Instituto Superior de Economia e Gestão
UNIVERSIDADE TÉCNICA DE LISBOA

**MASTER IN MANAGEMENT AND INDUSTRIAL STRATEGY**

# RFID AND THE INTERNET OF THINGS IN FREIGHT AND HANDLING OPERATIONS

**OCTÁVIO ANTUNES LOPES**

Supervised

by

**Professor Doutor José Miguel Aragão Celestino Soares**

**Professor Doutor Michael ten Hompel**

**Jury:**

**Chairman:** Professor Doctor Manuel Duarte Mendes Monteiro Laranja, assistant professor of Instituto Superior de Economia e Gestão from Univesidade Técnica de Lisboa

**Members of the Jury:** Professor Doctor José Miguel Aragão Celestino Soares, assistant professor of Instituto Superior de Economia e Gestão from Univesidade Técnica de Lisboa

Professor Doctor Michael ten Hompel, professor of Technischen Universität Dortmund, Germany

Professor Licentiate Fernando Miranda Borges Gonçalves Soares, invited associate professor of Instituto Superior de Economia e Gestão from Univesidade Técnica de Lisboa

**JULY 2010**

## Abstract

RFID technology (Radio Frequency IDentification) is an automatic identification method relying on storing and remotely retrieving data using devices (RFID tags or transponders) enabling the contactless identification of objects.

RFID has been around for decades but only during the last years has become one of the most promising research areas with more and more attention focused on it.

The retail sector had been leading the way with logistics applications, followed by some government agencies with identification systems and by different sectors of activity (pharmaceuticals, aircraft manufacturing, etc).

Together with the last technological developments, new ideas and concepts are generating new paradigms as the "*Internet of Things*".

The *"Internet of Things"* can be described as *"Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts"*.[1]

Also during the last decades, air transportation has become more and more important for people mobility and goods transportation in the global economy environment.

According to IATA[2], RFID can be used as a way to improve a range of airline business processes while cutting costs. IATA had developed a standard for RFID baggage tags and recommended practices and business cases for the use of RFID in baggage handling.

With this study it is planed to analyse the situation in the two main airports in Portugal (Lisbon and Oporto), based in Portway[3] ground handling operations, compare it with some actual developments, the E-Cab Project and IATA proposals and recommendations, and to evaluate scenarios and their feasibility in a near future.

**Keywords:** Logistics; RFID; Internet of Things; Freight; Baggage; Airport; Ground Handling

[1] Internet of Things in 2020, Roadmap for the future, Working Group RFID of the ETP EPoSS, 19 May 2008

[2] IATA – International Air Transport Association (www.iata.org)

[3] Portway, Handling de Portugal SA (www.portway.pt)

## Resumo

A tecnologia RFID (Radio Frequency IDentification) é um método de identificação automático de armazenamento e recuperação remota de informação, recorrendo a dispositivos (etiquetas ou transmissores-receptores RFID) que permitem a sua leitura à distância e sem necessidade de qualquer contacto directo com os objectos.

Sendo uma tecnologia já com décadas de existência, só durante os últimos anos é que se tem evidenciado como uma das mais promissoras , captando cada vez mais atenção por parte dos diversos actores .

O sector de retalho tem vindo a promover a sua divulgação, liderando o desenvolvimento de diversas aplicações logísticas e sendo seguido, durante os últimos anos, por algumas agências governamentais com o desenvolvimento de sistemas de identificação e por diversos outrossectores de actividade (farmacêutica, construção aeronáutica, etc).

Em simultâneo com os mais recentes progressos tecnológicos e com o desenvolvimento de conceitos mais inovadores, um novo paradigma tem aparecido com a designação da "Internet dos Objectos".

A "Internet dos Objectos" pode ser descrita como "objectos possuindo identidades e personalidades virtuais operando em espaços inteligentes usando interfaces inteligentes para ligar e comunicar em contextos sociais, ambientais e no seio dos utilizadores".

Também durante as últimas décadas, o transporte aéreo tem vindo a desempenhar um papel cada vez mais importante para a mobilidade das populações e para o transporte de mercadorias no ambiente da economia global.

De acordo com a IATA, as tecnologias RFID poderão vir a ser utilizadas com sucesso, reduzindo custos e melhorando um vasto conjunto de processos correntes no sector, tendo já desenvolvido alguns normativos e recomendações relativas à aplicação de etiquetas RFID na identificação e monitorização de bagagem

Com este trabalho pretende-se analisar a situação nos dois principais aeroportos Portugueses (Lisboa e Porto), baseada nas operações de *handling* da Portway, comparar os resultados obtidos com os desenvolvimentos actuais resultantes do Projecto E-Cab e com as propostas e recomendações da IATA, avaliando cenários e a possibilidade da sua concretização num futuro próximo.

**Keywords:** Logística; RFID; Internet dos Objectos; Carga; Bagagem; Aeroporto; *Ground Handling*

# CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# ABBREVIATIONS

| | |
|---|---|
| A/C | Aircraft |
| AHL | Advise If Hold |
| AWB | Air Way Bill |
| BFO | Before Flight Operation |
| BHS | Baggage Handling System |
| BMM | Baggage Manifest Message |
| BSM | Baggage Sorting Message |
| E2E | End to End |
| E2EC | End to End Chain |
| E-CAB | E-enabled Cabin and Associated Logistics for Improved Passenger Services and Operational Efficiency |
| FBL | Flight Boarding List |
| GPS | Global Position Satellite |
| GSA | Global Sales Agent |
| IATA | International Air Transport Association |
| ID | Identification |
| ICT | Information and Communications Tecnhologies |
| IoT | Internet of Things |
| LoS | Level of Service |
| LR | Long Range |
| MDA | Movement Daily Aircrafts |
| NOTOC | Notification to Captain |
| OHD | On Hand |
| PAX | Passanger |

| | |
|---|---|
| PDA | Personal Digital Agenda |
| PFO | Post Flight Operation |
| PIR | Propriety Irregularity Report |
| PTM | Passanger Transfer Manifest |
| RFID | Radio Frequency Identification |
| SITA | Société Internationale de Telecomunications Aéronautiques |
| TBT | Transfer Baggage Terminal |
| ULD | Unit Load Device |

## Special Thanks

With so many people who had gave me their unconditional support during my master studies, I would like to start expressing my gratitude to my family, special to my wife, Maria Eugénia, for her unconditional love and persistent support, to my son Bruno Miguel and my daughter Inês Sofia who were always marvellously smiling and pushing for my success.

I also would like to express my gratitude to Manuel Cruz for the opportunity and to Professor Michael ten Hompel for his support and for showing me the way to RFID and to the future.

My special thanks to my colleagues Nuno Miguel Mana and Miran Vrhovac, to Niko Hossain, Frank Neubauer and Volker Hasbach, and to my friend António Baptista, for their cooperation.

My special thanks also to Professor José Miguel Soares and to Professor Manuel Laranja for their availability and understanding during my preparation.

I also have to thanks to ISQ, IBERLog, Fraunhofer IML, Airbus and EADS, for their support, as well as to ANA and Portway for the availability and information during our visits to the handling operations.

Finally, I also would like to dedicate this work to the memory of my mother, Tilda, who always believed I could reach the moon, my father, Felismino, who was always listening all my projects with a happy and stimulated smile in his face, and to my grandfather Pepio who show me the high values of life.

# 1. Introduction

During the last decades the increasing growth in the number of air passengers and the resulting increase in checked baggage are straining the world's baggage handling infrastructure, as evidenced by major increases in reports of mishandled baggage across the globe.

As a result for the passenger, baggage is a continuing source of concern and stress from the moment they arrive in the terminal to the moment they leave their destination airport.

At arrival, insufficient or missing markings and the limited capacity of the baggage claim belts often leads to inconvenient waiting, confused and stressful situations as large numbers of passengers jostle for position at the edge of the baggage claim conveyor to recover their belongings. The recovery of lost baggage takes too much time and is often without success, as baggage often just "disappears" without trace.

The ground logistics time for short-range flights is presently unacceptably high in relation to flight time. At the moment it is difficult for airport service providers to handle the baggage within the given time for dispatching the aircraft. There is a very short time between last check-in for passengers and the take-off time of the aircraft, exacerbated by the tendency to dispatch short-range flights from remote areas of the airport and not directly at the boarding gate. This means that baggage has to move quickly from the airport gate to the apron where the aircraft is parked and the passengers are boarding.

On long-range flights the baggage logistic at airports is equally demanding due to huge amounts of baggage for a flight with feeder and connecting flights baggage adding to that of the originating passengers. This needs a significant time in order to unload the bags and ensure that the correct baggage and freight is put on the correct forward flight.

As a result the periodical analysis performed by independent international organizations reports a continuous increase of mishandling baggage in all regions.

In the United States the US Department of Transportation[4] has reported an increase from 3.84 mishandled bags per thousand enplaned passengers in 2002 to 6.73 in 2006, which means an effective 75 % increase over a four year period and representing an additional 2.3 million mishandled bags each year.

The AEA[5] reported that in Europe the incidence of mishandled bags has increased 14.6 % which represents an additional 1.2 million bags reported missing on arrival.

Also according to **AEA**, in Europe and during 2007, for a total of more than 377 millions passengers enplaned, the number of bags delayed upon arrival was of about 6.2 million, representing 1.66% of the passengers. In the top of the list there was TAP Portugal with 2.78% (229.642 bags for 8.250.411 passengers) and British Airways with 2.65% (1.140.990 bags for 43.064.346 passengers) followed by Alitalia and KLM, both with 1.97%, and Air France with 1.76%.

If we consider the IATA calculation which estimates that every missing or mishandling bag costs the responsible airline approximately $80 to $120, or an average of $100 per bag (labour and transportation costs), the impact for example in TAP Portugal operations costs, during 2007, will represent a total of:

229.642 bags * $100 per bag = $22.964.200 in 2007 (about 16 million Euros)[6]

Also according to IATA[7] analysis, in 2005 the single largest cause of baggage delay was

[4] www.dot.gov, last time consulted on the 2009/01/18

[5] Association of European Airlines, AEA (www.aea.be)

[6] 2009/01/21 rate

in transfer baggage mishandling (Table 1-1).

| Mishandling reasons | Distribution |
|---|---|
| Transfer baggage mishandling | 61% |
| Failure to load at originating airport | 15% |
| Ticketing error/passenger bag switch/security/other | 9% |
| Loading/Offloading error | 4% |
| Space-weight restriction | 5% |
| Arrival station mishandling | 3% |
| Tagging errors | 3% |

Table 1-1: World Tracer mishandling reasons in 2005[8]

For IATA, RFID can be used as a way to improve a range of airline business processes while cutting costs, including baggage management, and for that purpose some IATA projects and initiatives had been lunched during the last few years.

Also a standard for RFID baggage tags has already been developed by IATA and has recommended practices and business cases for the use of RFID in baggage and in-flight equipment management.

Additionally, IATA has also identified opportunities for the RFID management of aircraft parts and unit loading devices (ULDs) and reduction of aircraft turnaround times by up to 7% by speeding the loading process, reducing documentation, and providing more-accurate flight status information.

Again following the IATA analysis and conclusions, RFID technology brings a number of advantages when compared with barcode solutions (Table 1-2).

[7] RFID Business Case for Baggage Tagging, IATA Simplifying the Business, IATA 2007

| Capability & Cost | Bar Code | RFID |
|---|---|---|
| ↗ Flexibility<br>Line of sight Reading | ↗ Required | ↗ Not required |
| ↗ Ability<br>Number of simultaneous scan | ↗ One | ↗ Multiple and distinguish bags from other items |
| ↗ Accuracy | ↗ Read rate highly variable | ↗ Fully automated & accurate<br>↗ Read rate > 99% |
| ↗ Durability | ↗ Can be easily damage | ↗ More durable, withstands handling |
| ↗ Data support | ↗ No write capability | ↗ Possible to update data |
| ↗ Maintenance | ↗ High Maintenance | ↗ Low Maintenance |
| ↗ Cost | ↗ Cheap tag<br>↗ Expensive readers | ↗ Expensive tags<br>↗ Cheap readers |

Table 1-2: Bar code versus RFID Costs and Capability[8]

But the results of the research conducted by IATA showed the technology will rectify only 20% of baggage mishandlings.

To more effectively restrain the surge in baggage mishandling rates caused by growing volumes and heightened security measures, IATA launched a Baggage management Improvement Programme (BIP) in December 2007, which will provide volunteer stakeholders with a toolkit of 40 solutions designed to address the prime causes of baggage mishandling. These will include tools that help airlines and airports integrate systems, conduct training, improve baggage tag read rates, ensure baggage message availability and increase passenger awareness of the value of checking baggage in early, attaching proper labels and distributing weight evenly within a bag.

Resulting from the last technological developments and the attention given to RFID by the major business players, some pilot schemes started to be run in different airports and regions (Table 1-3).

| Trial / Implementation | Technology Used | Purpose | Status |
|---|---|---|---|
| Las Vegas McCarren Airport | UHF RFID | Security | Ongoing Implementation |
| ASTREC | UHF RFID | Proof of concept | Ongoing |
| Auto-ID centre @ HKG | UHF RFID | Proof of concept | Completed |
| TSA | UHF RFID | Global Interoperability | Completed |
| Hong Kong International | UHF RFID | Baggage sorting and reconciliation | Implemented, now adopting IATA RP |
| KLM / AF | UHF RFID | Baggage sorting | Implementing |
| SFO | UHF RFID | Baggage Security | Ongoing |
| Asiana Airlines | UHF RFID | Tracking | Completed |
| Delta Airlines | UHF RFID read only | Proof of concept | Completed |
| British Airways | HF RFID | Proof of concept | Completed |
| SIA, SIN, FRA, AUK | HF RFID | Baggage sorting | Closed |
| Heathrow Airport baggage collection | HF RFID | Baggage collection and delivery services. | Implemented |
| ASTREC | HF RFID | Baggage collection & Security | Implemented |
| Seattle Airport SeaTac Terminal | Microwave RFID | Tracking | Closed |

Table 1-3: RFID Trials and Implementations[8]

It is easily understandable and very clear to all stakeholders that RFID really represents a very promising technology with a large potential to improve the efficiency of handling operations in air transportation, reducing drastically the operations times with baggage handling and mishandling, speeding the loading and unloading, reducing the number of lost baggage, cutting costs and, simultaneously, improving the service quality to the passengers and their satisfaction level.

Also the vision for the new paradigm of the *Internet of Things* represents a promising way for the future and an opportunity for new smart products and systems in many different fields of applications, including air transportation.

All this circumstances and chances are actually in the mind of almost all the major players in the world and it is easy to see all the efforts in different initiatives in the US, Europe or even in Asia, with so many projects and pilots running at present moment and in Portugal, with the vision of the New Lisbon Airport, RFID could represent a tremendous opportunity to design, test, develop and production of a new generation of products, with high added value, for the global market in the field of air transport applications.

