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Managing the process of passenger security control at an airport using the fuzzy inference system

Jacek Skorupski[a,*], Piotr Uchroński[a,b]

[a] Warsaw University of Technology, Faculty of Transport, ul. Koszykowa 75, 00-662 Warszawa, Poland
[b] Upper Silesian Aviation Group, al. Korfantego 38, 40-161 Katowice, Poland

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ABSTRACT

Elements of air transport infrastructure as well as passengers and aircraft are constantly at risk of terrorist attack. One of the most important preventative methods is the security control of persons and baggage at airports. Managing this process requires finding a compromise between high capacity of the terminal and the high effectiveness of the security control. The purpose of this study is to show the applicability of an expert system, which assists security managers in deciding how to organise the security screening process. Due to the important role of the human factor, the need to use expert's opinions and the high uncertainty and imprecise nature of information, the developed model and computer tool FUPSCA (FUzzy Passenger Security Control Assessment) uses the fuzzy sets theory and a fuzzy inference system. It's use allows us to adjust the operating parameters of the security screening checkpoint, namely the WTMD sensitivity, number of employees and the frequency of manual controls, to the current level of terrorist threat. As a result of the study it was found that if we want to achieve higher security control effectiveness we should first increase the WTMD's sensitivity and only then increase the frequency of additional manual controls and not the other way round. Of course the FUPSCA system provides specific, quantitative answers. In the future it will be necessary to manage the operation of the passenger security control system using multi-criteria evaluations of: capacity, effectiveness, passenger comfort. FUPSCA will be able to effectively support this process.

1. Introduction

The transport systems considered parts of critical infrastructure are constantly at risk of terrorist threat. Airport terminals, although reasonably well protected, are a frequent target for attacks. In addition, they are in practice the only locations where it is possible to detect and foil an attempt to bring explosives or weapons onboard an aircraft.

In the recent years particularly dramatic attacks took place at airports in Burgas and Moscow. The first of the attacks took place in 2012 when a bomb was detonated in a bus at the airport in Burgas in Bulgaria. As a result of the explosion caused by a suicide bomber seven people were killed and 32 persons were injured (Shmulovich & Zion, 2012). The attack took place on the 18th anniversary of a bombing in Buenos Aires, which occurred on the 18th July 1994 and 85 people were killed. The attack at Domodiedowo airport in Moscow occurred in 2011. At least 36 people were killed and at least 180 people were injured (Rosenberg, 2011).

An attempt to actively respond to the terrorist threat involves security control performed at airports. The subject of our study is a method for quantitative evaluation of the effectiveness of passenger security control at a security checkpoint (SCP). In practice, a considerable problem is managing the security checkpoint operation, including the selection of settings for the devices used to detect prohibited items and the selection of SCP operators. The qualitative relation between the various parameters of system operation and the obtained operation effectiveness is quite obvious. However, the quantitative relation is at this point unknown. The existing few scientific analyses of this question are related mostly to the capacity of SCP, assuming that the security level is appropriate.

1.1. Organisation of passenger security control at an airport

The person security control is one of the basic methods of protection against acts of unlawful interference (ICAO, 2010). The safety of departing passengers relies mostly on its effectiveness. It is therefore very important that the tools used during the security control of persons are adequate to the development of methods employed by terrorists around the world.

* Corresponding author. Tel.: +48 222347339.
E-mail addresses: jsk@wt.pw.edu.pl (J. Skorupski), puchronski@gtl.com.pl (P. Uchroński).

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The passenger security control may be conducted using:

- manual control,
- walk-through metal detectors (WTMD),
- explosive detection dogs (EDD),
- devices used for scanning persons without using ionising radiation,
- explosives trace detectors (ETD) and hand held metal detectors (HHMD).

In practice the first two methods are commonly used. They are the subject of analysis in this study. Also the rule of "assumed guilt" is applied which means that if the security control operator (SCO) cannot be sure whether the passenger carries forbidden items, this passenger is denied access to the restricted areas or is subject to security control until the operator decides that the security requirements have been met (European Commission, 2010).

