossing the restricted security area. Thus, the security guard must ascertain at the access control point whether the person has a valid document based on which access to the prohibited areas of the airport is allowed. These activities are vital because they will enable the separation of people who need to be screened from other people in the airport's public area. It should be noted that the scope of information that the guard must verify differs depending on whether these activities are performed for the passenger, staff, or vehicle. In the case of a passenger, the security control operator must check the travel document's validity. In contrast, in the case of personnel whose security control rules are less stringent, the security guard additionally verifies the expiry date of the identification card, the membership of this card for the person, the right to reside in specific zones, and what is essential, whether the identification card has not been stolen, lost or blocked due to the loss of, for example, the validity of employee training or lack of justification for which it was issued.

Also, in the case of one-off car passes or identification cards, there is a necessity to ensure that the period they were given for does not exceed 24 hours, which is required by the National Civil Aviation Security Program. This is an essential task because even though people travelling on a one-time pass must have the so-called escorting person with appropriate permissions, there is a high risk of using such a card in the event of its loss or theft. This is treated as unlawful interference and perceived as an attempt to commit a crime against Civil Aviation. Access control has, therefore, an essential task for airport security. However, since it is somehow a supplement to security control, often tasks related to it are unfairly marginalized. SCO (Security Control Operator) at the security control point is obliged to perform many tasks that, in addition to proper control, significantly affect the entire process of security control. Belong to them:

– preparing the person for inspection,
– establishing the operational need for entry,
– observation of the surroundings of the security checkpoint.

If we add to this access control and security control often implemented in the sense of time pressure, we will picture SCO's entire responsibility. As already mentioned, within the scope of the issue discussed here, access control is designed to detect unauthorized attempts to enter the airport's restricted security area, particularly those who are moving on invalid (stolen or blocked) personal passes. It is almost natural that at the airport, where several to several dozen thousand people with airport identification cards work, some people may lose a pass or annulled and not returned to the airport manager. It is the airport managing body that is obliged to issue passes and carry out activities related to the verification of persons walking to the airport's restricted area. It is easy to imagine that, given the scale of the number of issued identification cards made up by employees' rotation, this is often an organizational challenge for the airport manager.

3. Literature review

When assessing the checked baggage checkpoint, essential factors are its equipment, organization, staff, and methods of carrying out checks, taking into account the technology used. They are evaluated for security screening effectiveness, security system throughput [19], and security assurance cost optimization [9]. This assessment is essential when deciding whether modernization is necessary and when choosing this modernization's scope and directions. There are many alternative solutions. For example, [23] made an interesting review of techniques for detecting explosives in checked baggage. [13, 14] analysed the technology of grouping passengers by risk level and its impact on assessing the effectiveness of security controls. A similar analysis, but concerning checked baggage, was carried out in [16]. An essential element is the assessment of explosive screening devices [18] and the method of their allocation [15]. [5] analysed the organization strategies of the HBSS system in relation to system capability and human reliability. Naji et al. (2018) reviewed the existing methods used to optimize the security process at airports, the technology being used, the importance of experienced security officers, and the impact of the screening process on passengers and the economy.

An essential element of our work, extending the current state of research, is the simultaneous consideration of many criteria for assessing the control point. Besides, some of these criteria are objective and can be determined by analytical or simulation methods, while some are subjective and require a descriptive assessment by experts.

Among the factors influencing the decision to modernize the terminal's infrastructure, for example, the problem of congestion was analysed [22] depending, among other things, on the functioning of the baggage control system. [2] examined the impact of increased security requirements at airports on the planning and operation of airport passenger terminals. [6] suggests the need to take into account infrastructure requirements when allocating space dedicated to security control. An essential element when making modernization decisions is the cost [20], which should be combined with a quantitative assessment of the benefits obtained in the form of increased detection efficiency of prohibited items [17, 19]. The most critical elements of the HBSS system were identified and assessed in the paper [10]. Using

an analytical model, they determine the optimal number of explosives detection system equipment based on passenger demand levels and security protocols.

The research to date, even though it deals with significant security issues, the authors' analysis focuses primarily on the process of security control and the capacity of the security control point. This paper addresses the problem faced more and more frequently by those responsible for ensuring airport security, namely providing ongoing responses to any attempts at the unauthorized entry to the airport. The paper presents proposals for solutions to this problem that combine human work elements with the access verification process's automation. These actions allow for an immediate reaction in the event of circumstances affecting the security of the airport. Moreover, the introduction of automation and computerization to the management system brings an additional benefit for security. It consists in the minimization of the risk of errors caused by the human factor.

4. Research methods in the analysis of airport security control

The airport security control system is a complex socio-technical system. For its analysis, it is necessary to use models, often hybrid ones that consider various aspects of its functioning. [24] reviewed models for analysing an airport as a complex system. The paper [21] proposes risk assessment techniques in aviation security to be applied to access control. [7] presented an example of a simulation model supporting the management of a check-in system in such a way as to minimize security checkpoint variability.

In analysing security control systems, there is considerable uncertainty of information and subjectivity of some assessments. Therefore, it is necessary to use soft methods, for example, based on fuzzy logic [1, 8]. Naji et al. [12] reviewed the existing techniques used to optimize the security process at airports, the technology being used, the importance of experienced security officers, and the impact of the screening process on passengers and the economy. Many of them are based on techniques derived from fuzzy logic. In turn, in [11], it was proposed to use the rough sets based on dominance to examine airports' service systems. In [24], the necessity to analyse the airport security system in terms of two criteria, both capacity and efficiency, was suggested. Some of the criteria taken into account in the analysis are subjective. Therefore, the method [16] based on the fuzzy inference theory was used. The extension of existing studies consists of considering the different points of view of experts making subjective assessments, which is implemented by treating the problem as group decision making.

5. Variants of access control organization

At Polish airports only, the number of people holding identification cards is between several hundred and several thousand. Even if we assume that only a small percentage of this number is lost or blocked, we will receive at least several dozen invalid passes that can potentially be used to commit an act of unlawful interference. Assuming that the given identification card has been intentionally stolen, we can realize its importance. For this reason, it is crucial to ensure the proper organization of access control with an emphasis on the effectiveness of its implementation and the time it takes to perform the control. This issue should be analysed in two variants:

1. Activities carried out manually by the security control operator and
2. Activities performed using IT systems and specialized software.

In this respect, tests were carried out at the Katowice Pyrzowice airport with certified and trained operators who were to verify the permissions of persons entering the zone based on lists submitted with the list of lost passes previously provided. During the study, we measured the time of verification of the employee's ID card by SCO. The template for such a card is shown in table 1.

Table 1. Specimen list of lost passes

Temporary identification cards								
No.	**Surname**	**Name**	**Company**	**ID No.**	**Colour of ID**	**Access zones**	**Active card number**	**Circumstances of losing your pass**
1.								
2.								
3.								

(source: own study)

5.1. Activities performed manually by the security control operator

About 50 entries were on the list containing names and surname of the persons who reported her loss. This study was carried out at a dedicated staff crossing, during the station's highest occupancy from 6.00 a.m. to 8.00 a.m. During this time, measurements were made on a sample of 20 passing airport employees. The results of these tests are presented in Table 2, and their graphical representation is shown in Figure 2.

Table 2. Identification card verification time

No.	**identification card verification time [sec]**	**No.**	**identification card verification time [sec]**
1	10	11	11
2	15	12	10
3	8	13	10
4	7	14	15
5	20	15	16
6	15	16	10
7	5	17	5
8	10	18	8
9	8	19	10
10	25	20	16

(source: own study)

The experiment results show that the time of manual verification of personnel entering the security zone is, on average, about 12 seconds, which is a relatively large unit of time, especially when we care about the bandwidth of security checkpoints. This value applies to the verification activity itself and does not consider the cases when a given person's rights are doubtful for the operator.