In line with the strategy commonly adopted in many regions in the world, the handling

operations in the Portuguese airports are actually managed by specialized and private companies, mainly by Groundforce[8] and Portway[9].

Portway is operating in Lisbon, Oporto, Faro and Funchal airports, with a staff of roughly 850 employees and providing a complete airport handling service. The company has a share capital of 9.500.000 Euros held at the moment entirely by ANA[10] and has succeeded in attaining market shares of close on 35% in the number of aircraft movements handled, and more than 50% in the total number of air cargo movements handled at Portuguese airports.

In 2006 Airbus, based on the RFID opportunities and concepts and in cooperation with 34 others partners in Europe (including Centro IBERLog in Portugal), had submitted a proposal for an Integrated Project to be funded by the European Commission. The proposal, identified as *E-Cab Project "E-enabled Cabin and Associated Logistics for Improved Passenger Services and Operational Efficiency"* and approved in 2007, was run with the involvement of some Portuguese investigators.

The main goal of *E-Cab, E-enabled Cabin and Associated Logistics for Improved Passenger Services and Operational Efficiency*, was to set up the technical framework of processes, technologies, architectures, functions and associated services to provide:

- Passengers with office/home like services in the cabin,
- Cabin crew with efficient and flexible means of handling service logistics,
- Airlines with cabin and cargo information management tools using air-to-ground

[8] Groundforce Portugal (www.groundforce.pt)

[9] Portway, Handling de Portugal SA (www.portway.pt)

[10] ANA, Aeroportos de Portugal, SA (www.ana.pt)

communications, and

- Airports with e-enable ground infrastructure management tools.

It was also a goal of the E-Cab Project to provide the European aeronautical industry with the ability to produce the information management system of the future aircraft cabin for improved passenger and crew convenience.

Under the vision of E-Cab it was estimated that in the near future it will be possible to:

- Reduce passengers' moving time in airport to less than 30 minutes,
- Reduce boarding time by 20%,
- Reduce passengers impact on aircraft turnaround time by 30%,
- Reduce lost baggage compensation (2,350 M€ loss in 2002).

All my main activities in the project were focus in the improvement of ground services by the use of innovative technologies and procedures, special **Radio Frequency IDentification** technologies, for baggage identification and control.

Within the present **Final Master Project** (*RFID and the Internet of Things in Freight and Handling Operations*) it is planed to produce a study of the situation in the two major airports in Portugal (Lisbon and Oporto), based in **Portway** ground handling operations, compare it with the actual developments, the E-Cab and IATA proposals and recommendations, and to evaluate the opportunity and feasibility of RFID technologies to improve the efficiency of the handling operations.

# 2. Technological overview

RFID technology (Radio Frequency IDentification) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders, enabling the contactless identification of objects.

A RFID tag is an object that can be applied to or incorporated into a product, animal or person for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader.

Most RFID tags contain at least two parts: an integrated circuit for storing and processing information, modulating and demodulating a Radio Frequency signal and other specialized functions, and an antenna for receiving and transmitting the signal.

Chip less RFID allows for discrete identification of tags without an integrated circuit, thereby allowing tags to be printed directly onto assets at a lower cost than traditional tags.

Radio Frequency Identification technology is already being used in many processes in both the private and public sectors.

A real boom in RFID has developed since about 2000 driven by technical progress in microelectronics, with new groups of users becoming deeply involved with new application possibilities which are now being implemented.

The retail sector had been leading the way with logistics applications, followed by some government agencies with identification systems such as the electronic passport and the planned digital personal identity card.

Other sectors of activity, such as pharmaceuticals and aircraft manufacturing, have seized on this trend and are also discussing innovative applications intensively.

Due to its diverse application possibilities, RFID as a cross-sectional technology holds great innovation and growth potential and not just for users but also for providers of technological products and services.

Under the actual challengeable technological and innovation developments and trends, it is easily foreseeable that in the coming near future, any object will have for sure a unique way of identification, commonly know in computer sciences as "Unique Address", enabling the creation of an addressable continuum of any *thing* or object around us (computers, sensors, actuators, mobile phones, etc).

Having the capacity of addressing each other and verifying their identities, all these objects will be able to exchange information and, if necessary, actively process information according to predefined schemes, which may or may not be deterministic.

Coming to a definition for *"Internet of Things"*, which has still some fuzziness but considering the functionality and identity as central, it is possible to describe it as *"Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts"*. A different definition that puts the focus on the seamless integration could be formulated as *"Interconnected objects having an active role in what might be called the Future Internet"*.[11]

The semantic origin of the expression is composed by two words and concepts: *"Internet"* and *"Thing"*, where *"Internet"* can be defined as "*The world-wide network of interconnected computer networks, based on a standard communication protocol, the Internet suite (TCP/IP)*", while *"Thing"* is "*an object not precisely identifiable*".

[11] Internet of Things in 2020, Roadmap for the future, Working Group RFID of the ETP EPoSS, 19 May 2008

Therefore *"Internet of Things"* will mean *"a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols"*.

The set of actions that the future objects should be able to do is a matter of research. In general, enabling the object to know its common properties such as creation, recycling, transformation, ownership change, or use for different purposes will enable objects or things of the physical world to interact actively and decisively with the environment.

# 3. Analyse of the international situation

For a century, air travel has grown from being an adventure through the height of the "golden age" when the mere ability to travel accorded a person significant privilege to end it up on the actual situation where the enormous volume of passengers and the increasing complexity of airports have reduced air travel quality.

Figure 3-1: From a travel adventure to a travel experience in the "Golden Age"[12]

Figure 3-2: Today's travel experience[13]

The exponential increasing on the volume of passengers, together with more and more complex new airports and in addition with the recent security issues, have diminished travel quality to the point where it directly affects all passengers, whether they travel in executive classes, economy classes, long or short range or even in business aircrafts.

In the next 20 years air traffic is predicted to triple and with the introduction of new large

[12] E-Cab Project Proposal

aircrafts, airport congestion is expected to be significant if *status quo* is maintained in terms of passenger services and logistic processes (Figure 3-3)[13].

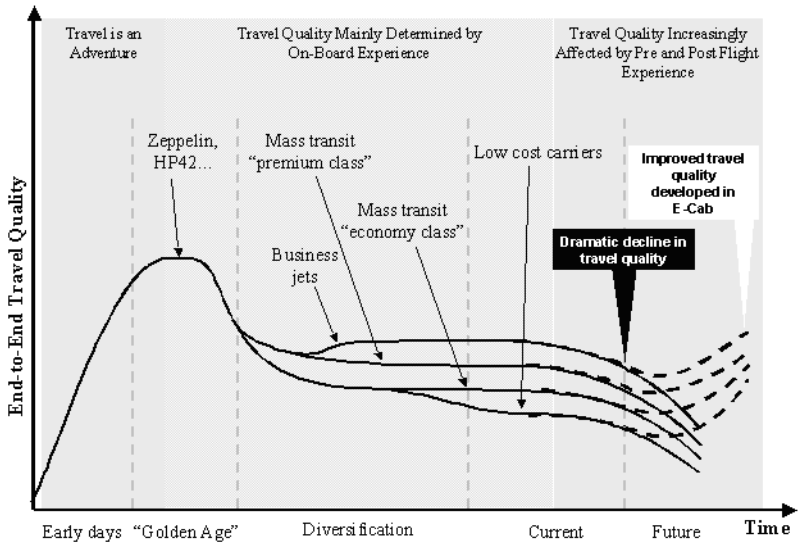


Figure 3-3: The progression of end-to-end travel quality[14]

Under this scenario, the resulting increase in checked baggage are straining the world's baggage handling infrastructure, as evidenced by major increases in reports of mishandled baggage across the globe, requiring more staff (approximate 5 percent more per year[14]) to handle the increase in the number of checked bags now driven by the new safety regulations.

The AEA[15] reported that in Europe, the incidence of mishandled bags has increased 14.6 percent which represents an additional 1.2 million bags reported missing on arrival. In the United States, the US Department of Transportation has reported an increase from 3.84 mishandled bags per thousand enplaned passengers in 2002 to 6.73 in 2006 (75 percent

[13] E-Cab Project

[14] RFID Business Case for Baggage Tagging; International Air Transport Association (IATA 2007)

[15] Association of European Airlines

increase over a four year period and representing an additional 2.3 million mishandled bags each year[16]).

In "The Baggage Report", for 2006 SITA had estimated approximately 34.3 million bags mishandled globally, costing the airline industry US $3.8 Billion. Passenger volume is projected to increase to more than four billion by 2019[17] and, at the current mishandled bag rate it will result in nearly 70 million mishandled bags per year.

Within the main factors responsible for mishandled baggage according to IATA[18], airlines had identified two important reasons:

- Barcode reading problems which is causing 9.97% of all mishandled baggage, and
- Failure to receive a BSM[19] message as contributing to a further 10,9% of mishandled.

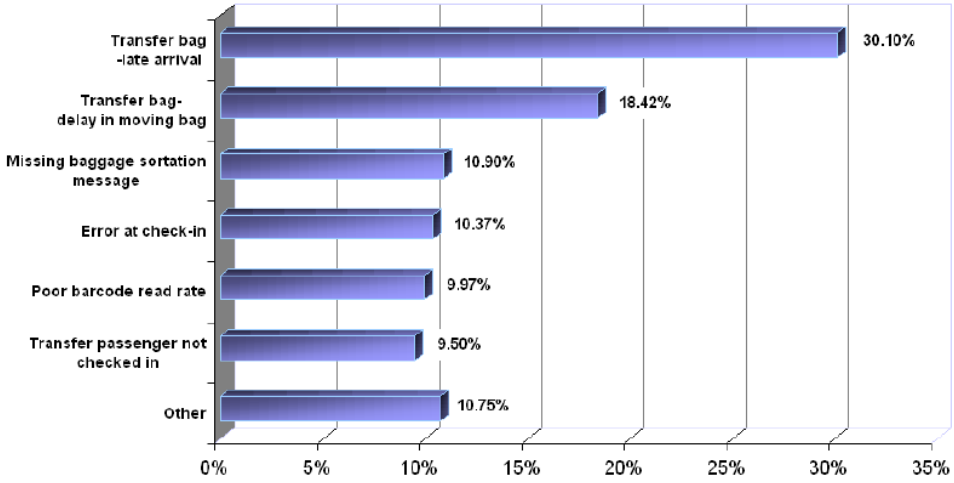


Figure 3-4: Reasons for baggage mishandling[18]

[16] The Baggage Report 2007, SITA

[17] IATA Passenger and Freight Forecasts 2006-2010

[18] RFID Business Case for Baggage Tagging – IATA 2007

[19] BSM – Baggage Sortation Message

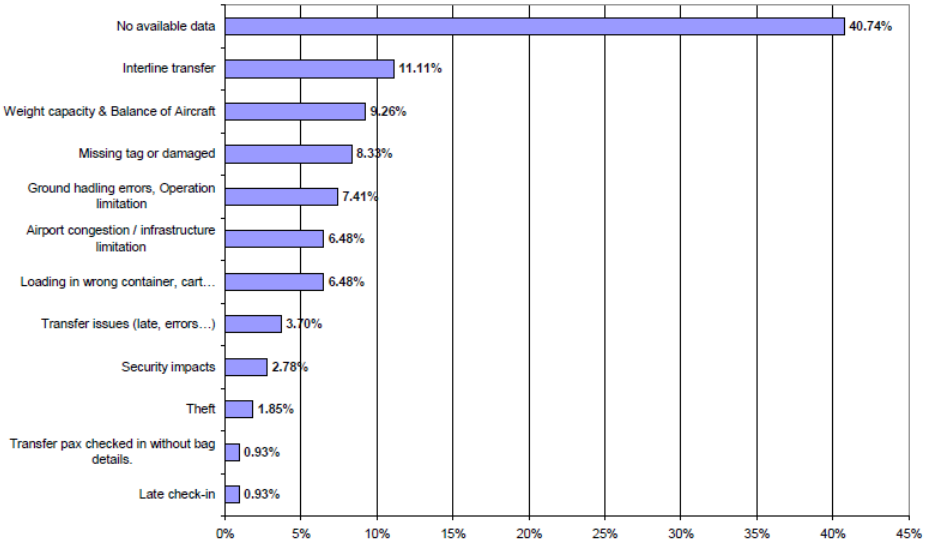


Figure 3-5: Categories of mishandling in "other" group[18]

Since the cost of a mishandled bag is approximately US $80 to US $120, it is clear that airports can significantly reduce operational expenses by reducing the number of mishandled bags. But it is also clear to everyone that arriving with baggage is one of the most important factors in having a pleasant trip for the passengers which means that, in addition to the hard costs associated with physically managing of the mishandled baggage, a mishandled bag causing customer frustration and delay, will directly reduce customer satisfaction and loyalty normal associated with a specific airline or a specific airport.

In parallel with the transport of passengers, the aviation promoters early started looking for other practical uses of the aircraft, special how to use them as carriers of freight.

A first practical demonstration of air freight occurred in November 1910 when a department store shipped a bolt of silk by air from Dayton to Columbus, Ohio[20], beating the railroad express between the two cities as reported at that time by a local newspaper.

[20] U.S. Centennial of Flight Commission

In 1919 the American Railway Express used a converted Handley-Page bomber in an attempt to fly 500 kilograms of freight from Washington, D.C., to Chicago but a frozen radiator forced the plane to land in Ohio.

During the 1920s, the volume of freight shipped by air grew significantly with only 20,000 kilograms shipped in 1927 but by 1929 the figure had grown to about 115,000 kilograms and by 1931 to more than 450,000 kilograms per year.

Simultaneously in 1925 Henry Ford's express company carried 450.000 kilograms of freight for the Ford Company and averaged more than 1.36 million kilograms by the end of 1929. Also the U.S. Post Office shipped additional air freight.

Despite all the efforts and attempts to organize air freight airlines only after the World War II a first commercial airlines emerged to all-air cargo business and only in the 1980s a new airline changed the face of the air freight business: Fred Smith a young entrepreneur who believed that combining passenger air traffic with freight air traffic was not the most efficient way of doing business since the route patterns for the two were totally different and because combining freight with passenger traffic slowed down cargo delivery.

With the backup of a lot of financial support, Fred Smith built a hub in Memphis, Tennessee, exclusive for his freight air delivery operations with his guarantee of a next-day delivery service. The company, called Federal Express, began operations in April 1973, by 1982 had as many as 76 aircraft and in 1983 reported revenues of $1 billion.

In 1989, after acquiring Tiger International, Inc., the two airlines merged and, as a result, Federal Express became the world's largest full-service all-cargo airline. In 1994, the company officially changed the name of its operating division to FedEx.