The security control of persons performed using the WTMD is not fully effective as it is only able to detect metal items. Usually, manual control is used as a supplementary passenger security control method. It involves "moving the hands, without withdrawing them, over the body and clothes in front and at the back". This method is considered the most effective and not requiring large financial means to achieve the desired results. It is used every time the WTMD is triggered and at random at a set frequency in case of persons who did not trigger it. Other methods of security control are only intended to supplement the traditional security controls performed using WTMD. Due to their cost, the existing commercially available devices for scanning persons which do not use ionising radiation and do not require the removal of clothes are not always present at airports (especially if the traffic is not very heavy).

1.2. Literature review

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 organisation of the security control process. The third one covers the security policy and management of the security control process organisation.

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 operator. Gkritza, Niemeier, and Mannering (2006) have analysed the impact of the type and intensity of the taken control actions on the subjective satisfaction of the passenger. Similar studies were performed by Alards-Tomalin et al. (2014). Their study has shown that the type of actions taken at the SCP has a considerable impact on 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, 2011). In general, the results of studies in this field indicate to 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 our study bring the analysis to a higher level. They allow for the selection of such passenger security control system configuration parameters which will allow minimising the nuisance experienced by passengers therefore maximising their satisfaction level while maintaining the assumed security level. An example of such selection is found in Section 3.2.

The capacity analysis trend is the most developed one and usually applies to registered baggage control (Butler & Poole, 2002; Leone & Liu, 2005) or cabin baggage control (Perboli, Musso, Perfetti, & Trapani, 2014; Sterchi & Schwaninger, 2015). In the work by Hainen, Remias, Bullock, and Mannering (2013) the factors influencing the time of passenger's presence at the SCP were analysed. Another view of the problem is presented by Kirschenbaum (2013), who analysed 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 and Tomber (2007) while the model analysis can be found in Boekhold, Faghri, and Li (2014). The work by Yu (2010) analyses the effectiveness of operation of an airport taking into consideration the processes involving passengers performed in the terminal part of an airport. These processes also include the passenger security control. The relation between the way flight safety and aviation security is organised in civil aviation was analysed by Pettersen and Bjørnskau (2015). The questions related to the proper organisation without infrastructure development has been analysed in Narciso and Piera (2015). In our study we assume that in the future it will be required to jointly analyse the questions of capacity and effectiveness of the security control as a multiple-criteria issue. Our work is an attempt to provide methods and tools for the quantitative evaluation of the second factor - effectiveness of security control. When combined with the present knowledge about capacity, this opens the route to the future multiple-criteria analyses. This will be the subject of our next study. Taking into consideration 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, 2014).

The analysis of literature related to managing the security control organisation at an airport indicates that there are no useful practical methods and systems to support the airport managers. Attempts are made to develop alternative solutions integrating all types of control to which the passenger and the baggage are subjected (Yildiz, Abraham, Panetta, & Agaian, 2008). The review of new methods can be found in Leone and Liu (2011). An interesting method involves dynamically assigning a threat level to a passenger (Nie, Parab, Batta, Lin, 2012; Nikolaev, Lee, & Jacobson, 2012). Another problem is finding a balance between profiling and screening (Bagchi & Paul, 2014). In the work by Yoo and Choi (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 & LaTourrette, 2015). Many authors claim that the most important is the human factor. Our research confirms the importance of this factor. However, expanding our 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 and Koch (2009) suggest a method involving automatic tracking and classification of moving passengers using numerous chemical sensors. This method allows for localising threats and quickly informing the security control operators. Gerstenfeld and Berger (2011) suggest a method for selecting the number and type of devices used at a security checkpoint. Adler, Liebert, and Yazhemsky (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 costs analysis is often undertaken in articles in recent years (Gillen & Morrison, 2015; Stewart & Mueller, 2014). Our work, to a considerable degree, belongs in the same group. It offers a fuzzy model and method for the evaluation of the effectiveness of security control (Section 2) and also provides a practical tool (the FUPSCA computer system) for the evaluation of airports in this respect (Section 3.1). It supports the making of real, practical