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Evaluation of the effectiveness of an airport passenger and baggage security screening system

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ABSTRACT

Airport security managers need methods to quantify changes in security level to prevent terrorist attacks. This study presents a method using a fuzzy inference system to assess the overall effectiveness of prohibited items detection during passenger and baggage security screening. The results show that the screening system performance can be improved from *medium* to *high* by upgrading screening devices at hold baggage checkpoints and by increasing the frequency of training sessions. In the case of increased risk of terrorist attacks an obligation to control 20 percent of passengers manually and 30 percent increase in the sensitivity of metal detectors increases system performance to *very high* detection level. On the positive side our results show that these results can be achieved with minimum financial outlays, while on the negative side system throughput is somewhat reduced. Overall our results show that screening performance can be improved substantially, but as the required performance level rises there is a trade-off with system throughput and personnel training costs.

1. Introduction

In most airports in the world every air travel is preceded by passenger and baggage screening. There are many detailed solutions in different countries. In our study we have adopted the standards and legal regulations in force in the European Union. However, security is a global issue. Susceptibility of air transport to terrorist threats forces the airport management to take effective measures to ensure security to the passengers and personnel. These involve considerable expenses and pose a serious organisational challenge. Therefore, the security control becomes a significant part of airport budget and considerably affects the functioning of the entire company. At the same time, process management is difficult due to the lack of proper supporting methods. This applies particularly to evaluating the effects of the measures taken in relation to the achievable security levels. While resolving on the specific financial effects, a manager is willing to know how much the effectiveness of detection of prohibited objects, and thus the security level, will increase. That would make it possible to determine whether such decision is reasonable (whether the effect justifies the cost to be borne) or, possibly to compare two alternatives (which of two possible actions will have better results at a similar cost level). Regrettably, there is still a shortage of quantitative methods allowing for such analyses, particularly in the practical, managerial perspective. This study aims to bridge this gap. It summarizes the scholar's work made so far, which resulted in creating a quantitative method for evaluating the effectiveness of the airport passenger and baggage security screening system. It is difficult to accurately describe this ill-defined problem, so it often comes down to an intuitive or a 'trial and error' approach. Our approach allows us to formalize the expert knowledge and achieve more objective results, and certainly makes it possible to carry out a comparative analysis. The method is based on fuzzy logic, more precisely on the fuzzy inference systems. The computer-aided tool FASAS (Fuzzy Airport Security Assessment System) enables practical support of airport management in terms of security control.

1.1. Managing the system of an airport passenger and baggage security screening

The security checks of passengers and baggage in airports are regulated by extensive regulatory system (European Commission, 2015). It applies mainly to the control methods, training and supervising the tasks performed by airport management in this respect. However, compliance with the regulatory requirements does not exclude the option of making individual managerial decisions that can significantly affect security, capacity or comfort of passengers. Such decisions usually refer to the scope of extensions beyond the minimum required by law. The legislation in force does not give an indication on how to practically organize the airport control system, which includes

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not only the physical activities visible to the passengers, but also a series of infrastructural, personal and procedural actions, requiring expenses relevant to the scale of passenger traffic. For example, there are many manufacturers on the market who offer passenger and baggage security screening devices that meet the minimum standards set in the regulations. However, these devices differ from each other in detailed technical parameters, ergonomics or available additional features, which ultimately have a significant impact on the effectiveness of screening and thus on the airport security. The system organisation is a similar issue. For example, checked baggage screening requires examination using an explosives detection system (EDS) X-ray device and evaluation of the image. However, it is not specified how many levels of such screening is needed. Similarly in the case of security screening operators (SSO) – they can be sent to additional trainings beyond those required.

As already mentioned, a passenger and baggage security screening system is required to comply with valid regulations setting out the lower limits for the system operating parameters. On the other hand, it has to be scaled to the magnitude of traffic involved. It should also ensure, as far as possible, sufficient comfort to passengers, which will have a great impact on how the quality of airport services is assessed.

There are usually several key issues found in the passenger and baggage security screening management.

