Journal of Air Transport Management xxx (2017) 1–8

Contents lists available at ScienceDirect

Journal of Air Transport Management

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

Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports

Duarte Amorim da Cunha*, Rosário Macário, Vasco Reis

CERIS, CESUR, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, 1049-001 Lisboa, Portugal

ARTICLE INFO

Article history:
Received 25 February 2016
Received in revised form
9 January 2017
Accepted 20 January 2017
Available online xxx

Keywords:
Security
Cargo
Small and medium airport
Risk assessment

ABSTRACT

European Union regulations are not sensible to the proportionality of measures and provide fixed orientations and standards irrespective from the dimension of the airports. Additional security measures have been added over the years resulting in increasing security-related costs. The cost structure of security exhibits the existence of a relevant fixed component, concerning staff, equipment, or certification. Notable, smaller, and medium airports support higher costs of security than larger airports, due to the low volumes of cargo and passenger movements. Alternative approaches, notably risk based, have been advocated to support the definition of security procedures at airport level. Although studies have been conducted, none was found concerning these types of airports.

This paper presents a research aimed to analyse the appropriateness of a risk based approach in the context of small to medium airports. The research focused in understanding whether such approach could provide tailored security requirements and, ideally, lower costs.

A case study considering six airports - Horta, Lisbon, and Ponta Delgada (Portugal), and Adana Şakirpaşa, Erkilet International and Istanbul (Turkey) - of different sizes and located in different regions was conducted. The results make evident the advantages of a risk based approach to define appropriate security procedures, although it is not evident that a risk based approach will lower costs.

1. Introduction

According to EUROCONTROL,[1] there are little more than 2000 airports in Europe that handle IFR (Instrument Flight Rules) flights, with only 500 having more than 1000 IFR departures per year (Wegner and Marsh, 2007), and from which only about 300 board more than 15 000 passengers per year (European Commission, 2015). In 2013,a total of 14,4million tonnes of air freight were transported through EU airports, (European Commission, 2015). If we consider the Top 25 airports that handle the largest freight traffic amount *per se*, together they sum up to almost 12.8 million tonnes of air freight handled in 2013 and even the Top 5 sum almost 7 million tonnes. This means that only 1.6 million tonnes are handled by the remaining airports, but we should bear in mind that not all smaller airports handle freight. In the absence of a classification of airports by size regarding the amount of cargo loaded, and since we do not solely consider cargo specialized airports, we use the definition of small and medium airports by number of departures per year, being small and medium airports those with a maximum of 3.000 and 6.000 departures respectively.

Regional airports are vital for economic growth of Europe's regional communities. The worldwide connection and speed of air travel gives remote regions more accessibility than other means of transport being an enabler for social development and economic growth. In Norway, for example, a study concluded that residents in remote regions have a higher frequency of travel by air on domestic services than the national average (Halpern and Bråthen, 2011). In the same study, the main reasons for travel for residents in those remote regions was work, followed by visiting family and friends. But the global financial crisis created a great impact on these airports, and their recovery has not been as quick as the rest of the industry. Nevertheless, in 2014 regional airports recovered as much as in the earlier years (Sadler, 2015).

* Corresponding author.
E-mail addresses: duartecunha@tecnico.ulisboa.pt (D. Amorim da Cunha), rosariomacario@tecnico.ulisboa.pt (R. Macário), vascoreis@tecnico.ulisboa.pt (V. Reis).

[1] We should also consider that these values provided by the EUROCONTROL refer to loading and unloading of freight which, in cases of transfer freight, may consider the same consignment twice.

http://dx.doi.org/10.1016/j.jairtraman.2017.01.003
0969-6997/

Due to its high price, air freight (which include the transportation by air of cargo and mail) is competitive mainly for long distances and relatively light, high-value or perishable goods, and time-sensitive cargo. As an example, for typical air freight consignments, the high-value machine parts and manufacturing equipment, electronic components for manufactured goods, consumer electronics, jewellery, and perishable items as flowers, fruits, and even fresh fish. Hence, it plays a relevant role in moving certain types of goods across the globe, consequently some sectors could be seriously affected by eventual disruptions (e.g. remote regions) (Williams and Bråthen, 2010).

Regarding security risks, the ones related with terrorism include the hijacking of an aircraft with the intention to be used as a weapon of mass-destruction, as it was done in the 9/11 attacks, or the introduction of an explosive on passenger aircrafts thru the cargo supply chain, resembling the Yemen air cargo bombs in 2010. Other security risk associated with terrorism is the introduction of weapons or CBRN (chemical, biological, radiological, and nuclear) devices. Theft, smuggling and cargo with undeclared and potentially harmful material also consists as a security risk (Price and Forrest, 2013). Air cargo can be considered as exposed to this very same list of potential risk, although the larger impact caused by any incident engaging human lives makes full air cargo less attractive for terrorism attacks.

The literature concerning security in general in small and medium airports is very reduced. A search[2] conducted on the Science Direct database yield a total of 266 papers, addressing mostly screening technologies, rather than aviation security strategies or policies. The papers focusing on cost and finance of aviation security are mainly directed to passenger security, rather than to air cargo. Regarding air cargo security, a reduced number of articles was found, all relating to screening technologies, once again. The literature discusses the security challenges in general and not specifically in the case of small to medium airports, and are more focused on passenger security, rather than air cargo and mail security (Gillen and Morrison, 2015).

The current security procedures are imposed in a top-down approach starting with ICAO guidelines aiming to promote a harmonisation in all airports. The objective is to impose a maximum vulnerability threshold, which all airports must comply. Although theoretically adequate, this approach presents some practical limitations. Foremost, regional specificities can be considered solely to a small extent. These may include airports localised in remote regions, such as island, in which the threat is almost inexistent. The consequence is the need to implement security procedures without a rational justification. Secondly, security costs exhibit a substantial fixed component (e.g., equipment or staff) and high economies of scale. Hence, air transport agents will endure proportionally higher security costs than those located in larger airports. If these costs are too high, their survivability is in jeopardy. Indeed, smaller exporters and freight forwarders may opt for other means of transport, in deterrence of air transportation. Additionally, in case of remote regions, the alternatives may not be suitable, due to limited accessibility of these regions.