Unfortunately, it is difficult to determine the level of operators' errors in such a simulated situation, resulting in the granting of permission to enter the airport's restricted area to an unauthorized person. Given the above, an additional survey was conducted among 20 operators. The operators were to answer the percentage of errors (incorrect verification of the

identification card) that could occur when working with the access control organization described above. The results of this expert judgment are presented in Table 3.

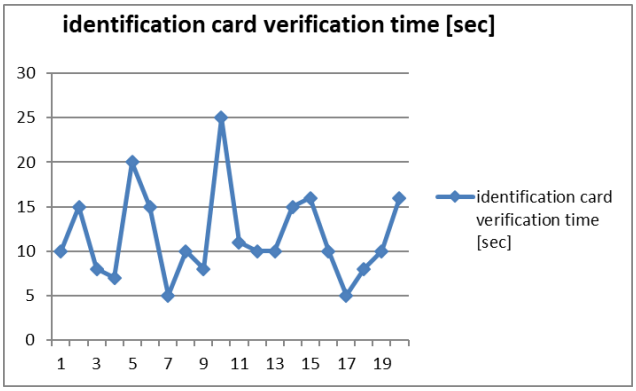

Fig. 2. Identification card verification time (source: own study)

Table 3. Percentage of errors made by SCO during manual verification of identification cards

No.	Percentage of errors made by SCO during the manual verification of identification cards	No.	Percentage of errors made by SCO during the manual verification of identification cards
1	10	11	5
2	5	12	5
3	10	13	15
4	5	14	10
5	5	15	5
6	10	16	5
7	20	17	0
8	10	18	10
9	10	19	5
10	10	20	10

(source: own study)

It should also be noted that the examination did not include verification of the personnel's authorization to bring prohibited items, which is also time-consuming. However, since there are few such situations in MPL Katowice, this element was omitted in the study. The conducted research showed that in addition to the relatively long time devoted to access control in its manual organization, you could also see a relatively large percentage of possible errors made by security staff. On average, SCO determined the number of mistakes that could be made at just over 8%. This is primarily due to time pressure, staff accumulation at the security checkpoint and the need to analyse the environment and respond to any irregularities noticed simultaneously. Therefore, the average effectiveness of personnel access control was determined by SCO to be around 92%. Besides, attention should be paid to a particular relationship between ID card verification and the number of errors made. Based on experts' opinions, we can state that SCO's mistakes are made almost exclusively in increased traffic at the station. The time pressure causes SCO to spend less time verifying the rights of persons entering the restricted zone. The intensity of work and the implementation of numerous duties means that SCO may misinterpret the verified documents.

The situation is similar in the case of passenger access control. Here, since SCO only needs to verify the boarding pass's validity without the obligation to transfer it to the passenger, this manual check is shorter than in staff dedicated stations. The time SCO has to devote to manual verification of the date and number of cruises is about 6 seconds in the tested period. The average passenger access control time was just over 6.4 seconds. This is close to half as much compared to the time of personnel access control. However, it should be borne in mind the number of passengers operating at the airport, which exceeds the number of personnel entering the restricted security area several times.

Summary of access control time performed by SCO manually at the passenger and staff control point is presented in Table 4.

Table 4. Time for manual verification of the boarding pass (source: own study)

No.	manual boarding pass verification time [sec]	No.	manual boarding pass verification time [sec]
1	5	11	7
2	3	12	5
3	10	13	4
4	10	14	5
5	5	15	10
6	10	16	8
7	5	17	5
8	5	18	6
9	10	19	4
10	6	20	5

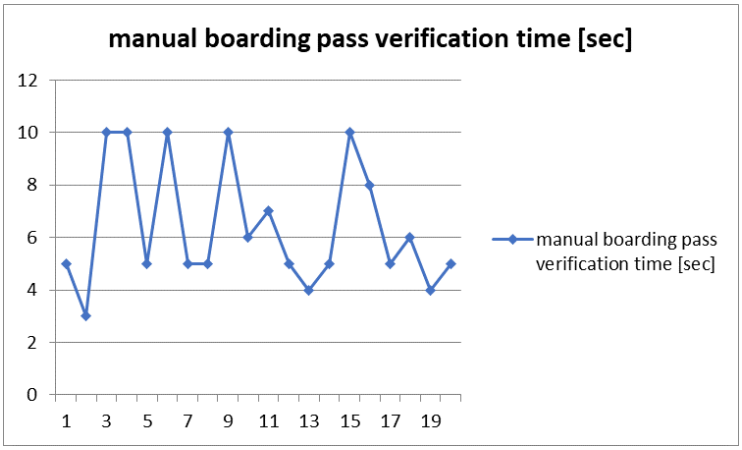

Fig. 3. Time for manual verification of the boarding pass (source: own study)

In this case, the control operators also assessed this form of passenger access control's effectiveness, indicating the percentage of errors during their work in the examined area. The results are presented in Table 5.

As can be seen, SCO pointed to a significantly lower percentage of errors in implementing access control at passenger crossings. It is, on average, slightly above 4%. This assessment is undoubtedly influenced by the fact that during the verification of passenger entitlements, SCO only checks the document's compliance with airport operations performed at the airport. Simultaneously, in the case of personnel access control, the card's membership is also verified.

Table 5. Percentage of errors made by SCO during manual verification of boarding passes

No.	Percentage of errors made by SCO during manual verification of boarding passes	No.	Percentage of errors made by SCO during manual verification of boarding passes
1	5	11	5
2	5	12	5
3	3	13	5
4	5	14	3
5	5	15	5
6	5	16	5
7	4	17	0
8	5	18	2
9	3	19	5
10	2	20	5

(source: own study)

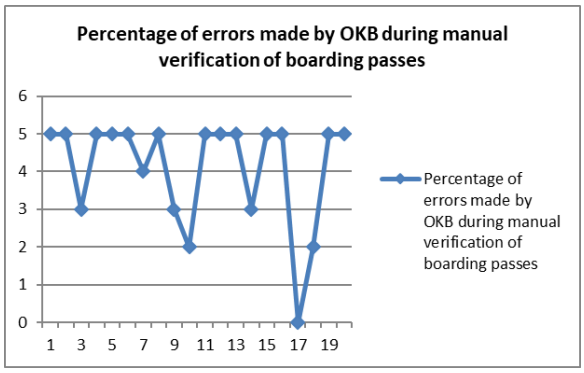

Fig. 4. Percentage of errors made by SCO during manual verification of boarding passes (source: own study)

5.2. Activities performed using IT systems and specialized software

To compare the efficiency and effectiveness of the tasks related to access control, we have to examine the situation in which this process will be fully automated. SCO's role will be limited only to actions envisaged to be carried out with persons having or without the appropriate permissions. For this purpose, an experiment was carried out involving IT systems at service and passenger passes to check incoming people's permissions and enter vehicles.

The system verifying airport passes validity provides information about the permitted zones, training validity, and authorizations to bring prohibited items. An example of such a system is shown in figure 5.

An employee who applies to enter the airport must use his identification card and put it on a dedicated reader. The screen then displays information based on which the operator receives precise data on the pass and employee rights' validity. The time of this verification lasts from 2 to 3 seconds. A visual alarm is generated on the monitor to facilitate the operator's work, in the event of any irregularities, indicating the need to take additional action on the ID cardholder. Besides, it should be emphasized that in addition to typical standard data that must be verified following the regulations during access control, the manager can check additional elements that significantly impact airport security. These include the validity of training and authorization to bring items on the prohibited list necessary to perform specific

tasks. This solution is an additional advantage due to the possibility of providing better supervision over arriving persons, thus increasing the level of airport security.

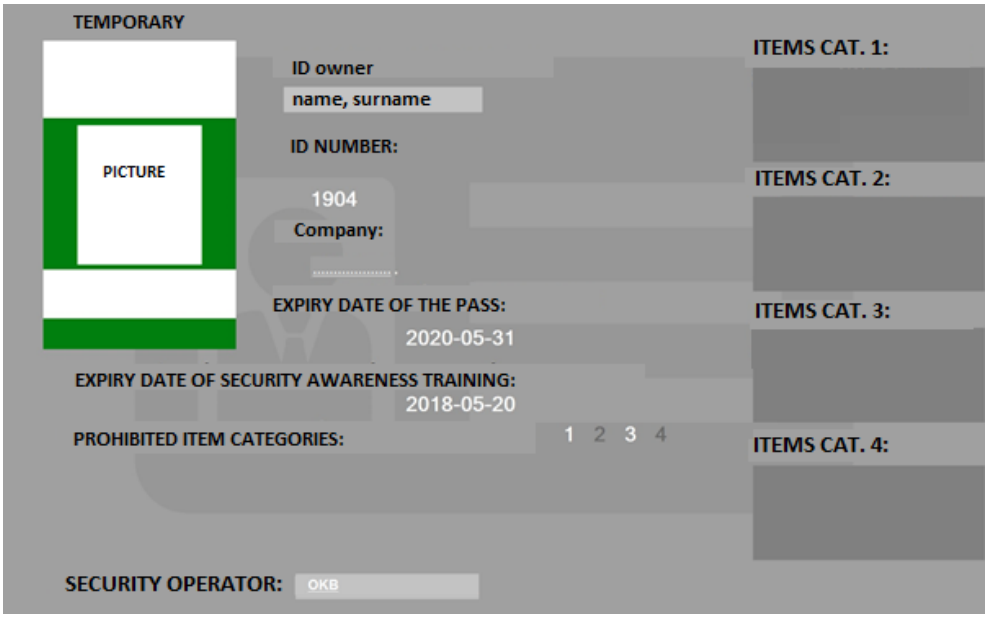

Fig. 5. Visualization of the system graphic layout to verify the validity of airport passes (source: own study)

The situation is similar when verifying the permissions of passengers going to the restricted security area. With automatic access control, verification usually consists of scanning a bar code from the boarding card and verifying the dedicated monitor's information. An example of such a solution is shown in Figure 6.

In negative verification, SCO also receives an acoustic and graphic signal informing about an invalid boarding pass. The passenger attempts to get on board the aircraft. Due to the similar tool used, this verification time is very similar to the time of passenger access control and is also about 3 seconds.

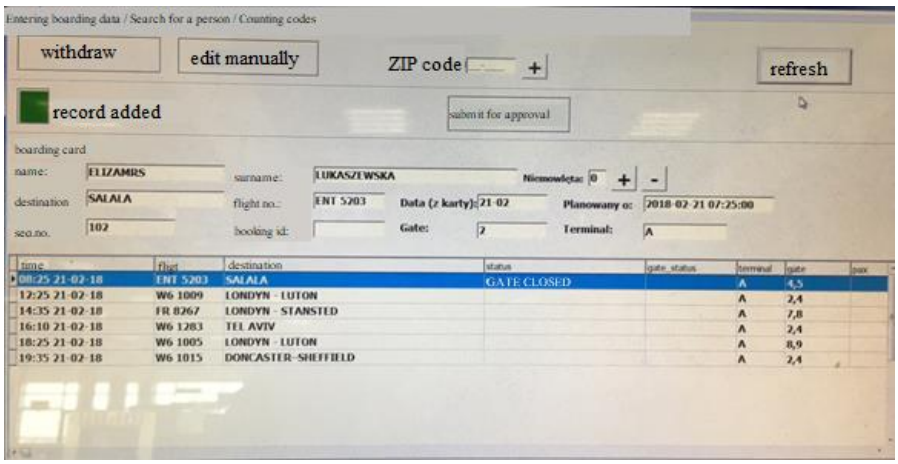

Fig 6. Visualization of graphic system layout for verification of boarding passes (source: own study)

6. Summary of test results

Comparing the solutions described above in the scope of access control implementation (manual and automatic), one should point out the fundamental differences resulting from the way of performing these activities.

Analysing the subject according to time that should be devoted to access control, the test results undoubtedly speak in favour of automatic access control, which is more than twice as fast when controlling employee access and nearly four times faster when controlling passenger access.

To assess the effectiveness of the tasks performed, SCO participated in the research. Their task was to evaluate the effectiveness of automatic access control as a percentage. At twenty SCO, as many as 17 rated this form of control's effectiveness at 100%. Only three people rated effectiveness at 90%. In this respect, doubts arose from the fear that the person administering the system, which enters information into the system, thereby providing the comparative material necessary for verification during access control carried out by security personnel, may also make a mistake, which may consequently affect the operator error.

Figure 7 presents the ratings of operators who, by assigning values in the range of 0–100%, determined the effectiveness of the described methods of passenger and personnel access control.

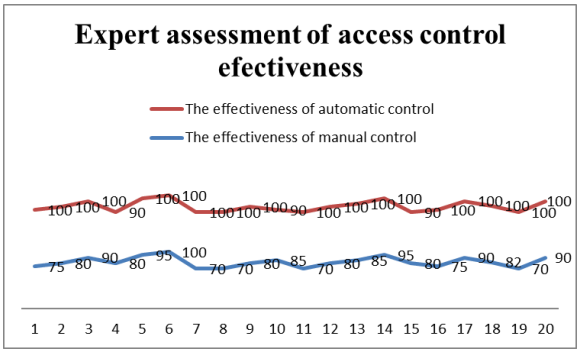

Fig. 7. Expert assessment of the effectiveness of the access control system

These values clearly show that the access control process's automation has a significant impact, among others, for a sense of greater security for security guards. The average assessment of the effectiveness of manual control, which is just over 82% and automatic control of 98.5%, indicates a trend in airport security systems development. Minimizing the so-called human factor, determined among other things and the mere fact of increasing the quality of tasks performed, also relieving SCO of its tasks, and thus removing part of its responsibility for assessing the rights of the person entering the zone. The use of IT solutions also has other, more measurable benefits for the airport manager. They allow for limiting the employment of personnel necessary to ensure an access control point's required capacity.

In Figure 8 and Table 6, we see in tabular and graphical form the average values of control time and expert assessments of access control carried out manually and with additional software.

We should note that the high rating of the SCO automatic access control system was influenced by the fact that it allows for fulfilling primary obligations arising from current

legal acts. But this system also significantly supports other areas' supervision with a high impact on airport security.

These values illustrate the differences between the applied access control solutions, which may be the starting point for further considerations in the area.

Table 6. Averaged values of control time and expert assessments of access control carried out manually and with the use of additional software

Type of control	passenger access control time	personnel access control time	Number of errors made during passenger access control [%]	Number of mistakes made during personnel access control [%]
manual	6.4	11.7	4.1	8.25
automatic	3	3	2	2

(source: own study)

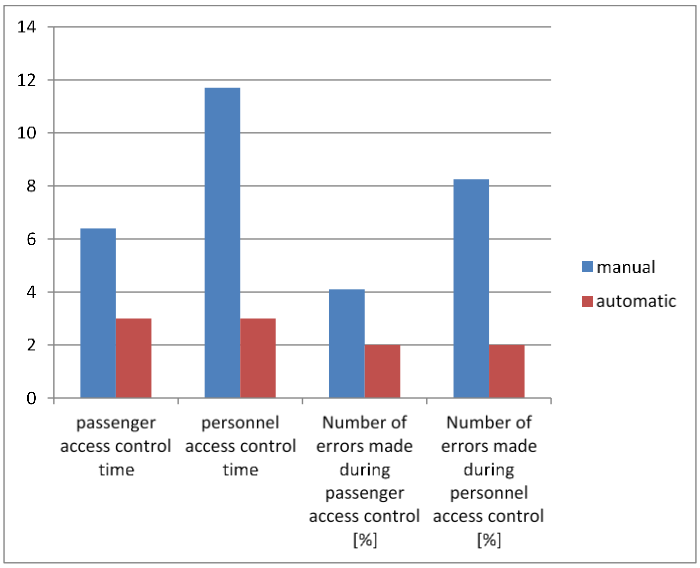

Fig. 8. Averaged values of control time and expert assessments of access control carried out manually and with the use of additional software (source: own study)

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