At the turn of the century, the air freight industry remains a mix of dedicated large

companies (such as FedEx, UPS and DHL), small-time operators and passenger airlines that operate cargo divisions, with a global volume of 28.8 million tonnes in 2001 and 40.5 million tonnes in 2008[21].

[21] IATA Fact Sheet: Industry Statistics, update on 12/2009

# 4. Analyse of the Portuguese situation

## 4.1 The Ground Handling Operations in Lisbon and Oporto Airports

In order to have a proper understanding of the possibilities to improve the processes in Ground Handling Operations through the use of RFID technologies, it is fundamental start to know and understand the different steps of the actual processes, considering the state of the art of E2EC[22] of freight and baggage services, at a typical middle size airports such as Lisbon and Oporto.

For that purpose, the operations were analysed in two main phases:

- BFO, Before Flight Operation, and
- PFO, Post Flight Operation,

for the activities of:

- Freight Services, and
- Baggage Handling.

With the final results acquired during the analysis to the different operations for identification, tracking, tracing and reconciliation of freight and baggage, it is expected to be possible to provide a reference for service improvement proposals based in RFID technologies.

### 4.1.1 Freight Services in the E2EC

#### 4.1.1.1 Before Flight Operation – BFO

The operations required to load the freight in the aircraft cargo compartment, since the

[22] E2EC – End To End Chain

moment when the need is identified by the Forwarder, are grouped in the following steps:

**Commission**

The Cargo Forwarder Staff retrieves the air freight assigned to the particular flight from the storage racks in the Forwarder's Warehouse, located outside the airport.

The freight's size and weight are measured and the Cargo Forwarder Staff moves the respective freight to the Warehouse Inbound Buffer.

The data of each distinct freight item, or group of equal items, is documented by a consignment note known as the Air Way Bill (AWB). The freight items are described by the consignee's name, destination, weight, size, etc and each AWB is attached to the related shipping order.

The Cargo Forwarder Staff checks the time schedule and accuracy of each shipping order and informs the Forwarder's Commissioning Staff about its content.

The shipment's total size and weight, computed from the referent data by the Cargo Forwarder Staff, are introduced in the transportation request.

The Cargo Forwarder Staff, previously informed about the required ULD[23] type, fetches an empty ULD from the Forwarder's ULD Depot and, according to the shipping data, loads the freight assigned to the particular flight into the ULD at the Warehouse Inbound Buffer.

The transportation request is handed to the Forwarder's Transportation Department and an adequate transportation vehicle is supplied.

The commissioned ULD freight, ready for transportation to the airport, is loaded as

[23] ULD – Unit Load Device

prepared into the transportation vehicle and the freight AWB are forwarded to the Customs Office, located at the airport or outside the airport.


Figure 4-1: ULD – Unit Load Devices on the way to the aircraft

The Forwarder's Transportation Staffs moves the freight to the Customs Office.

**Airport Cargo Information**

The Cargo Handling Company receives in advance the Flight Boarding List (FBL) message from the Airline Company or from the Global Sales Agent (GSA).

The Flight Boarding List contains the flight associated freight data, such as the nature of goods, size, weight, air waybill reference, ULD type, and accordingly assigned loading priority.

The Cargo Handling Company informs in advance the Aircraft Capitan that dangerous e/or perishable goods will be transported onboard the aircraft by sending him the so called NOTOC message.

The Freight shall be delivered to the Cargo Handling Company at least two hours before the flight schedule.

**Customs Office**

The Customs Office compares the AWB and other declarations to the actual freight inventory by crosschecking all available information from the associated documents and, eventually, the Customs Office Staff performs also a physical inspection of the goods.

The freight delivery can proceed to the Cargo Handling Company at the airport after the Customs Clearance.

**Transhipping**

The freight arrives at the airport, next to the Cargo Handling Company Reception Warehouse and the Cargo Handling Staff unloads the freight onto the pallets at the Reception Warehouse Outbound Buffer. The ULD are placed on the pallets too for a better handling inside the warehouse.

Portway has two separated warehouses:

- The Reception Warehouse where they receive the freight for exportation, providing the sortation and interim storage of the freight assigned to different flights. Before a flight departure, the associated freight is assembled at the Reception Warehouse Inbound Buffer for stacking in ULD or on pallets, and transfer to the Central Warehouse Inbound Buffer, located 500 meters away, before the transportation to the aircraft stand.
- The Central Warehouse where they receives the freight for importation from the arrived flight. The freight is unloaded at the Central Warehouse Outbound Buffer, disassembled and delivered to the expedition Forwarding Agents.

The Warehouse Agent visually inspects the freight condition about any eventual damage and he can refuse to receive the damaged freight if assesses that its condition can further

deteriorate. The inspection report is added to the freight documentation.

The Warehouse Agent crosschecks the freight data from the AWB, the Flight Boarding List, customs papers and the inspection report, allowing the freight entrance into the Reception Warehouse if the data is coherent.

The Airline Company can ask the Cargo Handling Company to retrieve all the freight data from the respective documents and introduce it into the information system.

The Warehouse Agent measures the incoming freight's weight and size to confirm the information provided by the Forwarding Agent. The difference between the weight stated by the Forwarding Agent and the one measured in house can not be more than 5%. The sticker showing the measured weight value is thereby printed and attached to the freight and the complete information is registered in the measurement report.

The decision for a X-Ray scan of the receiving freight will depend on the Cargo Handling Company's internal classification of the forwarder, the Airline Company demands and the air transport regulations at the freight destination.

Some Airline Companies only accept a complete security scan by the Cargo Handling Company, while others accept the forwarders' too. Moreover, as additional security measure, some Airline Companies require the 48 hours freight quarantine (e.g. when the destination is Israel).

After the freight reception, the Warehouse Agent produces a preliminary freight manifest, informing the Central Warehouse and the Airline Company or its Global Sales Agent that the freight arrived at the Reception Warehouse and is accepted by the Cargo Handling Company.

The information is sent to the Airline Company, or to the Global Sales Agent, by a

standard IATA message.

After build up, the pallets with freight references are registered in a paper document.

In this process the Cargo Handling Company does not use an identification technology. The Warehouse Agent controls the process by checking every item and document without any support on barcodes or other ID system.

The pallets with freight are provisionally stored in the dedicated Reception Warehouse area assigned to the Airline Company, in different storage areas according to the intended storage type, such as for regular and express freight, quarantine, perishable and dangerous goods, etc. Moreover, the Central Warehouse has the areas providing special climate conditions, storage of valuable goods, animals and plants.

**Interim Storage**

The Warehouse Agent seeks the freight departure schedule for the particular flight assisted by the Cargo Handling Company from the information system.

According to the received information, the Warehouse Agent asks a corresponding number of empty ULD from the Ground Transportation Department.

In the dedicated Reception Warehouse storage area, the Agent takes the respective freight off the storage racks assigned to the Airline Company and places it near the empty ULD.

The Warehouse Agent controls the process by checking every item and documents without any support in a barcode or other ID technology or system, producing, at the end of the process, a paper report.

The Reception Warehouse pallets are built up from different kind of wood, depending on their final destination (Asia, North America or Europe).

**ULD Loading Inside Warehouse**

The ULD stacking order depends on the assigned freight loading priority and the flight schedule.

The ULD management is whether performed by the Airline Company or the subcontracted ULD Management Company, such as the example of "Jettainer" in Germany. The Cargo Handling Company guarantees that the used ULD type and the referent IATA number correspond to the specification issued by either of them.

The Central Warehouse Operation Centre informs the Warehouse Agent to retrieve the freight from the warehouse. The Warehouse Agent retrieves the loose freight from the racks or fetches the previously assembled ULD in the dedicated area of the Reception Warehouse assigned to the Airline Company.

After moving the retrieved freight to the Reception Warehouse Inbound Buffer, the Warehouse Staff starts the freight items stacking into the ULD. Each item placed inside the ULD is first identified by the Warehouse Agent.

The Warehouse Agent manually copies the freight AWB number and weight into the paper report. The report called ULD Manifest provides the list of freight items inside the ULD. The process duration is considerable and the procedure is susceptible to errors.

The system shall acquire their identities through a wireless network (Wi-Fi, Wi-Max, etc.) for automatic registration in the corresponding digital ULD inventory list. As soon as the ULD manifest is concluded, it shall be available in the electronic form (by the system) to the Handling Company Load Control. The system shall equally operate with the other means of containerized transportation such as pallets and boxes.

At this moment the ULD prepared for transport is transferred to the delivery buffer.

**Transportation to Apron**

The announced aircraft availability triggers the freight transportation request and the transportation order is sent to the Ground Transportation Staff with the information concerning which delivery buffer to pick up the freight.

Usually the freight is available at the Central Warehouse Inbound Buffer and is collected by the Ground Transportation Staff according to the instructions.

The Ground Transportation Staff does not necessarily collect all the freight at once, since some may be still in preparation.

Usually the freight and baggage arrive separately at the aircraft stand, since the baggage is loaded last because of the possible late checks-in and baggage off-loads.

**Loading into Aircraft**

The Ramp Agent confirms the final version of the loading instruction document with the Handling Company Load Control and the Ramp Staff moves the lifter already available in the ramp area in the position to access the aircraft cargo compartment door.

The Ramp Staff moves the ULD already available in the ramp area next to the lifter and queues the ULD in the right order, according to the loading instruction.

Provided by the system with the information about the ULD content and weight, the Ramp Staff checks the preliminary flight manifest and if necessary updates it. The updated flight manifest is sent back to the Handling Company Load Control to recalculate the final loading instruction and the dollies will be moved closer to the aircraft cargo compartment.

The Ramp Staff transfers the ULD onto the lifter and elevates the lifter up to the cargo compartment door.


Figure 4-2: Loading Freight into the Aircraft Cargo Compartment

Before the ULD enters the cargo compartment door, the Ramp Staff performs a crosscheck of the loading instruction with the ULD unique IATA reference number.

The Ramp Staff moves the approved ULD into the cargo compartment, first automatically then manually, next to its final position and locks the ULD (all the ULD are locked to avoid unwanted movement during the flight at its final position). This procedure is repeated until completing the loading of all ULD.

The Ramp Staff lowers de lifter to the ground, removes it from the ramp area, and after all the ULD are loaded into the aircraft, they closes the cargo compartment door and informs the Ramp Agent that everything is loaded. The Ramp Staff clears the ramp area.

#### 4.1.1.2 Post Flight Operation - PFO

**Unloading from Aircraft**

After the aircraft completing the parking, the lifter, already available near the aircraft stand, is brought to the position to access the cargo compartment door.

The freight transportation dollies are parked in front of the lifter and after taking over the

freight documentation, the Ramp Agent sends it to the Central Warehouse Operation Centre to inform the Forwarding Agent about the freight arrival and pick-up time interval.

The Ramp Staff crosschecks the loading instruction against the unique ULD IATA reference number and unlocks the ULD from its hold position.

The ULD is brought to the cargo compartment entrance and then retrieved by sliding onto the lifter. The lifter carries the ULD to the ground and the Ramp Staff transfers the ULD from the lifter to dolly. The procedure is repeated until completing the unloading.

The Ramp Staff informs the Ramp Agent that everything is unloaded and the ULD are ready for transportation to the Outbound Buffer.

The Ramp Staff prepares the ramp area for loading of the next flight.

**Transportation to Warehouse**

The Ramp Agent sends a transportation order to the Ground Transportation Staff indicating the aircraft stand and the ULD inventory placed on the dollies.

The Ground Transportation Staff collects the freight according to the instruction.

The freight and baggage leaves the aircraft stand separately.

The transportation service carries the freight to the Central Warehouse.

**Unloading and Storage in Warehouse**

The freight transported by the Ground Transportation Staff arrives at the Central Warehouse Outbound Buffer, where is unloaded from the dollies.

The Warehouse Agent checks the freight delivery mode and the ULD are broken down into the single packages, except when the Forwarding Agent requests to acquire the entire ULD.

The Warehouse Staff fetches the necessary number of empty pallets. The ULD to remain assembled are loaded directly onto the pallets.

The loose freight items are first placed in the special boxes. Each item is thereby identified by the Warehouse Agent.

The Warehouse Agent manually copies / crosschecks the freight AWB number into / with the paper report. The report provides the freight inventory confirmation. The process duration is considerable and the procedure is susceptible to errors.

The empty ULD are forwarded to the storage / maintenance area and the Warehouse Agent informs the Central Warehouse Operation Centre about the freight pick-up time interval.

Depending on the pick-up time, the freight is stored in the Central Warehouse until it is picked-up or directly brought to the handover counter.

Following the delivery instruction, the Warehouse Agent stores the loose freight items onto the racks or parks the ULD in the dedicated Central Warehouse area assigned to the respective Airline Company or the Forwarding Agent. The storage location is registered.

The Customs Office is notified and the necessary documents are forwarded.

**Empty ULD Storage**

The empty ULD are transported by the Ground Transportation Staff to the ULD storage area where, after inspection, they are eventually sent to maintenance.

Otherwise, they are registered as available by the system and this information is sent to the responsible ULD Management Company or to the Airline Company.

**Informing Cargo Forwarder**

After freight unloading and storage in the Central Warehouse, the Forwarding Agent gets the freight arrival confirmation from the Central Warehouse Operation Centre, needed for the Customs Office clearance.

**Freight Delivery**

The Cargo Handling Company receives the clearance to release the freight from the Customs Office.

The Warehouse Agent checks the storage location in the register and sends there the Warehouse Stuff to retrieve the freight.

The freight from the different Forwarding Agents is loaded onto the separate pallets and thus transported to the handover counter. There, the freight is crosschecked again with the pertinent documents before loading into the Forwarding Agent's transportation vehicle.

The vehicle loaded with the designated freight leaves.

### 4.1.2 Baggage Handling in the E2EC

#### 4.1.2.1 Before Flight Operation – BFO

**Loading Bulk Baggage into Aircraft**

The Ramp Staff moves the baggage belt already available in the ramp area to the aircraft baggage compartment door and after they moves the loaded dollies already parked in the ramp area near to the baggage belt.

The Ramp Staff first transfers the non-transfer baggage from the dollies onto the belt, piece by piece. On the other end of the belt, the Ramp Staff retrieves the baggage from the belt and puts it inside the baggage compartment. After completing the non-transfer baggage loading, the Ramp Staff starts the transfer baggage loading, placing it

intentionally next to the compartment door.

All the baggage is tided up and secured by nets to avoid the unwanted movement during the flight.

Figure 4-3: Loading Bulk Baggage into Aircraft

After all the baggage is loaded into the aircraft, the Ramp Staff closes the aircraft baggage compartment doors, informs the Ramp Agent that everything is loaded and clears the ramp area.

**Off-Loading Bulk Baggage (No Show Passenger)**

After receiving clearance from the Handling Company Operation Centre, the Passengers Boarding Staff can open the boarding gate and start the boarding procedure.

During the boarding procedure dedicated software automatically updates the list of passengers remaining to board, after each passenger delivers the boarding ticket to the Boarding Staff. A counter and the list are displayed in the gate's monitor.

When the number of such passengers is reduced and the time to close the gate is coming, the Boarding Staff communicates via radio with the Ramp Staff to inform them in advance about the possibility to have a "no show passenger" situation, and the Ramp Staff starts searching for the possible respective baggage inside the aircraft baggage compartment.

Such proactive procedure is performed with the objective to minimize a time delay caused by the eventual "no show passenger" situation.

The final decision regarding the boarding gates closure belongs to the Airline Company. In case of the "no show passenger" situation, the Airline Company orders the baggage off-loading. If the Airline Company does not have a local embody at the airport, the decision is made by the Aircraft Captain.

The Ramp Staff moves the baggage belt (still) available in the ramp area to the aircraft cargo compartment door and enters in the aircraft baggage compartment to search for the already identified baggage. The Ramp Staff has to search inside the aircraft baggage compartment, checking every baggage identity, piece by piece, until the moment they found the wanted one.

The Ramp Staff places the baggage found in the aircraft onto the belt, retrieves the baggage from the belt, transfer it on a dolly for further transportation and the unloaded baggage is brought back to the Baggage Handling Terminal.

The Ramp Staff closes the aircraft baggage compartment door, informs the Ramp Agent that everything is off-loaded and clears the ramp area.

**Loading Baggage ULD into Aircraft**

The Ramp Agent confirms with the Handling Company Load Control the final version of

the loading instruction document and the Ramp Staff moves the lifter, already available in the ramp area, in the position to access the aircraft cargo compartment door.

The Ramp Staff moves the ULD already available in the ramp area next to the lifter and queues the ULD in the right order, according to the loading instructions.

The Ramp Staff transfers the ULD onto the lifter and raises the lifter to the level of cargo compartment.

Before the ULD passes the cargo compartment door, the Ramp Staff performs a crosscheck with the load instruction provided by the Handling Company Load Control and the ULD is approved for loading.

The Ramp Staff moves the ULD into the cargo compartment to fit into its final position first automatically then manually and locks the ULD at its final position to avoid unwanted movement during the flight.

This procedure is repeated until loading of all the ULD is completed.

The Ramp Staff lowers de lifter, removes it from the ramp area and after all the ULD are loaded into the aircraft, they closes the cargo compartment door and informs the Ramp Agent that everything is loaded.

The Ramp Staff clears the ramp area.

**Off-Loading Baggage ULD (No Show Passenger)**

In case of the “no show passenger” situation, the Airline Company orders the off-loading of the baggage.

The Ramp Staff communicates with the Handling Company Load Control to obtain the information in which ULD the baggage is found.

The Load Control informs the Ramp Staff about the corresponding ULD number and the

position in the aircraft (which baggage is placed in each ULD is known by a Bingo Chart).

The Ramp Staff moves the lifter (still) available in the ramp area in the position to access the aircraft cargo compartment door, moves the lifter up and opens the aircraft cargo compartment doors.

The Ramp Staff unlocks the ULD inside the aircraft cargo compartment.If the ULD is not stored at the cargo compartment entrance area, the Ramp Staff has to bring it into this position. The ULD is retrieved from the cargo compartment entrance area and moved onto the lifter.

The Ramp Staff searches for the particular baggage inside the ULD. If the baggage is not found, other ULD have to be removed and searched. This situation occurs if the information available in Bingo Charts is incorrect. The process of removing stubs from the baggage tags and sticking them into the Bingo Chart can easily produce errors, such as missing a stub or sticking it in a wrong document.

After the Ramp Staff founds the baggage, it is interim stored on the lifter. The Ramp Staff moves the ULD into the cargo compartment to fit into its original position, first automatically then manually, and locks the ULD at its final position.

The Ramp Staff lowers the lifter, removes it from the ramp area and the unloaded baggage is brought back to the Baggage Handling Terminal.

After all the ULD are loaded into the aircraft, the Ramp Staff closes the cargo compartment door and informs the Ramp Agent that everything is loaded. The Ramp Staff clears the ramp area.

**Collect Baggage Dollies / ULD**

The Ground Transportation Coordinator receives with anticipation the updated information from the Airport Authority with the relevant data about the assisted flights, such as aircraft type, updated landing and take-off schedules, destination, number of passengers, aircraft stand reference, etc. With this information, the Transportation Coordinator assesses all human and non-human resources allocation for each flight.

The process preparation is performed by gathering the information through the interactive communication with the available software applications. A spreadsheet is used to register the assessed allocations 3 times a day, whereby they are sent by e-mail to the Ground Transportation Manager.

The Baggage Reconciliation Staff asks the handling company Ground Transportation Department for a tractor and empty dollies / ULD for baggage transportation from the Baggage Handling Terminal to the aircraft stand.

The Ground Transportation Staff transports the empty dollies / ULD to the Baggage Handling System handover place.

**Loading Baggage into Dollies / ULD**

After check-in is open, usually 2 to 4 hours before the flight schedule, the Ground Handling Staff prepares to receive baggage from the Baggage Handling System.

If the Check-in Operator mistakenly inserts the baggage into the Baggage Handling System without the identification tag, the system will not recognize the baggage and later will never be possible to link it with the corresponding flight and passenger.

At Lisbon Airport the Baggage Handling System (BHS) is managed by Siemens. The handling companies do not have a direct access to the system. After the check-in is

completed, baggage tagged with a barcode and placed on the conveyer, a handling company is allowed to access the baggage again, when delivered by the system to the particular handover chutes.

The Baggage Handling System performs the baggage security check through the X-Rays machine and if it is allowed to continue, the baggage travels trough the system until reaching the handover chute assigned to corresponding flight.

If it is not allowed to continue, or when it is necessary to open it to clarify a security issue, the baggage is removed by the External Security Authorities (*Prosegur*) from the Baggage Handling System and moved to a security area called Level 4.

The External Security (*Prosegur*) communicates with the Check-in Staff to inform that the particular baggage (identified by barcode) needs to be open. The Check-in Staff with the check-in list (passenger / baggage) identifies the passenger / baggage owner and calls for him / her using the airport terminal audio system.

A Check-in Staff identifies and introduces the passenger to the External Security Authorities to open the baggage and to clarify the content. Checked baggage is retagged and if allowed to continue, delivered again to the Baggage Handling System.

The Baggage Handling System performs the baggage sortation based on barcode technology. A barcode scanner needs a proper visual exposure of the attached barcode identification tag for the successful reading. The baggage passes aside the barcode scanners that identify the corresponding flight associated chute, while travelling along the Baggage Handling System conveyers. A remotely controlled pusher, tipped by successful identification, hits the baggage when passing the respective chute entrance, sending it down by the corresponding chute. When a baggage can not be identified in the first passage, it will perform a second one. If the identification would lack again, the baggage

will be delivered by the auxiliary chutes, commonly used by all handling companies. If the Baggage Handling System is in maintenance, shut down or with operational problems, all baggage will be delivered by the auxiliary chutes.

The Ground Handling Staff confirms that the handover chute is the correct one against the information (flight number, airline and destination) displayed on the monitor placed above each chute.

The Ground Handling Staff Coordinator receives in advance the information about the flights to be assisted by the handling company during the day. The document is called the Aircraft Daily Movement (MDA).

The Ground Handling Staff retrieves the baggage from the handover chute, place it into the dollies / ULD and for each baggage removes a barcode stub from the baggage tag and sticks it in the company's internal document called the Baggage Record or Bingo Chart.

The Bingo Chart is created for each dolly / ULD, providing the information in which dolly / ULD a baggage is found. They are also used to control how many bags in total are placed into the dollies / ULD and to cross-check that information with the number of checked-in bags.

The process of removing stubs from the baggage tags and sticking them into the Bingo Chart can easily produce errors, such as missing a stub or sticking it in a wrong document.

After the baggage transfer from the Baggage Handling System into the dollies / ULD is completed, the Ground Handling Staff checks if any baggage for the related flight is found elsewhere in other chutes, before transporting the dollies / ULD to the aircraft stand. This procedure is needed because the Baggage Handling System can not provide a completely acceptable level of confidence in that respect.

The number of baggage mistakenly delivered into the other chutes depends on the Baggage Handling System status. Auxiliary chutes for unrecognized baggage are used by all handling companies at the airport. Any delay in retrieving the baggage from these chutes makes them overloaded and thereby unavailable.

The Ground Handling Staff checks also if any baggage for the related flight is found in the out-of-dimension chute and two transfer baggage inbound buffers, one in the Transfer Baggage Terminal and other in the Baggage Handling Terminal.

The cross-check of the total number of bags received from Baggage Handling System with the number of checked-in bags would provide the evidence of how many out-of-dimension and transfer bags are yet to be collected before the dollies / ULD transportation to the aircraft stand.

The Ground Handling Staff informs the Ground Transportation Staff that all the baggage is placed in the dollies / ULD and is ready for transportation to the aircraft stand.

**Transport Baggage Dollies / ULD to Apron**

After official check-in is closed, usually 30 minutes before take-off, all the regular baggage for the flight should have reached the collecting area down by the particular handover chute.

Despite receiving the information from the Check-in Staff that the last baggage was checked-in into the Baggage Handling System, the Ground Handling Staff does not exactly know when to expect its arrival to the collecting area.

After taking over the dollies / ULD in front of the handover chute, the Ground Transportation Staff collects the out-of-dimension and transfer baggage from the Baggage Handling Terminal and eventually from the Transfer Baggage Terminal located on the

opposite side of the runway and transports it to the designated aircraft stand.

Usually freight and baggage arrive separately at the aircraft stand since the baggage is loaded last because of the possible late checks-in and baggage drops.

**Ground Handling Management**

The handling company receives in advance from the Airport Authority and the Airline Companies the information relevant for the assisted flights (updated occasionally), such as flight number, aircraft type, landing and take-off schedules, number of passengers, aircraft stand, etc.

The Ground Transportation Coordinator determines the allocation of the necessary resources according to the assisted flight aircraft type.

All information is prepared manually. The Ground Transportation Coordinator checks with the Ramp Coordinators the equipment location and availability via radio. After gathering sufficient information, the Ground Transportation Coordinator determines the equipment to assist the flights. All allocations are registered in a spreadsheet 3 times a day (3 working shifts) and sent by e-mail to the Ground Transportation Manager.

The Ground Transportation Coordinator asks the Ramp Coordinators via radio to move the allocated resources to the corresponding stands.

#### 4.1.2.2 Post Flight Operation – PFO

**Unloading Bulk Baggage from Aircraft**

The Ramp Agent receives from the Cabin Crew the flight associated documentation in paper form, and forwards to the Aircraft Captain the information from the Load Control concerning aircraft refuelling, available load capacity, actual weather conditions, etc. needed for the return flight.

The Ramp Agent informs the Ramp Staff that they can open the aircraft baggage compartment door and begin the unloading operation. The Ramp Staff opens the aircraft baggage compartment door and unfasten the tied baggage.

The Ramp Staff moves the baggage belt already available in the ramp area to the aircraft baggage compartment door, moves the dollies already available in the ramp area near to the baggage belt, and starts the unloading operation placing the transfer baggage onto the belt.

The transfer baggage is retrieved from the belt and then placed on a separate dolly for further transportation.

The Ramp Staff performs the separation of transfer from local baggage at unloading by visual inspection of the final destination printed on the baggage tag.

The Ramp Staff needs to distinguish between the local and transfer baggage and thereby count the number of transfer bags. Available in advance, this information would allow the Ramp Staff to control if all the transfer baggage is identified and placed on the separate dolly.

After the transfer baggage is unloaded, the Ramp Staff informs the Ground Transportation Department that the dolly is ready for transport to the Transfer Baggage Terminal (TBT).

In Lisbon Airport, at the moment, the Transfer Baggage Terminal (TBT) is operated by Ground Force, from 9h to 16h.

The Ramp Staff unloads the remaining local baggage from the aircraft by the belt to the rest of the dollies.

**Bulk Baggage Transportation to Baggage Handling Terminal**

After the local baggage is unloaded and placed onto the respective dollies, the Ramp Staff

informs the Ground Transportation Department that the dollies are ready for transport to the Baggage Handling Terminal and delivery to the Baggage Handling System.

The Ground Transportation Staff transports the dollies from the aircraft stand to the Baggage Handling Terminal. The terminal is shared by all handling companies operating at Lisbon Airport.

The Ground Transportation Staff gets informed where to drive and park the dollies in the Baggage Handling Terminal by the display above the entrance indicating the flight number, airline, departure airport and the belt whereby to handover the transported baggage. Nevertheless, the tractor driver knows in advance which handover belt belongs to the flight.

The Ground Transportation Staff parks the dollies next to the respective handover belt.

**Unloading Bulk Baggage to Baggage Handling System**

The Ground Handling Staff confirms that the baggage is on the right handover belt through the information about the flight number, airline and departure airport displayed in a monitor above the belt, and presses a signalization button to inform the Baggage Handling System that the first bag is placed on the belt, thus to start the conveyor.

The Ground Handling Staff transfers all the baggage from the dollies to the conveyor belt and, after the baggage transfer is completed, presses another button to inform the Baggage Handling System that the last bag was placed on the belt, thus to stop the conveyor.

The Ground Handling Staff informs the Ground Transportation Department that all the dollies are empty and ready to be collected.

**Unloading Baggage ULD from Aircraft**

The Ramp Agent receives from the Cabin Crew the flight associated documentation in

paper mode and forwards to the Aircraft Captain the information from the Load Control concerning the aircraft refuelling, available load capacity, actual weather conditions, etc. needed for the return flight.

The Ramp Agent informs the Ramp Staff, via radio, that they can open the aircraft cargo compartment door and begin the unloading operation.

The Ramp Staff moves the lifter already available in the ramp area in the position to access the aircraft cargo compartment door, moves the dollies already available in the ramp area near to the ULD lifter, and moves the lifter up and opens the aircraft cargo door.

The Ramp Agent informs the Ramp Staff about the IATA reference number of the transfer baggage ULD to be unloaded first (the ULD identification is simple, as each one has a unique IATA reference number).

The Ramp Staff unlocks the ULD inside the aircraft cargo compartment and if the transfer baggage ULD is not located in the cargo compartment entrance area, they shall bring it to this position.

The ULD is retrieved from the cargo compartment entrance area and moved onto the lifter. The Ramp Staff lowers the lifter to the ground level and moves the ULD to the separate dolly for further transportation.

After the transfer baggage ULD is unloaded, the Ramp Staff informs the Ground Transportation Department that the dolly is ready for transport to the Transfer Baggage Terminal (TBT).

The Ramp Staff retrieves the remaining ULD in the lifter. After lowered to the ground, the ULD are moved one by one onto the respective dollies for further transportation.

**ULD Transportation to Baggage Handling Terminal**

After the local baggage is unloaded and placed onto the respective dollies, the Ramp Staff informs the Ground Transportation Department that the dollies are ready for transport to the Baggage Handling Terminal and delivery to the Baggage Handling System.

The Ramp Staff also informs the Ground Transportation Department about the baggage ULD inventories.

The Ground Transportation Staff transports the dollies from the aircraft stand to the Baggage Handling Terminal. The terminal is shared by all handling companies operating at Lisbon Airport.

The Ground Transportation Staff get informed where to drive and park the dollies in the Baggage Handling Terminal by the display above the entrance, indicating the flight number, airline, departure airport and the belt whereby to handover the transported baggage ULD. Nevertheless, the tractor driver knows in advance which handover belt belongs to the flight.

The Ground Transportation Staff parks the dollies next to the respective handover belt.

**Unloading ULD to Baggage Handling System**

The Ground Handling Staff confirms that the baggage ULD are next to the right handover belt through the information about the flight number, airline and departure airport displayed in a monitor above the belt, and presses a signalization button to inform the Baggage Handling System that the first bag will be placed on the belt, thus to start the conveyor.

The Ground Handling Staff opens the ULD and transfers all the baggage to the conveyor belt. After the baggage transfer is completed, the Ground Handling Staff presses another

button to inform the Baggage Handling System that the last bag was placed on the belt, thus to stop the conveyor.

The Ground Handling Staff informs the Ground Transportation Department that all the dollies and ULD are empty and ready to be collected.

**Unloading Bulk / ULD Baggage at Transfer Baggage Terminal**

The transfer baggage designated to the imminent connection flights is transported to the Transfer Baggage Terminal. The baggage is stored in the inbound buffer, inside the terminal, aimed for baggage interim storage. The inbound buffer has no distinct boundaries inside the terminal building and is identified only by a reference sign.

The baggage arriving to the Transfer Baggage Terminal is transferred to the circular conveyer where the Ground Force Terminal Staff sorts the baggage by reading its destination from the barcode tag.

Sometimes, it is impossible to circulate inside the terminal building, due to the number of bags waiting to be sorted. In that situation the inbound buffer becomes inaccessible, blocking the transfer baggage retrieval. There are actual plans to increase the terminal capacity.

The handling companies do not inform each other about the transfer baggage they have to collect from their inbound buffers for the connection flights. Thus, they need to check in the Transfer Baggage Terminal (usually half an hour before the take-off) if there is any transfer baggage for the assisted flights.

Sometimes, the ground handling staffs find in inbound buffer areas the transfer baggage from not assisted flights.

When a handling company at Lisbon Airport is about to transfer the baggage from the

flight assisted by other company, then it has no information about the number and identity of the arrived bags, crucial for the process control.

When having the flight with transfer passengers, the airlines are sending the Passenger Transfer Manifest (PTM) to the assisting handling company, with the passenger names and the corresponding baggage identity.

The exchange of responsibility for transfer baggage occurs on delivery to an inbound buffer located in the Transfer Baggage Terminal. In that occasion, the Passenger Transfer Manifest should be also forwarded to the company responsible for the buffer that is taking over the baggage handling. Instead, a transfer passenger at Lisbon Airport has to check-in to the connecting flight and thereby to show to the Check-in Staff the barcode sticker obtained at the baggage check-in on the departure airport. The Check-in Staff inserts the identification code in the system and gets the baggage identity data, needed by the Ground Handling Staff to start searching for the baggage at the inbound buffers.

Portway is responsible for two inbound buffers, one in the Transfer Baggage Terminal (4 storage locations) and other in the Baggage Handling Terminal (one storage location). Normally, Portway handles the baggage transfer in approximately 30 minutes, while Ground Force does it in 4 hours. However, the Transfer Baggage Terminal is operated by Ground Force from 9h to 16h, where Portway is just a user. After 16h, all the baggage is sorted for both companies in the Baggage Handling Terminal.

**Lost and Found - Passenger without Baggage**

This procedure begins when a passenger enters the Lost and Found facilities complaining that the baggage did not appear at the carrousel and is nowhere to find.

The Warsaw convention and current IATA recommendations are usually applicable to most of the situations. If the Airline Companies are not IATA members (e.g. the Brazilian

BRA) the Lost and Found Service has to operate according to the legislation effective in their countries. Sometimes, this can bring additional difficulties to the related situations.

Portway has an internal guideline where the special requests allowed to the Airline Companies are defined.

The SITA's World Tracer is the principal software application used in the Lost and Found Service.

Lost and Found Staff starts the search process using the World Tracer by entering the AHL (Advise If Hold) command. The baggage code is composed by 2 alphabetic and 6 numeric characters, where the alphabetic characters represent the handling company (XH for Portway).

The Lost and Found Staff provides the passenger the IATA catalogue guide for baggage identification to identify the baggage type (trolley, leather, hard, soft), with / without a locker, secret code, respective colour, etc. and acquires the following data from the passenger:

- Name and gender
- Flight number and date
- Baggage factory brand
- Extra identification information
- Home / local address and contacts
- Baggage content description

The Airline Companies are obliged to deliver the Lost and Found baggage at the passenger addresses within the 50 km around the airport. However, some companies (e.g.

FinAir) can have special agreements, such as the extension of delivery radius up to 100 km. When the address is farther then 50 km from the airport, the Airline Companies use the National Express Network for the delivery.

After completing the World Tracer input with the information acquired from the passenger, the Lost and Found Staff runs the World Tracer search throughout the network of voluntarily participating Lost and Found services worldwide. The World Tracer then compares the acquired information, checking where and when is reported that the baggage with equal or similar description is found. As a result, the Lost and Found Staff gets the matched baggage list pondered with the matching probability by e-mail. The search procedure reference and the related data are presented in the PIR – Propriety Irregularity Report.

**Lost and Found - Baggage without Passenger**

The procedure begins the moment when the Lost and Found Staff finds a baggage claimed by nobody from the arrived assisted flight, anywhere at the airport.

For each assisted flight, the Lost and Found Staff needs the information about the identity of Baggage Handling Terminal conveyors whereto the baggage was delivered, as well as the baggage delivery status, e.g. when the first / last bag were placed on the handover belt, etc.

The Lost and Found Staff circulates periodically inside the baggage claim area to check which carrousels are assigned to the assisted flights and introduce this information timely in the Aircraft Daily Movement (MDA) document.

After finding a baggage claimed by nobody, the Lost and Found Staff starts the World Tracer procedure to report the lost baggage found at Lisbon airport by entering the OHD (On Hand) command.

The Lost and Found Staff provides the World Tracer information network with the baggage information by the following input:

- Tag identification number
- Passenger name and gender
- Flight number and date
- Baggage factory brand
- IATA baggage class reference
- Extra identification information
- Home / local address and contacts
- Baggage content description

When a match is approved somewhere worldwide, the Lost and Found Staff sends the baggage (with the RUSH tag) by first available flight to the destination airport, where it is delivered to its owner.

If there is no match, the Lost and Found Staff sends the baggage to the Airline Company after a 5 days period.

# 5. State of the Art

Completely aware of today challenges, IATA had been continuous monitoring the global situation for the air transport industry and, simultaneously, implementing IATA initiatives to help airlines in simplifying the processes, increasing passenger convenience while reducing costs and improving efficiency.

Under this environment, in 2004 IATA had lunch a new industry-wide change programme, sponsored by IATA Board of Governors (a group of 30 airline CEOs) and named Simplifying the Business (StB)[24].

With the mission of change the way the air transport industry operates in order to improve the service to the passengers and lower the costs to the industry, the original set of projects promised US $6.5 billion in annual savings to the industry.

The first project, E-ticketing, was concluded on June 2008 reaching an industry penetration from 19% to 100% in four years and saving the industry US $3 billion annually.

In 2008, five new initiatives were introduced by the Simplifying the Business team, each one with a three-to-five year timeframe and including the Baggage Improvement Programme (BIP) and the IATA e-freight project.

With the Baggage management Improvement Program (BIP), IATA hopes to reduce the rate of mishandled baggage by improving baggage performance, through an IATA lead industry wide action, to ensure passengers and their baggage are reunited at final destination.

[24] www.iata.org/stbsupportportal

At the moment each air cargo shipment carries with it as many as 30 paper documents, which, according to IATA, is enough to fill 80 Boeing 747 freighters every year.

With e-freight project, IATA aims is to take the paper out of air cargo, replacing them with electronic messages and involving the End-to-End Chain (E2EC): carriers, freight forwarders, ground handlers, shippers and customs authorities.

The use of RFID in baggage handling, catering and cargo had been examined by IATA which had conclude that all of these areas can benefit from the application of RFID to enable more event-driven and proactive processes. During the evaluation process the IATA Simplifying the Business team concludes that Radio Frequency IDentification (RFID) can solve some 20% of baggage mishandlings and decided its RFID work should be part of the Baggage management Improvement Program BIP.

In consequence, IATA has published a global RFID standard (RP1740C) and recommended practice in the Passenger Services Conference Resolution Manual that promotes global interoperability, a business case for the industry and a transition plan for the technology.

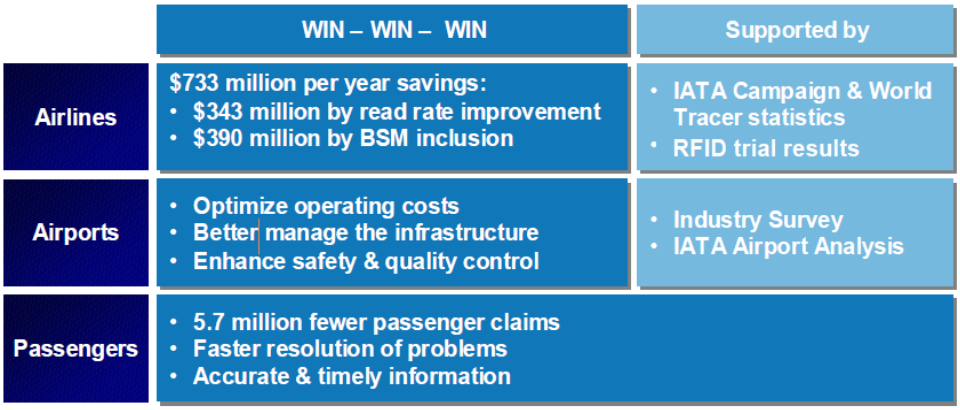


Figure 5-1: The Win Win Win for stakeholders[25]

[25] RFID Business Case for Baggage Tagging – IATA 2007

IATA Simplifying the Business team reported that "the adoption of the RFID technology for the sorting and handling of baggage along the global supply chain provides a Win-Win-Win for the three main stakeholders, the airlines, the airports and the passengers".

For the studies and analysis supported or monitored by the IATA Simplifying the Business team, the RFID project team had considered all the aspects of implementing RFID for airline baggage handling based in the main adopter drivers which are detailed in the figure herewith:

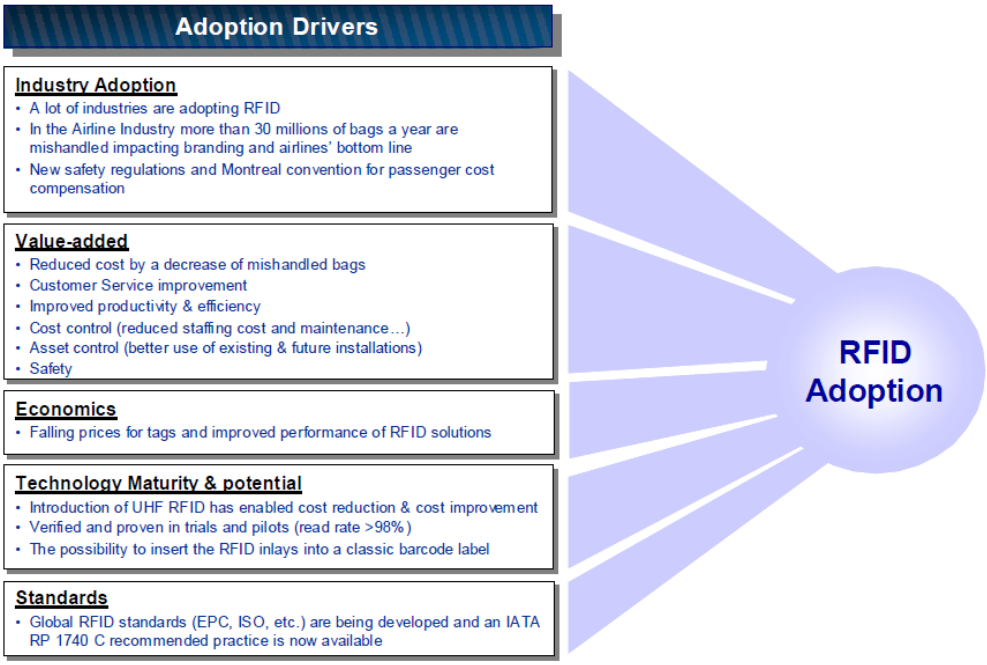


Figure 5-2: Adoption drivers for RFID[26]

During the last years and to confirm the feasibility of RFID technologies in the handling operations, a number of trials have been conducted between airports, airlines and manufacturers.

In the following tables and figure, the main results and locations of some of these trials

[26] IATA RP1740C Standard

are summarized.

| RFID Trial | Date | Read –Rate (Average) | Read-Rate Range (daily range) |
|---|---|---|---|
| Kuala Lumpur Airport | 2005 - 2006 | - With Gen 2: 100%<br>- With Class 0 Gen 1: > 98% | |
| Kansai Airport – Hong Kong Airport | 2005 | 95.54%<br>98.78% | 94.25%~100% |
| Asiana - Korean Airport Corporation | 2004 - 2005 | 97.00% | - |
| TSA World-wide Trial | 2004 - 2005 | ~99% | 96% - 100% |
| Narita Airport (HF) | 2004 | - | 92% - 95% |
| British Airways at Heathrow T1 | 1999 | 96.40% | 95.4% - 99.4% |

Table 5-1: Overview of RFID trial read rates[27]

| Trial / Implementation | Technology Used | Purpose | Status |
|---|---|---|---|
| Las Vegas McCarren Airport | UHF RFID | Security | Ongoing Implementation |
| ASTREC | UHF RFID | Proof of concept | Ongoing |
| Auto-ID centre @ HKG | UHF RFID | Proof of concept | Completed |
| TSA | UHF RFID | Global Interoperability | Completed |
| Hong Kong International | UHF RFID | Baggage sorting and reconciliation | Implemented, now adopting IATA RP |
| KLM / AF | UHF RFID | Baggage sorting | Implementing |
| SFO | UHF RFID | Baggage Security | Ongoing |
| Asiana Airlines | UHF RFID | Tracking | Completed |
| Delta Airlines | UHF RFID read only | Proof of concept | Completed |
| British Airways | HF RFID | Proof of concept | Completed |
| SIA, SIN, FRA, AUK | HF RFID | Baggage sorting | Closed |
| Heathrow Airport baggage collection | HF RFID | Baggage collection and delivery services. | Implemented |
| ASTREC | HF RFID | Baggage collection & Security | Implemented |
| Seattle Airport SeaTac Terminal | Microwave RFID | Tracking | Closed |

Table 5-2: RFID trials and implementations[26]

These results achieved during the identified trials was very clear in what concerns to the accuracy of RFID tags foreseeing a successful application of the technology enabling the systems with a very positive answer to the future challenges for the efficiency and competitiveness of baggage handling operations and air freight business.

[27] RFID Trials for Baggage Tagging - IATA

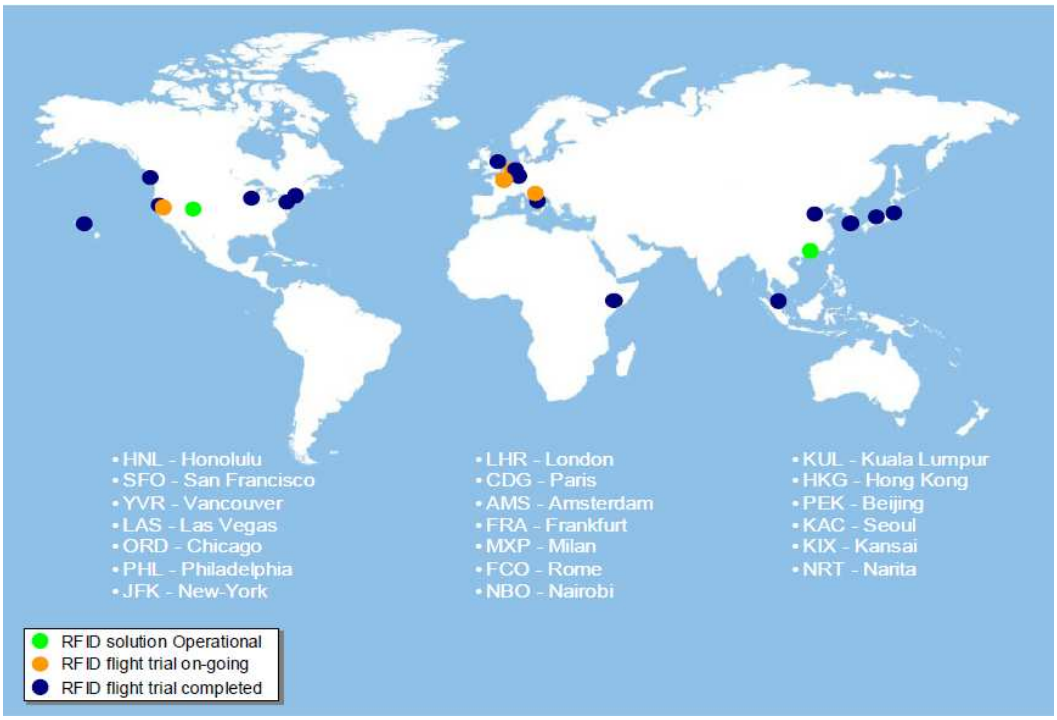


Figure 5-3: World trials distribution[28]

# 6. Vision, Gap Analysis and New Concepts and Scenarios

## 6.1 A Vision for Baggage & Freight

Following the vision of E-Cab Project for Freight Handling and the objectives and activities of the IATA Simplifying the Business team, there are no doubts about the fact that in the future all systems will ensure that only correctly identified baggage and freight items can be loaded on-board future aircraft.

In the case of missing passengers, loaded baggage will be easy to identify and therefore quicker to off-load and the airlines will have the knowledge and tools to inform passengers immediately in the case of lost baggage.

Radio frequency Identification (RFID) tags will reduce mishandled baggage by as much as 40%, bringing down service recovery costs and delivering greater efficiencies for off-loading baggage for no-show passengers. This means enhanced security, better baggage handling, fewer mishandled bags and fewer delays.

Freight covers more than just luggage and the future systems will enable important data to be exchanged between the aircraft and freight containers (ULD) by paperless means, ensuring that freight is loaded correctly and aircraft are trimmed efficiently. It will also be possible to transport "cool-chain" goods[28] with a higher confidence level and more safely by air.

## 6.2 Identified Gaps

During the analysis developed with the visits to Lisbon and Oporto Airports it was

[28] A cool chain is described as a logistics process where temperature-sensitive cargo will maintain its integrity through multi-modal movement and kept in ambient facilities to ensure 100% quality, freshness, and customer satisfaction.

possible to identify the gaps between the visions and the state of the art.

The main results of the Gap Analysis shows that for a profitable use of RFID technologies advantages in air freight and baggage handling operations, some important organizational improvements should be implemented in the operations and a full integration between the information's and communication's systems must be guarantee.

The Gap Analysis carried out in Lisbon and Oporto Airports, with the identification of urgency, rationale and technical feasibility of proposed methods and attainable improvements of handling services are described in the following pages.

## GAP ANALYSIS

| Gap Statement | Rationale | Urgency of Resolving | Technical Feasibility | Level of Service Improvement |
|---|---|---|---|---|
| More reliable freight / baggage / ULD identification. | Improved identification techniques enable enhanced handling information, which guarantees a higher quality of freight / baggage sorting and error-free operation that reduces time-consuming & expensive service recovery. | High | Medium, as available RFID technology need to be adapted to the task and yet fully standardized. | High |
| Real-time availability of freight / baggage chain events information. | Enables timely decision making and expands the time required to correct freight / baggage / ULD handling errors. Constant monitoring ensures a high level of service performance, flexible adjustment to customers' requirements and proactive provision of information in case of deviation from transportation plan. | Medium | Medium depends on exiting airport infrastructure. | High, efficient service recovery |
| Easy accessible global freight / baggage / ULD handling data management system. | Necessary to provide in real time the freight / baggage chain events information at / outside the airport. Provides event driven alerting of failures / discrepancies against the planned transportation cycle, accessible through global information service. Achieves time-definite freight delivery in a seamless transportation chain. | High | Medium depends on global acceptance and implementation. | High |
| Systematically collected information about individual freight / baggage localization. | Provides in real time the information of misrouted / missing freight, appeared / expected at particular service point within the programmed time frame. The missing freight / baggage can be easily found at wrong service point in time and rerouted to join the rest of flight cargo.<br>Optimizes the workflow by enabling the carriers to identify the freight / baggage status. | High | High | High |
| Tighter handling schedules to increase the efficiency of processes and reduce the needed resources at the airport. | Persistent material flow supervised by real time status / localization control throughout the automated identification network. Ensures a minimal freight re-handling and optimal use of available physical resources. | Low | Medium, depends on service automation level. | Medium |

## GAP ANALYSIS

| Gap Statement | Rationale | Urgency of Resolving | Technical Feasibility | Level of Service Improvement |
|---|---|---|---|---|
| More check / tracking service points throughout the chain. | The proper number / locations of freight / baggage / ULD check / tracking points throughout the chain achieves the fault tolerant status / localization control. Increased traceability throughout additional freight / baggage tracking points allows a seamless monitoring of the transportation progress and enables timely reaction in case of discrepancies. | High | High, even with the barcode technology. | High |
| (Fully) automated freight / baggage / ULD identification network at / outside the airport. | Prevents the freight / baggage handling contingencies throughout the chain and increases the reliability of freight and baggage processes.<br>Harmonizes the processes and standards, ensuring reliable and timely freight / baggage delivery. | Medium, depending of the airport size. | Medium | High |
| Automated freight identification network extended outside the airport. | Enables freight monitoring on the way from shipping to forwarding company's depot and further to cargo handling facilities at the airport. Also, enables freight monitoring in hub operations.<br>Extends existing process monitoring to door-airport-airport-door monitoring, compatible with IATA Cargo 2000. | Medium | Medium | High |
| Manual data input is substituted by data acquisition from global information system. | Eliminates manual data re-entry for local applications e.g. warehouse, material flow control etc. The necessary data are automatically provided by global information system, e.g. at transfer of jurisdiction, etc. | Medium | Medium, needs extensive software development. | High |
| Versatility of ways passengers check in and release their baggage for handling. | Prevents baggage check-in contingencies. | Medium | High | High |

## 6.3 New Concepts and Scenarios

From the analysis to the operations and to the research and development activities run during the E-Cab project, some new concepts and scenarios for freight and baggage handling services were prepared and presented to the European partners.

The concepts and the operational scenarios prepared describe important aspects of a proposed conceptual model for freight and baggage handling services. They enable the detailed overview of improvements and new ideas incorporated in the concepts, as well as completeness of the supporting technology scan. The importance of each scenario is emphasised by its Rationale.

A list of the New Concepts and Scenarios for Freight and Baggage Handling Services are presented in following pages.

# New Concepts and Scenarios for Freight & Baggage

### 6.3.1 Outbound On-Airport Monitoring for Freight Concept

| Description: | Innovation: |
|---|---|
| The real-time comparison of nominal and actual state of freight dispatch (ULD and shipment) concerning the outbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of freight under the responsibility / in the field of operations of the Outbound On-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Cargo Handling Services - Freight identification and monitoring at the acceptance. | During the acceptance, the shipment is automatically scanned and all relevant data are provided to the cargo handling system to validate the shipment (check if booking exists, embargos, restrictions, etc.). | Manual data input is substituted by data acquisition from global information system. |
| Cargo Handling Services - Freight identification and monitoring during the build up. | Shipments are loaded into a container or onto a pallet while being automatically scanned. The possible offload shipments are allocated. The shipments which could be preflown are identified. Estimates are sent to flight operations. | Reduction / elimination of faulty freight insertion while loading ULD. |
| Cargo Handling Services - Freight identification and monitoring during the flight preparation. | ULD or trolleys are closed, weighted and automatically scanned. The information is passed to the Weight & Balance System of the aircraft operator and to the Apron Handling Service Provider Transportation System. | Automatic identification of shipments / ULD. |
| Apron Handling Services - Freight identification and monitoring at transportation to A/C. | The trolleys are automatically scanned when set at the off-feed area of the cargo handling facility. The apron transportation company is automatically informed to transport the trolleys to the A/C marshalling area. | Automatic identification of shipments / ULD. |

| Description | Statement | Rationale |
|---|---|---|
| Ramp Handling Services - Freight identification and monitoring at A/C loading. | During the A/C loading process all ULD and other freight items are scanned automatically while passing the A/C cargo door. Also, the loading positions are compared automatically against the loading information sheet. In the case of mislead, an error message is launched. | The correct loading order according to the freight manifest is ensured by automatic scan at cargo compartment door. The automated evaluation of freight loading position is enabled. Misloads are thereby avoided. |
| Ramp Handling Services - Freight identification and monitoring of special shipments at A/C loading. | In the case of special shipments, e.g. dangerous goods, the pilot gets a so-called NOTOC (notification to captain). During the flight, the status of sensible goods is monitored all the time. | Easy access to handling information. |
| Ramp Handling Services - Freight identification and monitoring at A/C unloading. | Off-loaded ULD are automatically scanned and transfer to W/H initiated. | Automatic identification of ULD and trolleys. |
| Outbound On-Airport Freight Tracking – The missing freight is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight cargo. | Responsible stakeholders are informed in real time of misrouted / missing freight, appeared / expected at particular service point within the programmed time frame. | Advanced Outbound On-Airport service based on systematically collected information about individual freight localisation. Since the database has a complete record of freight localisation, it is possible to register / react to any routing divergence. |

### 6.3.2 Outbound Off-Airport Monitoring for Freight Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of freight dispatch (ULD and shipment) concerning the outbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of freight under the responsibility / in the field of operations of the Outbound Off-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Freight Forwarding Services - Freight monitoring on the way from the shipping company's to the forwarding company's depot. | The Forwarding Agent registers with the booking service, picks up the freight, prepares it for shipping and tags it with a scanning label. Each piece of freight is automatically scanned at the arrival to forwarding company's depot. | Automatic identification of shipments / ULD. |
| Freight Forwarding Services - Freight monitoring on the way from the forwarding company's depot to the cargo handling facilities at the airport. | The Forwarding Agent collects, consolidates and delivers the shipments after the flight booking confirmation to the cargo handling facilities at the airport. | Automatic identification of shipments / ULD. |
| Outbound Off-Airport Freight Tracking - The missing freight is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight cargo. | Responsible stakeholders are informed in real time of misrouted / missing freight, appeared / expected at particular service point within the programmed time frame. | Advanced Outbound Off-Airport service based on systematically collected information about individual freight localisation. Since the database has a complete record of freight localisation, it is possible to register / react to any routing divergence. |

### 6.3.3 Inbound On-Airport Monitoring for Freight Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of freight dispatch (ULD and shipment) concerning the inbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of freight under the responsibility / in the field of operations of the Inbound On-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Cargo Handling Services - Freight identification and monitoring at the arrival to cargo handling facilities. | When freight enters the out feed area of the cargo handling facilities the shipments / ULD are automatically scanned. The arrival information is passed to the inbound control system to steer the break down process. The dolly driver is instructed by the inbound control system where to place the ULD. | Optimised freight handling within the cargo facilities. Tracking within the cargo handler warehouse is useful for quick and easy freight localisation. |
| Cargo Handling Services - Freight identification and monitoring at the W/H door. | Shipments / ULD are automatically scanned while entering or leaving the warehouse door. Handling instructions might be given e.g. via a PDA or standard interface. The special ULD handling code controls the break down priority. | Optimised freight handling within the cargo facilities. Tracking within the cargo handler warehouse is useful for quick and easy freight localisation. |
| Cargo Handling Services - Freight identification and monitoring within the storage area. | Shipments are automatically scanned while being taken out the ULD and tracked when entering into a storage area. Information (e.g. customs status) is updated whenever the shipments passes a scanning point. | Optimised freight handling within the cargo facilities. Tracking within the cargo handler warehouse is useful for quick and easy freight localisation. |
| Cargo Handling Services - Freight cross-checking. | Freight and pertinent information are checked against the manifest and discrepancies reported to the stakeholders. | Optimised freight handling within the cargo facilities. |

| Description | Statement | Rationale |
|---|---|---|
| Freight Customs Services - Customs clearance. | Customs clearance status is checked. | Data required for customs clearance is sent automatically to customs authority / service provider (e.g. broker) in order to minimize cycle delays. |
| Freight Customs Services - Customs clearance. | Freight to be inspected by customs is ordered to a specific location. | Data required for customs clearance is sent automatically to customs authority / service provider (e.g. broker) in order to minimize cycle delays. |
| Freight Forwarding Services - Freight identification and monitoring from the departure to the destination airport cargo handling facilities. | The Forwarding Agent checks if the shipment / ULD will be delivered in time. | The Forwarding Agents are allowed to check the shipment / ULD whereabouts and the time of delivery. |
| Freight Forwarding Services - Freight identification and monitoring from the departure to the destination airport cargo handling facilities. | The Forwarding Agent checks if the shipment / ULD will be delivered in time. | The Forwarding Agent at destination airport is able to plan resources for unloading, unpacking, etc. |
| Freight Forwarding Services - Freight pick-up at destination airport. | Forwarding Agents get information that their freight will be ready for pickup within the next hours. The pick up location is provided automatically. | An authorization request ensures that only permitted Forwarding Agent can pick-up the freight. |
| Freight Forwarding Services - Freight pick-up at destination airport. | Forwarding Agent collects the cleared freight from the carrier. | More efficient handover process. |

| Description | Statement | Rationale |
|---|---|---|
| Apron Handling Services - Freight identification and monitoring during the transportation from the marshalling area to other local destination (e.g. out-feed area of the cargo handling facilities, customs, perishable centre, etc.). | ULD transported by dollies are automatically identified and their destination is monitored. Alerts shall be sent to the driver if the ULD enters an unknown or incorrect location (e.g. ULD destined for perishable centre should not be left at an outdoor location). | The right sequences of ULD shell reach the A/C marshalling area. |
| Ramp Handling Services - Freight identification and monitoring at the marshalling area. | "While unloading the freight from A/C cargo compartment, every shipment / ULD are identified. The information provided with the shipment / ULD allows dispatching the freight according to its handling as well as special code (e.g. for priority control) and other relevant data (temperature, shock detection, etc.):<br>Terminating ULD is moved directly from the marshalling area to the out feed area for immediate collection by the Forwarding Agent.<br>ULD for break down, containing mixed shipments, are moved to the ULD unload and loose sort facility (see cargo handling services).<br>Transfer ULD are retained in the marshalling area pending the outbound flight or moved instantly to outbound flight marshalling area.<br>Special containers or freight will be handled and transported accordingly." | Missing cargo shall be identified immediately and reported to the carrier, which authorises the immediate initiation of a transport recovery service. In the case of unloaded transit or transfer freight a warning message (e.g. urgency) is launched. Sensible goods shall be monitored to ensure the quality of goods. |
| Ramp Handling Services - Freight identification and monitoring at the marshalling area. | Ramp Agent uses mobile device to scan the ULD and get the handling instructions. | If global information system stops functioning, the operation shall continue locally. |

| Description | Statement | Rationale |
|---|---|---|
| Inbound On-Airport Freight Tracking - The missing freight is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight cargo. | Responsible stakeholders are informed in real time of misrouted / missing freight, appeared / expected at particular service point within the programmed time frame. | Advanced Inbound On-Airport service based on systematically collected information about individual freight localisation. Since the database has a complete record of freight localisation, it is possible to register / react to any routing divergence. |

### 6.3.4 Inbound Off-Airport Monitoring for Freight Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of freight dispatch (ULD and Shipment) concerning the inbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of freight under the responsibility / in the field of operations of the Inbound Off-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Freight Forwarding Service - Freight delivery. | Forwarding Agent notifies the consignee. | More efficient handover process. |
| Freight Forwarding Service - Freight delivery. | Consignee receives the freight with pertinent information and performs the physical check (inspection). | More efficient handover process. |
| Inbound Off-Airport Freight Tracking - The missing freight is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight cargo. | Responsible stakeholders are informed in real time of misrouted / missing freight, appeared / expected at particular service point within the programmed time frame. | Advanced Inbound Off-Airport service based on systematically collected information about individual freight localisation. Since the database has a complete record of freight localisation, it is possible to register / react to any routing divergence. |

### 6.3.5 Outbound On-Airport Monitoring for Baggage Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of baggage dispatch (ULD and Bulk) concerning the outbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of baggage under the responsibility / in the field of operations of the Outbound On-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| **Description:** | **Statement:** | **Rationale:** |
| Baggage Check-In Services - Baggage monitoring on the way from the check-in-counter to the ULD. | Baggage is handed over at the check in and tagged with RFID tags. Information about destination, owner, airline etc. are stored on the tag. | Enhanced tracing possibilities allow baggage handling company or passenger to early notice a wrong loading/routing of its baggage. Main focus is on the better baggage handling on airport side to reduce misrouted baggage and manual interaction caused by not readable tags. The unloading of no-show pax baggage causes time loss which might be reduced by enhanced the tracing possibilities. Courier baggage can be supervised by the Courier Handling Agent. |
| Baggage Check-In Services - Baggage monitoring on the way from the check-in-counter to the ULD. | Passengers get a status message upon request if their baggage is loaded into ULD or A/C. | The baggage handling company or passenger can trace the baggage via standard interface (Web Services etc.), PDA or cell phone. |

| Description | Statement | Rationale |
|---|---|---|
| Airport Baggage Handling Services (Airport authorities / Owner of the departure & transit baggage conveyor system) - Baggage monitoring on the way from ULD dispatching area / ULD loading area to A/C cargo compartment. | Baggage is loaded in the ULD. During the loading, all baggage pieces are scanned and a ULD content list is automatically created. Each piece is cross-checked against the list to prove the proper loading in right ULD. | The content of each ULD is known and in case of wrongly loaded / unloaded ULD a warning is launched and mishandling corrected. |
| Airport Baggage Handling Services (Airport authorities / Owner of the departure & transit baggage conveyor system) - Baggage monitoring on the way from ULD dispatching area / ULD loading area to A/C cargo compartment. | On the way to the A/C the baggage balk / ULD status is monitored. | To avoid the wrong routing the irregularities shall be tracked in time. |
| Apron Baggage Handling Services. | Trolleys are tagged according to the type of baggage. | Better baggage tracking services. Reduction in baggage mishandlings. |
| Ramp Baggage Handling Services - Baggage identification and monitoring at the marshalling area. | While passing the A/C cargo compartment, the ULD is scanned and the baggage items found in the content list are set to status "Loaded in A/C". | To avoid the wrong routing, the baggage bulk / ULD are also scanned during the A/C loading. |
| Ramp Baggage Handling Services - Baggage identification and monitoring at the marshalling area. | The no-show pax baggage location is easily found in the A/C cargo hold. | The exact location of the baggage is known all the time. The no-show pax baggage can be located and unloaded swiftly. |

| Description | Statement | Rationale |
|---|---|---|
| Outbound On-Airport Baggage Tracking - The missing baggage is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight baggage. | Responsible stakeholders are informed in real time of misrouted / missing baggage, appeared / expected at particular service point within the programmed time frame. | Advanced Outbound On-Airport service based on systematically collected information about individual baggage localisation. Since the database has a complete record of baggage localisation, it will be possible to register / react to any routing divergence. |

### 6.3.6 Outbound Off-Airport Monitoring for Baggage Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of baggage dispatch (only Bulk) concerning the outbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of baggage under the responsibility / in the field of operations of the Outbound Off-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| **Description:** | **Statement:** | **Rationale:** |
| Pre-Check-In Service. | Self-check-in with application of baggage tag obtained on request. | Interaction with other services. |
| Baggage Pick-Up Service - Monitoring and identification of baggage from pax home to the airport. | Baggage is picked up at passengers home and transported to the airport. | The baggage check-in is included. Passenger is automatically informed about the baggage status. |
| Outbound Off-Airport Baggage Tracking - The missing baggage is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight baggage. | Responsible stakeholders are informed in real time of misrouted / missing baggage, appeared / expected at particular service point within the programmed time frame. | Advanced Outbound Off-Airport service based on systematically collected information about individual baggage localisation. Since the database has a complete record of baggage localisation, it will be possible to register / react to any routing divergence. |

### 6.3.7 Inbound On-Airport Monitoring for Baggage Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of baggage dispatch (ULD and Bulk) concerning the inbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of baggage under the responsibility / in the field of operations of the Inbound On-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Ramp Baggage Handling Services - Baggage monitoring on the way from the A/C cargo compartment to the ULD loading / unloading area / dispatching area. | ULD are unloaded from the A/C cargo compartment. | During the flight the baggage ULD was kept under surveillance in order to notice eventual irregularities. Passengers were able to trace their baggage and get the status messages upon request. |
| Ramp Baggage Handling Services - Baggage monitoring on the way from the A/C cargo compartment to the ULD loading / unloading area / dispatching area. | While passing the A/C cargo compartment door, the ULD is scanned and all related baggage pieces are set to status "Unloaded from the A/C". | If baggage bulk / ULD are unloaded at the wrong location, a warning is launched and mishandling corrected. |

| Description | Statement | Rationale |
|---|---|---|
| Apron Baggage Handling Services - Baggage monitoring on the way from the A/C cargo compartment to the ULD loading / unloading area / dispatching area. | Priority baggage is handled first and delivered to a specific location. | The exact location of the baggage is known all the time. |
| Airport Baggage Handling Services (Airport authorities / Owner of the baggage claim belts) - Baggage monitoring on the way from the ULD dispatching area / ULD loading / unloading area to their owner (tracing ends at baggage claim). | Baggage is unloaded from the ULD. Every piece is scanned and routed to the baggage claim. | Passengers can check the status of their baggage and get the early notice of misrouted ones. |
| Airport Baggage Handling Services (Airport authorities / Owner of the baggage claim belts) - Baggage monitoring on the way from the ULD dispatching area / ULD loading / unloading area to their owner (tracing ends at baggage claim). | A high number of arrived passengers requires more than one baggage claim. The baggage is sorted by pax names in two claims, one for names from "A-L" and other from "M-Z". | A system message can indicate the right baggage claim. |

| Description | Statement | Rationale |
|---|---|---|
| Airport Baggage Handling Services (Airport authorities / Owner of the baggage claim belts) - Baggage monitoring on the way from the ULD dispatching area / ULD loading / unloading area to their owner (tracing ends at baggage claim). | Baggage is picked by Lost & Found service. | Baggage was not collected by its owner within a predefined amount of time. |
| Inbound On-Airport Baggage Tracking - The missing baggage is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight baggage. | Responsible stakeholders are informed in real time of misrouted / missing baggage, appeared / expected at particular service point within the programmed time frame. | Advanced Inbound On-Airport service based on systematically collected information about individual baggage localisation. Since the database has a complete record of baggage localisation, it will be possible to register / react to any routing divergence. |

### 6.3.8 Inbound Off-Airport Monitoring for Baggage Concept

| Description | Innovation |
|---|---|
| The real-time comparison of nominal and actual state of baggage dispatch (only Bulk) concerning the inbound processes increases the transparency of the process chain. Identification, status-recording and tracking (including documentation) of baggage under the responsibility / in the field of operations of the Inbound Off-Airport Services. | Continuous material flow supervised by real time status control throughout the identification network. The identification network of check/tracking points connected to the global information system. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Baggage Delivery Service - Baggage identification and monitoring is provided from the airport to passenger's home. | Service provider picks up the baggage at the airport and transports it to the passenger's home. The passenger is able to check if the baggage is already on the way. | Picking up of baggage by the delivery service provider is assured by the post baggage reconciliation system. |
| Inbound Off-Airport Baggage Tracking - The missing baggage is found at wrong service point in real time and rerouted to proper service point to join in time the rest of the flight baggage. | Responsible stakeholders are informed in real time of misrouted / missing baggage, appeared / expected at particular service point within the programmed time frame. | Advanced Inbound Off-Airport service based on systematically collected information about individual baggage localisation. Since the database has a complete record of baggage localisation, it will be possible to register / react to any routing divergence. |

### 6.3.9 Baggage Tagged in Advance Concept

| Description | Innovation |
|---|---|
| Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Prevention of baggage check-in contingencies. Reduction of baggage tag printing. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger checks in and applies the baggage tag ID. The passenger presents the baggage at the airport bag drop service assisted by the flight handling personnel. | Remote self check in with limitation of baggage inclusive travel to the airport terminal. This could supplement passenger preference. |
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger is self checked in using a kiosk at the railway station and applies the baggage tag ID ready to carry own baggage to the bag drop service assisted by the flight handling personnel. | Remote self check in with limitation of baggage inclusive travel to the airport terminal. This could supplement passenger preference. |
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger checks in via kiosk at the car park and applies the baggage tag ID. Then carries the baggage to the airport for submittal to the bag drop service assisted by the flight handling personnel. | Remote self check in with limitation of baggage inclusive travel to the airport terminal. This could supplement passenger preference. |

| Description | Statement | Rationale |
|---|---|---|
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger is self checked in at the hotel and applies the baggage tag ID. Then carries the baggage to the airport for submittal to the bag drop service assisted by the flight handling personnel. | Remote self check in with limitation of baggage inclusive travel to the airport terminal. This could supplement passenger preference. |
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger is self checked in at the airport departure hall and applies the baggage tag ID. Then carries the baggage to the bag drop location served by flight handling personnel. | Self check in with limitation of baggage inclusive travel to the airport terminal. This could supplement passenger preference or passenger additional baggage. |
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger desk check in other facility. | Remote check in with limitation of baggage inclusive transport to the airport terminal. |
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger kiosk check in other facility. | Remote check in with limitation of baggage inclusive transport to the airport terminal. |

| Description | Statement | Rationale |
|---|---|---|
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger exercises remote check in but prefer to carry own baggage. | Not identified. |
| Baggage tagged in advance - Passengers applying the unique baggage identifier to the baggage themselves, ready for the submittal to baggage handling chain. | Passenger acquires additional baggage. | Not identified. |
| Departing passenger self tagged baggage. | Passenger checks in via internet but does not apply the baggage tag ID. The passenger then presents the baggage at the airport bag drop location where an agent applies the baggage tag ID. | Remote self check in with limitation of baggage inclusive travel to the airport terminal and additional baggage processing. |
| Departing passenger self tagged baggage. | Passenger is checked in by the flight handling personnel at railway station who apply the baggage tag ID. The passenger then self transports the baggage for submittal at the airport bag drop location. | Remote check in with limitation of baggage inclusive transport to the airport terminal. This could supplement passenger preference. |
| Departing passenger self tagged baggage. | Passenger is checked in by the flight handling personnel at car park desk who apply the baggage tag ID. Then carries the baggage to the airport for submittal at the bag drop location. | Remote check in with limitation of baggage inclusive transport to the airport terminal. This could supplement passenger preference. |
| Departing passenger self tagged baggage. | Passenger is checked in by the flight handling personnel at hotel desk who then apply the baggage tag ID. Then carries the baggage to the airport for submittal at the bag drop location. | Remote check in with limitation of baggage inclusive transport to the airport terminal. This could supplement passenger preference. |

| Description | Statement | Rationale |
|---|---|---|
| Departing passenger self tagged baggage. | Check in by mobile flight handling personnel. Baggage tag ID is applied by the personnel but pax transports the baggage to the airport for submission at the bag drop location. | Remote check in with limitation of baggage inclusive transport to the airport terminal. This could supplement passenger preference. |
| Provision of baggage RFID tags - The baggage data obtained from (remote) check-in IT system shall be written in the protected format to the baggage tags by the airport check-in service and provided for self-tagging by the authorised agents. | After the check-in assisted by the agent, the baggage data shall by printed to the tag and the tag properly attached to / placed in the baggage by the check-in agent, at the check-in counter at the airport or elsewhere. | Pax shall not be allowed to write directly any data to the baggage tags. |
| Provision of baggage RFID tags - The baggage data obtained from (remote) check-in IT system shall be written in the protected format to the baggage tags by the airport check-in service and provided for self-tagging by the authorised agents. | After remote check-in, pax shall receive (secure) confirmation code on the used communication device. Pax transports the baggage and obtains the RFID tags on the airport. Pax attaches to / places in the baggage tags. | The dedicated airport / railway station / car park kiosk presented with the secure code (and other required data) shall provide the tags prepared according to the baggage data declared in remote check-in. |
| Provision of baggage RFID tags - The baggage data obtained from (remote) check-in IT system shall be written in the protected format to the baggage tags by the airport check-in service and provided for self-tagging by the authorised agents. | After remote check-in, pax baggage is transported to the airport by a dedicated transportation service. Pax attaches to / places in the baggage tags. | Pax shell receives already printed tags from the baggage transportation agent, who obtained them from the airport check-in service. |