There is also a discussion on who is responsible for security: National Security is a public good since everyone benefits from it and cannot exclude anyone or anything. It is provided by national governments thru national police, military or other defence forces. This contrasts with the current aviation security paradigm where there is a user-pays principle with the increasing taxes on security (Prentice, 2015).

[2] Search done the 2nd December 2015 to the following words in title and keywords: airport, aviation, security.

Alternative approaches to airport security have been advocated, namely risk based approach (Cole, 2014; McLay et al., 2010; Wong and Brooks, 2015), because they deliver tailored security procedures according to local contextual conditions. The customisation of security procedures promotes costs and resources rationalisation. Thus far, the debate has neglected the small and medium airports, which are those that borne higher security-related costs.

The purpose of this paper is to discuss eventual advantages in using a risk based approach for air freight security in small and medium airports, instead of the top-down approach that is currently imposed.

In the next chapter, a brief explanation of the current security framework for air cargo and mail will be presented, as well as considerations on its positive and negative aspects. The third chapter will present a case study where a qualitative risk assessment to a group of six airports with different sizes and in different contexts is made, and a comparison of costs in each airport, in order to examine the cost-benefit of the current security procedures. The last chapter will present our conclusions and the next steps on our research in this topic.

2. Regulatory framework for security

2.1. Current air cargo security paradigm

The 9/11 tragic events placed transport security under attention from worldwide authorities at the passenger level, but the October 2010 events involving the finding of two package-bombs in Britain and Dubai, originating from Yemen and destined for two synagogues in the USA, showed worldwide authorities that cargo and mail security should also be object of concern.

The International Civil Aviation Organization (ICAO – a specialized United Nations agency) sets the general rules and principles aimed at “safeguarding International Civil Aviation against Acts of Unlawful Interference”, to be implemented in each of the Contracting States and running the USAP, an audit programme to monitor the compliance of states with its SARPs.

In Europe, and in line with the ICAO SARPs (Standard and Recommended Practices), the Regulation (EC) 300/2008 sets the common rules and basic standards on aviation security and, therefore, on air cargo and mail security, and replaces the former Regulation (EC) 2320/2002. It sets general orientations and mechanisms for monitoring compliance which are adopted through the ordinary legislative procedure. The measures supplementing the basic standards and the detailed implementing aspects are adopted by the EC through the committee procedure. On its turn, the Commission Implementing Regulation (EU) 2015/1995 of 5 November 2015 lays down the detailed measures for implementation of the common basic rules and principles specified in the Regulation (EC) 300/2008.

At the national level, although it is the respective national authorities' responsibility to implement and enforce EU law, the EC has means to assess and enforce such implementation and conduct audits and inspections to all Member States concerning both authorities and operators.

A hierarchical relation is established (Fig. 1) in what concern the information details and the degree of compliance. The Information detail increases from the ICAO and EC, as legislators, to the airport stakeholders, as for example, the airport operators themselves, airlines, ground handlers, etc., while the responsibility for compliance increases in the opposite direction.

For air cargo and mail, the EU framework establishes that all consignments shall be subject to security controls prior to being loaded onto an aircraft. Security controls have to be applied by the air carrier itself or by a regulated agent, known consignor, or

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003

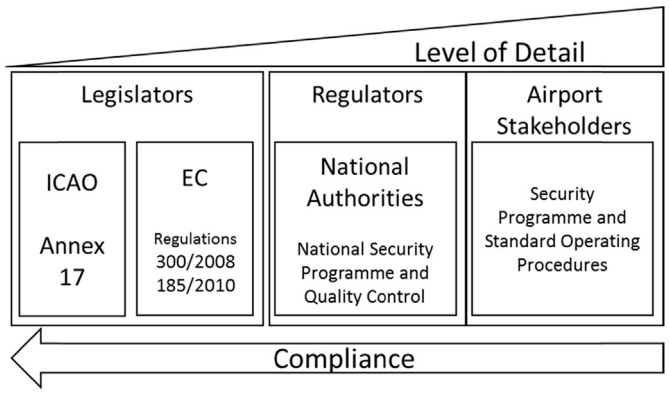

Fig. 1. Aviation Security Framework Structure (Adapted from Unitn et al., 2013)

account consignor. Cargo and mail shall be protected from unauthorized interference from the point at which security controls are applied until the departure of the aircraft, otherwise, they must be screened.

The Known Consignor (KC) and the Account Consignor (AC) are entities that originate cargo and mail for its own account. The security procedures implemented by KC allows the carriage of the consignments in all aircrafts, while consignments from AC can only be transported by all-cargo aircrafts. The Regulated Agent (RA) is an agent, freight forwarder or any other entity that handles cargo and ensures security controls in respect of cargo and mail. They are approved by the authority on site specific basis. The accreditation is attributed by undergoing an audit process, just like KCs, but with higher requirements. Upon receiving any consignments, a RA establishes whether the entity from which it receives the consignments is a RA, a KC, an AC or none of these and ensures that the consignments are properly secured and in accordance to the security regulations. Therefore, RA are a vital element in the Supply Chain Security (SCS), as they are responsible for guaranteeing that only consignments that have been subject to security procedures are loaded onto an aircraft, as well as responsible and qualified to handle and secure consignments that have an unsecured status.

As other entities involved in airport or air transport operations, KCs, ACs and RAs are required to implement a Security Program, subject to certain requirements and are under the scope of the national authority and international entities (such as the European Commission and ICAO) through the Quality Control Programme.