1. Choosing the number of security control areas (SCA). On making such decision, airport management takes into consideration the intensity of current traffic, but allowances must be also made for the planned airport development. Determination of the number of SCAs requires to establish the essential peak hourly passenger capacity. It may considerably exceed the average traffic intensity, also the off-peak traffic. The necessity for efficient management of traffic at peak hours results in that the security control systems are often oversized. This generates significant initial cost of equipping the SCAs, as well as the subsequent operating costs (including maintenance, inspections, energy consumed).
2. It also involves having a proper number of staff with all necessary qualifications and certificates to perform their duties. With simple calculations, it can be stated that the minimum staffing of a single SCA requires 4–5 employees in 24 h. This is a factor that generates huge cost of an airport security system. To ensure continued operation of a single SCA, 12–15 workers have to be employed. The above-mentioned problem of oversizing the system and of the cost of recruiting and training the staff might be the case here. Since it is required to consider the possible diverted, delayed or additional flights, security checks of aviation operations are often necessary to be performed at different times than scheduled. This requires additional workforce.
3. Selection of SCA equipment. The most important criterion in the choice of the equipment with proper certificates is usually the balance between the price and the achievable passenger capacity. Both variables can be precisely given in numbers. Unfortunately, however, we are unable to give precise figures to represent the effectiveness of the equipment used for detection of prohibited objects and substances. Therefore, this criterion is difficult to consider and is often disregarded. It is all limited to the information that the system meets the minimum standards.
4. SCA organisation. A large number of tasks to be performed by an SSO during security control operations, requires at the same time the SCA to be provided with special equipment for performing such checks. It is possible to designate dedicated SCAs to perform specific types of checks. It allows a cost reduction, since the management does not have to provide all SCAs with all types of equipment. However, this will compromise the versatility and may cause operating problems.
5. Dynamic modification of system operating parameters. The above issues are critical and are considered over a long time horizon. However, planning an airport security system is a very dynamic process. Legislation and the relevant requirements are often changed along with the security assessment on the national, regional and even global scale. Similarly, the technological advance requires the equipment and security measures to be adapted accordingly. This forces actions with medium time horizon to be taken. Refer to Section 3.2.1 for a more detailed description of those issues.
6. Operational management of the system. There are many detailed system performance parameters available in short term which can be adapted to temporary and current needs. An example of situations requiring such ad hoc actions is declaring the state of elevated risk of terrorist attack. Refer to Section 3.2.2 for a more detailed description.

For an airport with around 3 million passengers per year, the cost of security (equipment and staff) can reach about €4 million per annum. The airports mostly function as economic agents and attempt to achieve a positive financial result, which in turn is a determinant of the investments planned for airports. However, the managers responsible for planning investments (in security equipment or training, for example) would like to know the measurable effects of such actions. This also applies to the comparison of several alternative investment decisions. The lack of quantitative methods makes it impossible to evaluate their actual effects. Under such conditions, it is easy to make a wrong decision and to be accused of mismanagement. This may foster a policy of 'meeting only the minimum requirements'. Of course, such policy is not always used in such a situation. Right investment decisions, such as better equipment for security screening checkpoints, may positively influence not only the security of performed air operations. They can also improve the capacity or comfort of passengers. This increases the competitiveness and attractiveness of the airport, which in turn may positively affect the financial performance of the airport. But the key issue is to make the right investment decisions. Thanks to them we may avoid the cost of reputational damage or even real losses as a result of terrorist attack.

The presence of numerous factors forcing the system upgrade, particularly the medium- and short-term ones, should lead to basing the possible decisions not only on the cost and possible capacity, but also on the effectiveness of detection of prohibited objects and substances. We believe that thanks to the tool for quantitative assessment of effects relating to effectiveness of security screening, on the one hand we give managers (regulators) the ability to reliably assess the expected results, on the other we make it possible to find non-investment solutions that involve only organisational improvements.

1.2. Overview of the studies

This section gives an overview of the literature on airport security management. This is a complex problem that can be considered in different aspects. The study (Cole, 2014) highlights the necessity of proactive approach, i.e. analysing risk scenarios for seeking appropriate remedial actions. An important issue is the scope of control operations and their effect on an airport capacity (Hainen et al., 2013; Butler and Poole, 2002; Leone and Liu, 2005; Van Boekhold et al., 2014; Kierzkowski and Kisiel, 2015) and the passenger comfort and satisfaction (Alards-Tomalin et al., 2014; Benda, 2015; Gkritza et al., 2006; Sakano et al., 2016). The approach combining several criteria is also applied (Wu and Mengersen, 2013; Lee and Jacobson, 2011). Increasing the scope of control operations requires obviously increased expenditures which are not always reasonable (Stewart, 2010; Stewart and Mueller, 2014, 2015; Gerstenfeld and Berger, 2011; Gillen and Morrison, 2015; Prentice, 2015).

Attempts are made to develop new, alternative security control system solutions: