Transportation Research Part C 88 (2018) 52–73

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

A method of hold baggage security screening system throughput analysis with an application for a medium-sized airport

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ARTICLE INFO

Keywords:
Hold baggage security screening
Baggage handling system
Aviation safety and security
Petri nets
Discrete event simulation
Airport performance evaluation

ABSTRACT

The hold baggage security screening (HBSS) is one of the essential steps in a pre-flight operation process. With the continuous increase in the overall air traffic volume, the development of security screening (and control) technologies, and the changes in applicable regulations of law, the structure and equipment of HBSS systems require frequent upgrades. In order to make good, effective decisions about the upgrades, airport management requires tools for quantitative determination of their results. The aim of this work is to analyse the HBSS system throughput. The analysis can serve as an aid in airport management in on-the-go solving of operating issues and making decisions about HBSS upgrades. A mathematical model was established for the analysis in the form of a coloured timed Petri net, and implemented in a computer-aided solution. It was a microscale simulation model, in which every piece of hold baggage is localised in time and with a resolution of a single belt conveyor. The computer-simulated experiments completed with the model helped (i) determine the actual throughput of the HBSS system operated at the Katowice International Airport, (ii) determine the effects of disturbances on the HBSS system operation, (iii) evaluate the impact of the time windows available to SSO (security screening operators), the SSO's work organisation and the efficiency of automatic security screening on the HBSS system throughput, and (iv) determine the throughput for specific alternative variants of the HBSS organisation, including doubled automatic security screening. These results allow a conclusion, that a four-level HBSS system, which includes automatic security screening, two SSO screening levels based on X-ray imaging, and manual control is an HBSS solution adequate for a regional medium-sized airport. It was also found that, given the growth of airport facility complexity and area, an increase of HBSS throughput is viable rather not by improving the capacity of specific HBSS components, but by deploying them in parallel processing lines. The highest throughput growth potential lies in parallel deployment of automatic security screening lines.

1. Introduction

The hold baggage security screening (HBSS) is one of the essential steps in a pre-flight operation process. The hold baggage is the passengers' luggage that enters the luggage hold of passenger aircraft. The passengers cannot access their hold baggage during flight, irrespective of the flight route (direct or transit). This allows carriage of objects required by passengers for daily use and which cannot be carried in the passenger cabin due to the concerns of their potential use in acts of unlawful interference (ICAO, 2010). A specific regulation exists (European Commission, 2015) that establishes the categories of objects prohibited in both hand and hold baggage. It

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https://doi.org/10.1016/j.trc.2018.01.009
Received 28 August 2017; Received in revised form 17 November 2017; Accepted 9 January 2018
Available online 30 January 2018
0968-090X/

is against the law to keep explosives, flammables and incendiary materials or devices in hold baggage; however, the final qualification of questionable hold baggage contents as prohibited or not is at the discretion of the SSO (security screening operators). This assignment of discretion is justified as far as the sole technological progress of late enables building improvised explosive devices that had not been foreseen by lawmakers at the time of publishing applicable security regulations. Even if passenger is not able to access the contents of their hold baggage in flight, any failure to detect prohibited objects during a pre-flight security screening can be disastrous.

1.1. Hold baggage security screening (HBSS)

Depending on its configuration, infrastructure or airport performance requirements, the HBSS can vary and its performance can entail various technological solutions. Pursuant to applicable international regulatory guidelines, hold baggage can be inspected by:

- X-ray imaging machines (X-ray screeners);
- explosives detection systems (EDS);
- security manual control;
- explosives trace detectors (ETD);
- “sniffer dogs” for detection of explosive materials.

The essential type of HBSS equipment is an X-ray (radiographic imaging) machine with an EDS. Henceforth, it is referred to as an “EDS screener”. Regulations exist which establish the requirements for HBSS applications of EDS screeners (European Commission, 2015). However, the regulatory requirements have been seeing dynamic changes to adapt them to the reality of new security threats which emerge as technology is developed. Three standards for the requirements have been defined.

1. Dual-energy single-source EDS screeners, which were legal by 2008 (Standard I).
2. Dual-energy multi-source EDS screeners, which are legal by 2020 (Standard II).
3. CTX (computer tomography X-ray) EDS screeners, which will be enforced from 2020 (Standard III).

The three security screening technologies vary in prohibited object detection performance and the screening time. The continuous growth in passenger air traffic requires airport management organisations to adopt engineering and organisational solutions that reduce the security screening time while retaining minimum regulatory security standards.

Hence it is a decision-making problem to choose an HBSS method that maintains a high detection rate without inhibiting airport performance, or even better – to increase the latter. No HBSS solution exists that is explicitly most advantageous; what is more, all solutions are encumbered with high capital expenditure costs and a long deployment time. Hence, some airports operate redundant HBSS solutions that exceed their actual security screening demand; at other airports, the operated HBSS solutions are the performance bottleneck of passenger processing. This problem becomes crucial to the airports that compete for passengers on a free market by striving to apply the highest service standards.

1.2. Literature review

A review of literature on passenger and baggage handling and processing completed under this work provided several pertinent areas of investigation. This section presents some of these areas which are directly related to this paper and explains the extension proposed herein in short.

1.2.1. Security screening as a component of ground handling

Passenger and baggage security screening is a critical component of the overall aircraft ground handling and has been the subject of many research works. The research is mainly focused on the opportunities for improvement of security screening effectiveness, security system throughput, and security assurance cost optimisation (Kirschenbaum, 2013; Gillen and Morrison, 2015). The suggested measures to achieve these objectives include optimised security screening hardware allocation (Sewell et al., 2013), security screening operator training (McCarley et al., 2004; Schwaninger, 2005), passenger profiling and grouping (Wong and Brooks, 2015; Nie et al., 2009; Lazar Babu et al., 2006), better planning of airport passenger terminals (de Barros and Tomber, 2007), and application of high-reliability security screening equipment (Siergiejczyk et al., 2017).

An HBSS system is usually integrated with a baggage handling system (BHS). The design engineering aspects thereof were studied by Yu and Xu (2010). Wu and Xie (2017) investigated the impact of load-balancing policies on the system performance, by assuming an BHS organised as a multichannel queuing system with the specific handling channels endowed with identical characteristics. They proposed to use a join-shortest-queue (JSQ) policy in the airport screening process.

The HBSS effectiveness and investigation into HBSS system configurations with the highest prohibited object detection probability are prominent topics of the reference sources on the subject considered herein. The authors hereof analysed these problems in the past (Skorupski and Uchroński, 2015a,b; 2016). Testing of security screening effectiveness becomes a different problem from the above ones whenever automatic EDS screeners are required to handle 100% of screening. Nie (2011) presents a probabilistic analysis that enables selection of security screening levels in relation to risk classes assigned to baggage by the baggage risk characteristics. The work considers automatic security only as handled by various screening equipment types and focuses on the cost-effectiveness