The regulation determines that air cargo and mail consignments can be securely loaded on to an aircraft through two distinct processes: through Supply Chain Security (SCS) procedures or by screening the cargo or mail. Essentially, the Supply Chain Security (SCS) protects the cargo or mail by ensuring that prohibited articles are not introduced into a consignment from the moment it is "closed" and the consignment is subsequently protected from unauthorized interference until it is loaded onto the aircraft. In order to achieve this, a set of procedures is applied along the supply chain.

In the SCS the process starts with the requirement that cargo must have originated from a shipper certified as a KC or AC. This element must undertake specific actions in the selection and training of personnel and protection of cargo and mail that limits the possibilities of acts of unlawful interference to the consignment. This agent protects the cargo until it is taken on board the aircraft by handing it over to a freight forwarder/haulier who is certified as a RA who, in turn, will have a security programme implemented that ensures cargo/mail is protected. This protection is assured through appropriately trained and selected personnel, specific measures to protect the cargo or mail during transport by road and by placing the cargo in secure warehouses until it is delivered to the ground handler. Ground handlers will normally receive the cargo on behalf of the aircraft operator and, after verifying all the documentation, proving that the security procedures were implemented, protects the consignment until it is delivered to the aircraft (See Fig. 2).

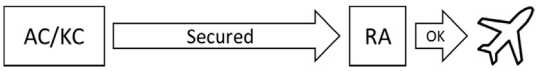

Fig. 2. Supply chain security process.

As for the Screening pathway, (See Fig. 3) it consists of applying means and methods to detect prohibited articles in a consignment, which take into account the nature of the consignment and are of a sufficient standard to reasonably ensure that there are no prohibited items concealed in it.

Freight forwarders can potentially screen cargo or mail (if certified as Known Consignors or Regulated Agents), but most screening is performed at airport's restricted areas by ground handlers, who are, in turn, certified Regulated Agents. Ground Handlers perform screening of cargo and mail from various freight forwarders on behalf of different aircraft operators. Integrators, for example, combine the work of freight forwarders, ground handlers and air carriers in one company or group and perform the screening internally.

The airlines have the primary responsibility for securing the consignments that are to be loaded on their aircrafts. In the Screening pathway, the security measures are applied closest to the aircraft, with the airlines transferring this responsibility to a Ground Handler (RA) or, in case of integrators, the security procedures are executed in the house. As for the SCS, there is a system of responsibility transfer, in which, due to certification, the entities earlier in the chain of custody secure the consignments and declare to the next entity that it is still secured, until it reaches the final entity before loading it to the aircraft, the airline.

The current regulatory framework considers the possibility of alternative measures providing the adequate level of security in the EU. The Commission Regulation (EC) 300/2008 states the alternatives are to be justified by reasons relating to the size of the aircraft operating in the airport, or by reasons relating to the nature, scale or frequency of operations or other relevant activities. This demand results from the fact that the level of threat is not the same in different types of civil aviation, as in commercial aviation and private aviation, disregarding different threat levels for different locations. The establishment of a derogation, as a single element of flexibility, is subject to a security risk assessment and is subject to very strict criteria. The Commission Regulation (EC) 272/2009 states that alternative or special procedures or exemptions from the regularly imposed security controls can only be applied when "(a) the procedure or exemption is established by the Commission or the appropriate authority; and (b) there are objective reasons that justify the procedure or exemption". But the main criteria for security derogation are set in the Commission Regulation (EC) 1254/2009, in which it is stated that such derogations can be applied at airports or demarcated areas of airports where traffic is limited to

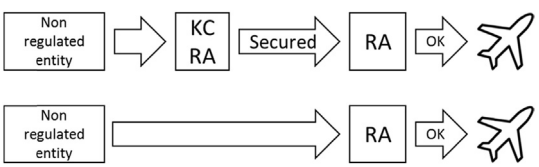

Fig. 3. Screening pathway process.

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003

non-commercial flights (such as law enforcement or fire suppression flights) and, in case of commercial flights, to airports operating aircrafts with a maximum take-off weight of 15 tonnes (see Fig. 2).

Non-commercial aerodromes can easily fit in the criteria for derogation. However, for airports with reduced traffic it is a very restrictive framework not allowing derogation of security standards in the clear majority of cases. Additionally, nothing is stated in relation to the kind of derogation to be considered. Assuming that the risk assessment results in a near zero possibility of introduction of restricted items both by passengers or in freight consignments, it is not clear that the authority can exempt such airport from screening cargo, even if the freight is shipped by a local known registered element, but without fully complying with the SCS registered entity.

2.2. Pros and cons of current air cargo security paradigm and the alternative risk based approach

Domingues et al. (2014) showed that the September 11th attacks created an impact, not only in media and policy makers, but also triggered an increase in publications and research projects in the Aviation Security field, especially in Europe and the USA. But this increase focused mainly on the "passenger side", leaving air cargo and mail security on the side-lines. The same authors present the results of a literature review in three major fields: critical issues in the air cargo security legislation; enhancement of civil aviation security; and supply chain security. Additionally, they present a description of recommendations and proposals on air cargo and mail security, showing that most relevant publications are done at the request of legislators.

The Aviation Security Regulations impose standardized and detailed routine ways of achieving security, that do not allow adaptations. This is considered a paradox, since due to the uncertainty that security has to handle in terms of terrorism threats against civil aviation some flexibility is desirable to adjust to different degrees of uncertainty (Pettersen and Bjørnskau, 2014). Additionally, on a reverse risk assessment and cost-benefit evaluation, the current general protective measures in aviation are found to be over costly, as the attack probabilities have to be much higher than the current to justify these measures (Stewart and Mueller, 2014).

Observing in detail the cargo and mail air transport, EU air cargo security regulations give security operators the choice of which of the previously presented pathways to apply. SCS implies a more structured effort in terms of investment in designing facilities, training, and certification, but its procedures are less arduous and it is more cost-efficient for organisations that handle large amounts of cargo and mail. As a result, Screening is the most common method to ensure the Security in Air Cargo and Mail, especially in airports with lower volumes of traffic, since it may not be economically viable to implement such costly operations. Regarding the Supply Chain Security, Macário et al. (2012) question whether the appropriate authorities can declare freight forwarders as facilitators in the SCS and how the effectiveness of the SCS can be improved with the knowledge of the consignment history that the freight forwarder holds (Domingues et al., 2014).

Nevertheless, in some circumstances there is no option regarding what security procedures are applied. For example, in flights to the US, all cargo and mail must be screened, regardless of the application of SCS controls due to USA own Air Cargo and Mail Security Framework, which means that the security inspection in the airport by the handler will be mandatory and it will be a "second inspection", with all the associated costs. Also, there are some aircraft operators that impose the screening of all cargo and mail, even for intra-European flights, not considering the SCS. As they are responsible for the security of the aircraft when it comes to cargo and mail, they do not intend to transfer that responsibility to others (European Parliament et al., 2012).

Other concerns on SCS is the transport of secured shipments to the airport: The chain of custody may be secure on paper, but the several transfers a shipment is subject to, makes the cargo exposed to potential interference or adulteration. The inside threat is also a concern. For example, certain shipping facilities have high rotation of employees, or what is called in Security as the Inside Threat (Wallace and Loffi, 2014). The main problem is that, even if SCS is secured on paper, it has many gaps that can be explored by perpetrators until the shipment reaches the airplane. Air freight consignments present the highest risk when they are being "handed-over" from one transport mode to another. For example, from the exporter to the logistics service provider, or from this one to a regulated agent, or even from the regulated agent to the airline or its representative, the ground handler. Although the biggest risk in transfers is theft, it is also a window of opportunity in the air transportation supply chain to introduce prohibited items that may affect the security of the air transportation (Innovative Compliance Europe Ltd, 2013).

An alternative to the current air cargo security paradigm is a risk rating regime, instead of imposing physical screening of all consignments, create a risk profile by analysing the origin and destination of the consignment and its route, and the intervenient companies. Consignments that, after analysis, are considered as high-risk, are then subject to the security screening. But this approach would require a more active intervention from the authorities, since, as the framework stands, the authorities have a much more passive role, just by certifying and auditing the regulated entities (KC, AC and RA) or imposing screening to all consignments (Heifetz, 2011; Wong and Brooks, 2015).

3. Case study

3.1. Background

In order to better understand how a risk based approach could capture airports' local specificities, we chose two small and medium airports located in the Azores islands (Portugal). These will be assessed against other four differentiated airports both in size and location.

In all nine airports in the Azores Islands, the same ground handler is responsible for cargo and mail security and handling. In most airports, it is already certified as a Regulated Agent, since this certification is site specific. In most airports, a private security company is contracted to execute the security procedures, although the Local Police is responsible in some airports, since there is no other public or private entity in the island the airport is located. For exporters, shippers and freight forwarders, the security certification is expensive and time consuming, and the amount of cargo that they generate or handle does not outweigh the security surcharges if they opt to only secure their cargo at the airport. This provides evidence that in remote regions, if there is no entity approved and certified and listed for the provision of security control services by the appropriate authority to be subcontracted by a Ground Handler or other Regulated Agent (as provided in Regulation (CE) 185/2010), the SCS is very difficult to implement, if not impossible.

Depending on the nature of the cargo, different security procedures have to be implemented in order to reduce costs. This means that, for example, for denser consignments, x-ray machines may not be able to confirm that no prohibited articles are contained in the consignment. Other types of authorized screening equipment could be used, as the EDS, ETD or even EDD, but due to the high costs that having more than one equipment can represent, the hand search and visual method are the supporting security screening

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003

method. Nevertheless, these two alternative methods may turn out to be time and resource consuming, and may not be as effective when the operator is under pressure to dispatch several consignments.

In one interview,[3] air mail was considered as more worrying than cargo, since that mail consignments are not required to have a description of contents, and mail is used to transport all sort of things, therefore, creating more difficulties when applying security measures in order to validate the consignment as secure.

Taking into account the historical data, there are no terrorist attacks registered in the Azores Islands nor has any presence of a terrorist organization been identified in the Azores. Nevertheless, the presence of a United States Air Force Base (Lajes Airfield) and the existence of commercial air transportation routes connecting the islands to the North American Continent and Europe that can be used as a travel point between the two, can be considered as a potential exploitation point.

3.2. Risk assessment

The classic formulation of risk is that it is a function of *threat*, *vulnerability*, and *criticality* (or Impact), and is normally a product of these terms. Using only the terms Threat and Vulnerability, we can deduce the Probability of an Attack.

$$Threat \times Vulnerability = Probability\ of\ an\ Attack$$

$$Risk = Threat \times Vulnerability \times Criticality$$

Risk is the potential loss, damage or destruction of an asset resulting from a successful attack from a threat. The threat is any action, intentional or not, that can damage or destroy an asset. Vulnerability are the weaknesses in a system that may be exploited by perpetrators to conduct an attack. It can also be considered as the inverse of the efficiency of the measures of protection installed. Finally, the criticality refers to the consequence of the loss of or of the damage to the infrastructure and assets, including human life.

The security procedures mainly act to mitigate the risk, as taking actions to reduce the probability and/or the impact of an attack. Which means that, when reducing the probability, they will work on the Threat and Vulnerability terms of the formulation, and when reducing the impact, will work on the Criticality term. Most of the security procedures described earlier and that are imposed by the regulatory framework work on reducing the probability of an attack, by creating filters that deny the entry of prohibited items, which may be used unlawfully, onto an aircraft.

As stated before, much of the current aviation security framework is created in reaction to specific terrorist attacks, which may be efficient in some areas of the globe, as it reduces the risk of a certain type of attack that is commonly used or preferable to a determined terrorist group, but may not be in other areas. To clarify, let us consider a general risk that two locations with the same criticality, but different threat level, and security procedures with an efficiency of 80% (meaning the vulnerability is 20%) have. If, for the first location, the threat is 7 incidents/10 years, the risk will be 1.4 incidents/10 years, and for the second location the threat is 1 incident/10 years, the risk will be 0.2 incidents/10 years. The cost/benefit of the security procedures in the second location is much higher than in the first location. In other Risk Assessments, the Risk Manager of the second location would probably choose other type of security procedures that would reduce the risk to an acceptable risk value, instead of using a security procedure that would give him a worst cost/benefit value.

This assumption has some limitations, such as considering that the security procedures have the same efficiency in different locations. Other limitations to the classical risk function are presented by Cox (2008), and include distortions due to the use of arithmetic averages, not considering non additive vulnerabilities, and the product of expected values may not be equal to the expected value of the product, as the terms may not be completely independent. For example, a target with a higher economic or human impact (Criticality), may be more appealing for a terrorist group action than another, which will influence the threat level.

The six airports considered in this case study are presented in the Table 1.

The general threat an airport is subject to is being considered, instead of considering each specific threat resulting from different types of attack tactics. Therefore, to assess the threat an airport is subject to, the methodology used by the U.S. Department of Justice (Gonzales et al., 2005), in which a combination of various factors presents the threat in five levels was used. The factors are:

- Existence: Presence of a terrorist group, or a terrorist group is able to access a given locality.
- Capability: A terrorist group is able to carry out an attack.
- Intention: A terrorist group has stated intentions to conduct terrorist activity or it has been assessed.
- History: Terrorist activity in the past.
- Targeting: Existence of terrorist activity or intelligence that indicates the preparations for a specific attack.

The Intention and targeting factors may induce some confusion, but they are, in fact, distinct. While the Intention refers only to the stated intentions of a terrorist group, the targeting implies the existence of preparations for an attack, such as disruptions of a terrorist cell while preparing an attack, or intelligence that indicates the preparations of an attack.

Table 2 presents the level of threat per the combination of the described factors, as depicted by the above-mentioned methodology. The resulting threat level for the considered airports is presented in Table 3: The existence and capability factors are present as we assume all countries are vulnerable to a terrorist attack, even the cases with remoter accessibility. As for intent, Portugal has not been threatened directly by any group, while Turkey has been constantly threatened, specially by domestic groups.[4] Regarding historical records, Portugal has no record of terrorist attacks in the past 10 years, specially targeting transportation infrastructure, while, in Turkey, the Kurdistan Worker's Party (PKK) has been active, registering more than 350 attacks in the last year, according to the Global Terrorism Database.

The Global Terrorism Index Report ranks Turkey in 27th with a score of 5737 and Portugal in 110th with a score of 0,267, which validates the resulting threat levels.

Given the current airport security framework, it is intended that all airports present the same vulnerability, as a set of security measures are imposed, whatever the context the airport is in.

The same methodology presented also has a criticality assessment which consists of a five-point scale, from Negligible (1) to Extreme (5). Different types of attack can impose different impacts, and hence, the criticality may be different, meaning that one type of attack can have a lower criticality than other. Since we are considering the global threat an airport is subject to, we will consider that the all airports in consideration have the highest

[3] Conducted on June 2015 to a freight forwarder manager.

[4] http://www.counterextremism.com/countries/turkey.

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003

Table 1
Airports and 2015 statistics.

IATA Code	Airport, Location	Passengers per year	Cargo and Mail boarded (thousand ton/year)
HOR	Horta Airport, Azores, Portugal	191 969	324
PDL	Ponta Delgada Airport, Azores, Portugal	1 265 792	2682
LIS	Lisbon Airport, Portugal	20 110 805	41 744
IST	Istambul Atatürt Airport, Turkey	61 322 729	498 049
ADA	Adana Şakirpaşa Airport, Turkey	5 369 260	5661
ASR	Erkilet International Airport, Kayseri, Turkey	1 223 760	354

criticality possible, reflecting that one of the type of attacks will impose the greatest impact.

3.3. Costs

Regarding security costs, Macário et al. (2012) confirmed that there is a great difficulty to retrieve information on this matter, for different reasons, but specially due to confidentiality. Security costs include screening equipment, staff training, and securing perimeters around facilities, auditing and validating regulated entities and, last but not least, investing under the scope of a sometimes vague framework. An average cost figures for air freight security screening were presented by the same authors:

- X-ray installation: €240 000;
- Explosive Detection System (EDS): €50 000;
- Human cost: €17 to €25 per hour (€90 with EDS);

To calculate the costs, we will use a generalised cost function considering the fixed costs of equipment and man hours. Considering that all screening equipment has an operating life of 4 years, the fixed cost for each equipment will be considered as the installation cost distributed per year.

$$Total\ Annual\ Cost = Equipment\ Cost + Human\ Cost$$

$$Equipment\ Cost = (\#\ of\ equipment) \times \frac{Installation\ Cost}{Operating\ lifetime\ (in\ years)}$$

$$Human\ Cost = \#\ of\ people \times human\ cost\ per\ hour \times operating\ hours \times operating\ days$$

With the help of these figures, we can now estimate the fixed costs for security for the airports considered. Due to their size, the lower movement airports only have 1 ground handler capable of receiving freight consignments, and there is only one x-ray machine in each airport. On the other hand, LIS, as a primary national airport and due to the amount of airlines serviced has two ground handlers, each one operating their own x-ray machine, plus one x-ray machine operated for integrators for air freight to board all-cargo aircrafts, and IST, due to the much larger air freight movement, has 6 cargo screening positions.

Table 2
Combination of factors to determine level of threat - Source: Gonzales et al. (2005).

Level		Are present
5	Critical	Existence AND Capability AND Targeting
4	High	Existence AND Capability AND History AND Intentions
3	Medium	Existence AND Capability AND History
2	Low	Existence AND Intention
1	Negligible	Existence OR Capability

For the busiest airports, we shall consider only air freight consignments that are loaded onto passenger aircrafts, consisting of approximately 80% of total traffic, and consider that all this cargo is evenly handled by ground handlers present at the airport.

The x-ray machines in LIS, PDL, IST and ADA are used for the total amount of air freight boarding in this airport. In HOR and ASR, the x-ray machine is used both for air freight consignments, as for passenger luggage, so we shall decrease the installation cost by 60%, assuming that there is a 60/40 distribution of utilization between luggage and air freight consignments.

Each security position is operated by 3 persons: a supervisor, the x-ray operator, and a third to confer the consignments documentation. The x-ray operator may switch position with one of the others since, by regulation, the x-ray machine may not be operated by the same person more than a certain amount of time. The same team is responsible for manual or visual search.

We also consider that all screening equipment has an operating life of 4 years, hence, we will consider the fixed cost per year related to the installation of the equipment.

Considering the results in Table 4, an airport with a highest amount of cargo is in advantage, while the smallest airport has a very high cost to secure the consignments in proportion. The higher costs are diluted with the higher amount of air freight boarded in larger airports, while smaller airports have a higher cost of securing air freight per ton. This cost tends to be transferred to the air cargo shippers, increasing the cost of air transportation, hence, decreasing its competitiveness to other transport modes. In case of remote regions, this can turn out to be problematic, as it reduces the accessibility, and, consequently, can have some implications in the social development and economic growth of the serviced region.

In larger airports, the cost per ton to screen cargo may be even higher, as in these airports, there is a much larger share of KC or AC entities, which reduce the amount of consignments screened by the RA (ground handler) as they are inserted in the SCS.

4. Results

Using an adapted risk matrix where we consider a third dimension which is the cost of screening per ton, we can present the results for the considered airports in Fig. 4. The current regulatory framework results in the implementation of security procedures that result in a much similar, if not equal, vulnerability

Table 3
Resulting threat level – Source: Authors.

Airport	Existence	Capability	Intent	History	Targeting	Threat Level
HOR	Present	Present				1
PDL	Present	Present				1
LIS	Present	Present	Present			2
IST	Present	Present	Present	Present	Present	5
ADA	Present	Present	Present	Present		4
ASR	Present	Present	Present	Present		4

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003

Table 4
Fixed costs for each airport.

Airport	LIS	PDL	HOR	IST	ADA	ASR
Equipment	X-ray + EDS	X-ray	X-ray	X-ray + EDS	X-ray	X-ray
Operating hours	12	10	6	24	6	6
Personnel cost per hour	90	17	17	90	17	17
Working days	251	251	251	251	251	251
# of positions	2	1	1	6	1	1
Total Annual Cost (€)	687 160	102 670	85 602	3 687 960	85 602	85 602
Annual Cargo boarded (thousand ton)	41 744	2682	324	498 049	5661	354
Cost per th ton (€)	16.46	38.28	264.20	7.40	15.12	241.81

across all airports, resulting in great discrepancies in the subsequent probability of an attack in different airports due to the different threat levels. This discrepancy can even be higher if we consider the criticality of an airport as being proportional to the amount of people and cargo it processes, as it can be seen in the Fig. 5.

By determining the necessary security processes thru a risk rating methodology, there is a need to establish a probability of attack or risk level that is acceptable. With this, the cost-efficiency of the security procedures for securing air freight consignments could be more appealing for smaller airports, by reducing the costs per tonne, sacrificing the efficiency of the security procedures, resulting in a higher probability of attack, or risk level, but still within an accepted value. On the other hand, airports with higher threat levels may be forced to implement more efficient security procedures to decrease the associated vulnerability, increasing its costs.

In Fig. 6 is presented, as a hypothesis, a situation where the costs of screening per ton in HOR and PDL were decreased by sacrificing the vulnerability, but still bellow an accepted attack probability and, if the same criticality is considered, same risk level. On the other hand, IST had an attack probability above the accepted level, and reducing its vulnerability level implied increasing the cost of screening.

One other aspect that can be highlighted in the above figure is that threat level can also be used to reduce the risk thru deterrence methods. For example, the simple fact that it is known that security procedures are in practice may have a reducing effect in the threat level, but reducing the threat level is outside the airports or airlines responsibility, it is a police and intelligence forces responsibility.

5. Conclusions and future research

Although the SCS pathway already facilitates air cargo and mail security, the current aviation security framework imposes strict rules in all domains which can produce inefficiencies and raise costs. This is especially relevant in small and medium airports, where entities do not consider the SCS since the respective costs are much higher than performing the security procedures at the airport. Nevertheless, even in the screening pathway, the cost benefit of the security measures and equipment is still much higher than in busiest airports, as we have evidenced. The cost of air transportation has been increasing due to several factors, including security. Our results show that it is plausible to reduce them by working on the security. No work on security in small and medium airports has been found.

The case study in this paper presents a qualitative risk assessment and cost efficiency analysis of cargo security screening, considering six airports of different sizes and located in different regions, to evidence the differences due to the characteristics of the airports and the geopolitical context. Our research evidences the advantages of a risk based approach to security in small and medium airports instead of the traditional top-down approach. Due to

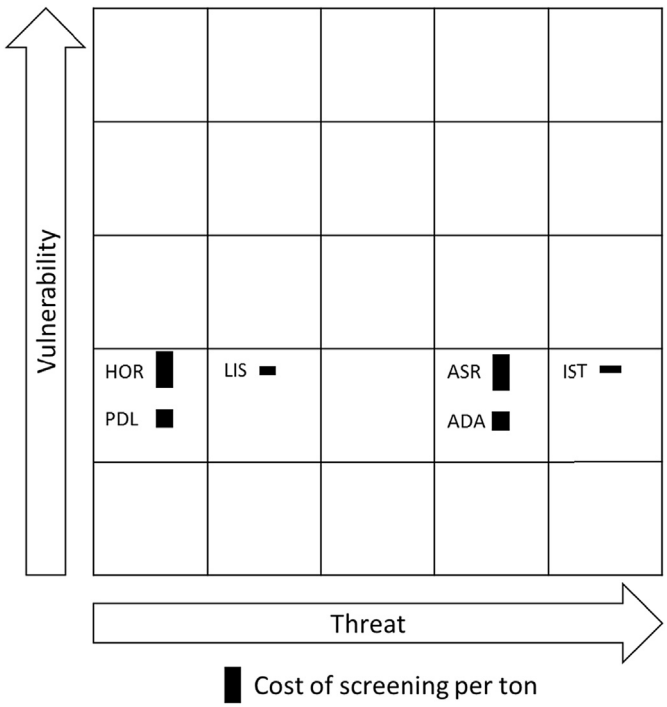

Fig. 4. Resulting risk matrix.

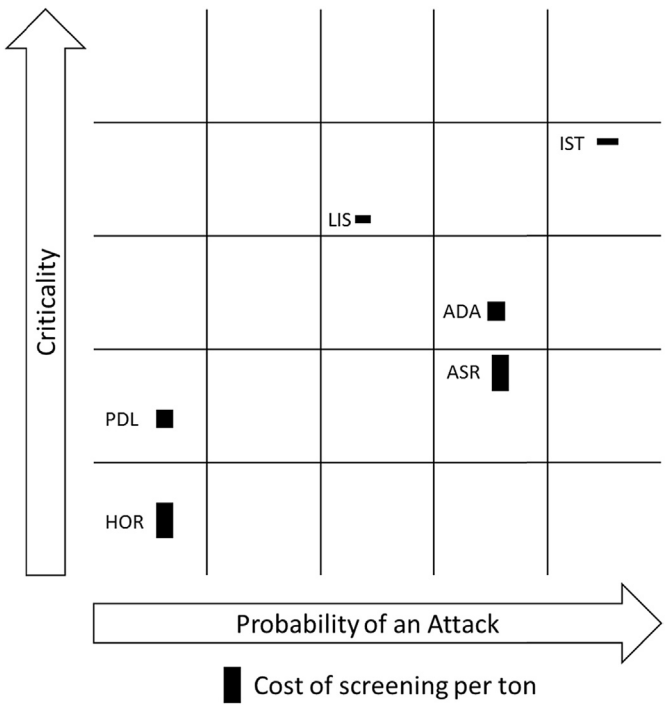

Fig. 5. Resulting risk matrix.

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003

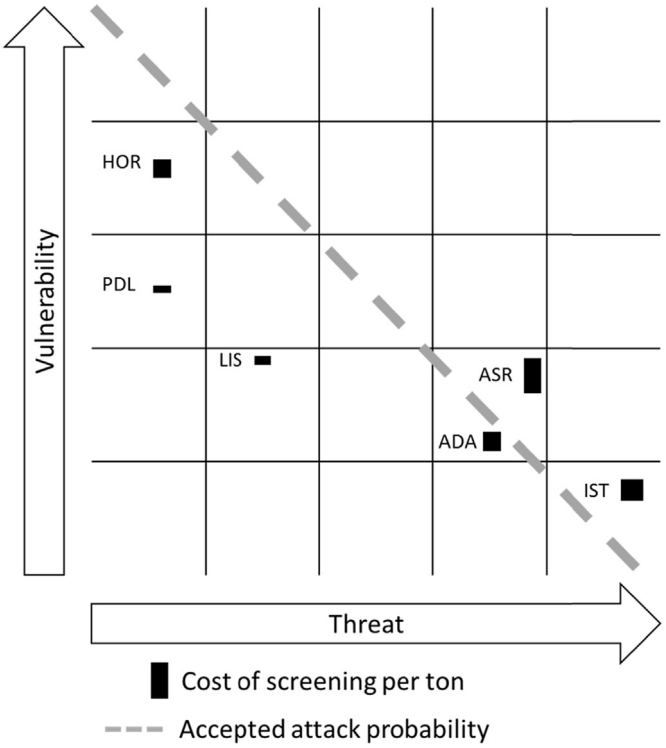

Fig. 6. Risk-based approach.

the fact of considering real elements of each airport, the risk based approach provides a closer and more accurate picture of the security needs, creating the conditions to the rationalisation of procedures and costs. Foremost, it is also pinpoints the case in which the prevalent security paradigm is insufficient and additional measures are required.

On the other hand, the reduction of security in low risk airports may increase the threat they are subject to, as the perpetrators may find new gaps to explore. We acknowledge this fact, and also acknowledge that moving from the current to a risk based paradigm will require further understanding as to prevent disruptions or unbalances in the airport security line protecting the air transportation network. For this risk to be eliminated or considered, different/more complex methodologies of risk assessment should be considered. To cope with the higher uncertainty of terrorist actions than random failure events in Risk Assessment, an Adversary Risk Analysis Methodology incorporating Game Theory, giving a possible reduction of Security in smaller airports a robust solution, together with Percolation Theory, to consider changes in the air transportation network instead of considering only the airport.

Probabilistic risk analysis methodologies including event trees, Bayesian networks, decision trees and game theory, can help predict intelligent actions from others, in this case, the perpetrators. Cano et al. (2016) considers that Event Trees are suitable for random event failures, but do not consider the intelligent adversaries as terrorists are. The author presented the Adversarial Risk Analysis with 4 basic counterterrorism models, where the Defender is a Decision Maker who has a portfolio of defence options, while dealing with an intelligent adversary, the Attacker, who, knowing the Defender options, can adjust its own actions.

A future research line is to develop methods and tools to deploy risk based approach in small and medium airports.

Acknowledgments

The authors thankfully acknowledge all the interviewees for all the insights and perceptive suggestions, constructive comments, and remarks, and for the financial support of Fundação para a Ciência e a Tecnologia (MIT Portugal Program scholarship PD/BD/113720/2015).

References

Cano, J., Ríos, D., Alessandra, I., 2016. Security Economics: an Adversarial Risk Analysis Approach to Airport Protection, pp. 359–378. http://dx.doi.org/10.1007/s10479-014-1690-7.

Cole, M., 2014. Towards proactive airport security management: supporting decision making through systematic threat scenario assessment. J. Air Transp. Manag. 35, 12–18. http://dx.doi.org/10.1016/j.jairtraman.2013.11.002.

Cox, L.A., 2008. Some limitations of "risk = threat x vulnerability x consequence" for risk analysis of terrorist attacks. Risk Anal. 28, 1749–1761. http://dx.doi.org/10.1111/j.1539-6924.2008.01142.x.

Domingues, S., Macário, R., Pauwels, T., Van de Voorde, E., Vanelslander, T., Vieira, J., 2014. An assessment of the regulation of air cargo security in europe: a belgian case study. J. Air Transp. Manag. 34, 131–139. http://dx.doi.org/10.1016/j.jairtraman.2013.10.001.

European Commission, 2015. EU Transport in Figures Statistical Pocketbook 2015. http://dx.doi.org/10.2832/91509.

European Parliament, Directorate-General for Internal Policies of the Union, Macário, R., Vieira, J., Mano, P., Renssen, S. van, Voorde, E. van der, Pauwels, T., Domingues, S., Dawkins, R., Todd, J., 2012. The Security of Air Cargo from Third Countries. http://dx.doi.org/10.2861/80196.

Gillen, D., Morrison, W.G., 2015. Aviation security: costing, pricing, finance and performance. J. Air Transp. Manag. 48, 1–12. http://dx.doi.org/10.1016/j.jairtraman.2014.12.005.

Gonzales, A.R., Schofield, R.B., Herraiz, D.S., 2005. Law Enforcement in the Post 9/11 Era Assessing and Managing the Terrorism Threat.

Halpern, N., Bråthen, S., 2011. Impact of airports on regional accessibility and social development. J. Transp. Geogr. 19, 1145–1154. http://dx.doi.org/10.1016/j.jtrangeo.2010.11.006.

Heifetz, S., 2011. Improve air cargo security with risk-based screening [WWW Document] Secur. Debr. http://securitydebrief.com/2011/05/24/improve-air-cargo-security-with-%851#axzz3tlwdO2LH (Accessed 9 October 15).

Innovative Compliance Europe Ltd, 2013. Air Cargo Security Compliance Requirements.

Macário, R., Vieira, J., Mano, P., Renssen, S., van, Voorde, E. van der, Pauwels, T., Domingues, S., Dawkins, R., Todd, J., European Parliament, Directorate-General for Internal Policies of the Union, 2012. The Security of Air Cargo from Third Countries. http://dx.doi.org/10.2861/80196.

McLay, L. a., Lee, a. J., Jacobson, S.H., 2010. Risk-based policies for airport security checkpoint screening. Transp. Sci. 44, 333–349. http://dx.doi.org/10.1287/trsc.1090.0308.

Pettersen, K. a., Bjørnskau, T., 2014. Organizational contradictions between safety and security - perceived challenges and ways of integrating critical infrastructure protection in civil aviation. Saf. Sci. 71, 167–177. http://dx.doi.org/10.1016/j.ssci.2014.04.018.

Prentice, B.E.B.E., 2015. Canadian airport security: the privatization of a public good. J. Air Transp. Manag. 48, 52–59. http://dx.doi.org/10.1016/j.jairtraman.2015.06.012.

Price, J.C., Forrest, J.S., 2013. In: Elsevier (Ed.), Practical Aviation Security Practical Aviation Security Predicting and Preventing Future Threats Second Edition, second ed.

Sadler, K., 2015. The role of regional airports comes to the forefront in European growth strategy 20. Retrieved May 22, 2015, from: http://www.internationalairportreview.com/19551/airport-news/the-role-of-regional-airports-comes-to-the-forefront-in-european-growth-strategy/.

Stewart, M.G., Mueller, J., 2014. Cost-benefit analysis of airport security: are airports too safe? J. Air Transp. Manag. 35, 19–28. http://dx.doi.org/10.1016/j.jairtraman.2013.11.003.

Unitn, W.S., Cano, J., Urjc, D.R.I., Williams, J., Collinson, M., Houmb, S.H., Snok, T.N., Rey, U., Carlos, J.,N.,C.T., 2013. Airport Requirements.

Wallace, R.J., Loffi, J.M., 2014. The unmitigated insider threat to aviation (Part 2): an analysis of countermeasures. J. Transp. Secur 7, 307–331. http://dx.doi.org/10.1007/s12198-014-0150-6.

Wegner, A., Marsh, D., 2007. EUROCONTROL Trends in Air Traffic, Volume 3-A Place to Stand: Airports in the European Air Network 3.

Williams, G., Bråthen, S., 2010. Air Transport Provision in Remoter Regions, Air Transport Provision in Remoter Regions. ASHGATE.

Wong, S., Brooks, N., 2015. Evolving risk-based security: a review of current issues and emerging trends impacting security screening in the aviation industry. J. Air Transp. Manag. 48, 60–64. http://dx.doi.org/10.1016/j.jairtraman.2015.06.013.

Please cite this article in press as: Amorim da Cunha, D., et al., Keeping cargo security costs down: A risk-based approach to air cargo airport security in small and medium airports, Journal of Air Transport Management (2017), http://dx.doi.org/10.1016/j.jairtraman.2017.01.003