### 6.3.10 Advanced Baggage Transportation Concept

| Description | Innovation |
|---|---|
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Not identified. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger performs mobile internet check in and applies the baggage tag ID. Then presents the baggage at the mobile bag drop (located outside the airport) wherefrom an agent transports it to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger is checked in at the rail desk and the baggage tag ID is applied by an agent. The agent then transports the baggage to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger is self checked in at the rail kiosk with the baggage tag ID applied. The kiosk personnel then transport the baggage to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger is checked in at the car park desk with the baggage tag ID applied by the agent who then transports the baggage to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |

| Description | Statement | Rationale |
|---|---|---|
| Enhanced remote self check in with baggage free transport to the airport terminal. | Passenger is checked in at the hotel desk with the baggage tag ID applied by the agent. The flight handling personnel then transport the baggage to the airport. | Remote check in with limitation of baggage inclusive transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger is self checked in at the hotel kiosk with the baggage tag ID applied. The kiosk personnel then transports the baggage to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Conventional check in where the passenger is checked in at the airport and the flight handling personnel apply the baggage tag ID. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger is self checked in at the airport kiosk with the baggage tag ID applied. The kiosk personnel then transport the baggage to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger desk check in other facility. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Passenger kiosk checks in at other facility. Passenger is self checked in at the kiosk with the baggage tag ID applied. The facility / kiosk personnel then transports the baggage to the airport. | Enhanced remote self check in with baggage free transport to the airport terminal. |
| Passengers releasing their baggage for baggage handling in advance of departure hall check in desk. | Check in by the mobile flight handling personnel. | Enhanced remote self check in with baggage free transport to the airport terminal. |

### 6.3.11 Arrival Baggage Sortation Concept

| Description | Statement | Innovation |
|---|---|---|
| To support arriving baggage enhanced self collection and arriving baggage agent collection for arrival. | Arriving baggage is automatically sorted for delivery to collection carousel / location. | Arriving baggage is automatically sorted for delivery to collection carousel / location. |

#### 6.3.11.1 Transfer Baggage Concept

| Description | Innovation |
|---|---|
| The tracking of passenger baggage transferred from one aircraft to another through the handling system. | Not identified. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| The tracking of passenger baggage transferred from one aircraft to another through the handling system. | Baggage arrive early, are put into storage and forgotten. | If tracked and logged by reconciliation system as entering storage, a reminder can be automatically displayed via reconciliation system, setting it for loading to its departing flight when that flight is opened also specifying its current location. |
| The tracking of passenger baggage transferred from one aircraft to another through the handling system. | Bags delayed due to security or other processing. | Identify the late baggage stuck in sortation queue and warn that priority processing needed, i.e. baggage likely to miss their departing flight can be identified, located and expedited through the process. |
| The tracking of passenger baggage transferred from one aircraft to another through the handling system. | Sortation system breaks down. | Tracking information helps prioritise time-critical baggage. The most important factor in this situation is recovery time. |

### 6.3.11.2 Baggage in Aircraft Reconciliation Concept

| Description | Innovation |
|---|---|
| The tracking of bulk baggage loaded onto an aircraft to 'close' the reconciliation loop. | Not identified. |

**Scenarios:**

| Description | Statement | Rationale |
|---|---|---|
| The tracking of bulk baggage loaded onto an aircraft to 'close' the reconciliation loop. | Late baggage offload message received, i.e. after the baggage is loaded on flight. | Reconciliation system tracks bags and records locations through the reconciliation and loading to trolleys / ULD so that offloads can be performed swiftly. The information on baggage location in the hold after A/C loading helps late offloads to be performed more swiftly. |
| The tracking of bulk baggage loaded onto an aircraft to 'close' the reconciliation loop. | Final confirmation that baggage authorised for loading by reconciliation system match the baggage actually loaded allows final Baggage Manifest Message (BMM) to be sent to down-line station. | BMM information allows the destination airport to prepare the baggage handling flight termination / transfer with any minimum connection time to the ongoing flights. Tracking of offloaded baggage at the down-line station allows the Transfer baggage management / handling improvements, i.e. better integration of the exiting baggage reconciliation, sortation and management systems, providing a more complete baggage handling E2EC. |

# 7. Costs and Benefits Analysis

For the costs and benefits evaluation of a RFID system for freight and handling operations, herewith presented, we will focus the analysis on baggage handling operations and considering the environment of Lisbon Airport.

The possible savings from the system usage will be assumed in the worst case of reducing only 60% of mishandling bags due to barcode errors and BSM messages failures, and estimated and compared to assessed system development, implementation and operational costs.

For the calculations we will estimate the number of mishandled bags based in data available in ANA Aeroportos de Portugal annual reports and in the already mentioned IATA studies and documents.

## 7.1. Lisbon Airport basic characterisation

Lisbon Airport, also known as Lisbon Portela Airport, is the main international gateway to Portugal and one of the largest airports in Southern Europe.

Opened on 15th of October of 1942, the airport is run by ANA Aeroportos de Portugal, a State-owned company, and is the main base-hub of TAP Portugal.

With two main runways and capable of accommodating large-size aircraft such as the Boeing 747, in 2008 the airport handled 13,626,358 passengers and 88,835 tonnes of cargo resulting from 144.771 ATM (Air Transport Movements, i.e. take-offs and landings)[29].

According to ANA Lisbon Annual Traffic Report 2008, the top 10 airlines in Lisbon Airport, passengers transported and freight, was as follow:

[29] ANA Aeroportos de Portugal SA (Annual Traffic Report 2008)

| Passengers | | | | Movements | | |
|---|---|---|---|---|---|---|
| order | Airline | Total passengers | % total | order | Total movements | % total |
| 1 | TAP Portugal | 7.511.241 | 55,2% | 1 | 84.065 | 60,0% |
| 2 | easyJet | 1.108.328 | 8,1% | 2 | 8.446 | 6,0% |
| 3 | SATA Internacional | 596.697 | 4,4% | 3 | 4.471 | 3,2% |
| 4 | Lufthansa | 503.411 | 3,7% | 6 | 3.645 | 2,6% |
| 5 | Iberia | 483.075 | 3,6% | 4 | 4.210 | 3,0% |
| 6 | Air France | 407.950 | 3,0% | 5 | 3.716 | 2,7% |
| 7 | British Airlines | 283.361 | 2,1% | 8 | 2.162 | 1,5% |
| 8 | Vueling | 276.916 | 2,0% | 7 | 2.764 | 2,0% |
| 9 | KLM | 247.571 | 1,8% | 11 | 1.678 | 1,2% |
| 10 | Brussels Airlines | 196.081 | 1,4% | 9 | 1.875 | 1,3% |

Table 7-1: Top 10 airlines for passengers in Lisbon Airport[30]

| Freight | | | |
|---|---|---|---|
| order | Airline | Ton | % total |
| 1 | TAP Portugal | 55.326 | 62,3% |
| 2 | SATA Internacional | 5.241 | 5,9% |
| 3 | European Air Transport | 5.055 | 5,7% |
| 4 | Star Air | 3.497 | 3,9% |
| 5 | TAAG | 3.409 | 3,9% |
| 6 | Lufthansa | 3.409 | 3,8% |
| 7 | Agroar | 3.197 | 3,6% |
| 8 | TNT Airways | 2.577 | 2,9% |
| 9 | Swiftair | 965 | 1,1% |
| 10 | Iberia | 817 | 0,9% |

Table 7-2: Top 10 airlines for cargo in Lisbon Airport[30]

About 98.5% of the passengers are using Lisbon Airport as origin or destination of their journey[30] and mainly for intra European Union travelling (62.8% in 2006 and 64.2% in 2007).

| | 2006 | 2007 | | 2006 | 2007 | | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Origin & Destination | 98.4% | 98.6% | Domestic | 22.3% | 20.1% | Scheduled | 86.5% | 87.9% |
| Transit | 1.6% | 1.4% | Intra EU | 62.8% | 64.2% | Charter | 13.5% | 12.1% |
| | | | Non-EU | 14.9% | 15.7% | | | |
| TOTAL | 100% | 100% | TOTAL | 100% | 100% | TOTAL | 100% | 100% |

Table 7-3: Passengers Mix in Lisbon Airport[31]

[30] Moody's Global Corporate Finance Analysis – Ana Aeroportos de Portugal SA, November 2008

| | Passenger Movements (million) | *Rank (Passenger Movements)* | ATM* ('000s) | Cargo Tonnes (000s) | *Rank (Cargo Tonnes)* |
|---|---|---|---|---|---|
| London (5 airports) | 139.9 | *1* | 1102.6 | 1731.3 | *3* |
| Paris (3 airports) | 88.5 | *2* | 792.1 | 2148.3 | *2* |
| Frankfurt (2 airports) | 58.2 | *3* | 524.8 | 2186.1 | *1* |
| Madrid (1 airport) | 52.1 | *4* | 481.9 | 322.2 | *6* |
| Amsterdam (1 airport) | 47.8 | *5* | 436.0 | 1610.3 | *4* |
| Moscow (3 airports) | 39.6 | *6* | 464.6 | 258.7 | *7* |
| Milan (3 airports) | 39.6 | 7 | 421.3 | 622.5 | *5* |
| Rome (2 airports) | 38.2 | 8 | 369.1 | 153.2 | *9* |
| Barcelona (2 airports) | 37.6 | *9* | 385.7 | 97.0 | *10* |
| Munich (1 airport) | 34.0 | *10* | 406.6 | 251.1 | *8* |
| Lisbon (1 airport) | 13.4 | *>10* | 139.5 | 82.9 | *>10* |
| ANA (all 9 airports) | 26.7 | | 276.8 | 138.6 | |

**Air Transport Movements, i.e. take-offs and landings*

Table 7-4: Comparison of Lisbon Airport with other major European Airports cities (2007) [31]

## 7.2. Data simulation of Lisbon Airport situation

**Number of bags handled**

For 2008 ANA reported a total of 13.626.358 passengers handled in Lisbon Airport. According to the previous mentioned Moody's Global Corporate Finance Analysis, only about 1,4% of the handled passengers are using Lisbon as a transfer airport and 20% of them normally use it for domestic flights.

Under these circumstances and if we assume a rate of 0,8 bags per passenger, a very normal figure used by IATA in their studies, we can estimate the total of bags handled per year in Lisbon Airport as follows:

13.626.358 passengers * 0,8 bags per passenger = **10.901.086 bags handled per year**

**Mishandling baggage volume and costs**

From the Association of European Airlines reports on mishandling baggage, in 2005 the number of delayed bags had oscillated between a minimum of 4,66 to a maximum of 19,40

delayed bags per 1.000 passengers, with an average number per 1.000 passengers of 14,09 delayed bags.

For our calculations we will estimate a conservative average of 10 bags mishandled per 1.000 passengers and an operational cost of € 71,23 (US$ 100) per mishandled bag, resulting in the following:

10.901.086 total bags * (10 bags /1.000 passengers) = **109.011** mishandled bags per year

109.011 mishandled bags * €71,23 per bag = **€7.764.844** per year with mishandling bags

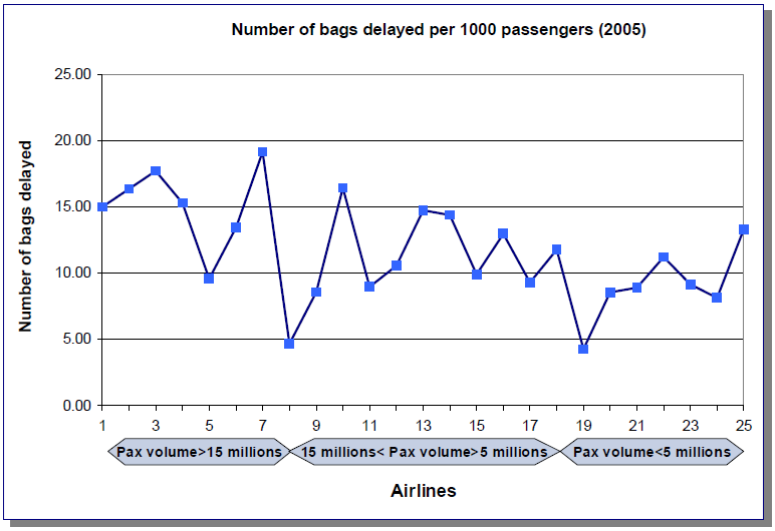


Figure 7-1: AEA Missing Bag Data[31]

**Mishandling baggage reduced by RFID implementation**

According to IATA data pointed out in Figure 3-4, within the main factors responsible for mishandled baggage, airlines had identified the following main reasons:

- Transfer bag of late arrival, which are responsible for 30.10% of all mishandled baggage,

[31] Association of European Airlines 2005

- Delay in moving bags from transfer flights, responsible for 18.42%,
- Barcode reading problems which is causing 9.97% of all mishandled baggage, and
- Failure to receive a BSM[32] message as contributing to a further 10.90% of mishandled.

Since just a few passengers (only about 1.4%) handled by Lisbon Airport, are normally using it as a transfer airport, we could easily conclude that the first and second reasons, responsible for a total of 48.52% in IATA reports, should be significantly less for Lisbon Airport.

This also should means that the two other reasons (barcode errors and BMS messages failures), may represent a higher responsibility in the mishandled baggage.

Nevertheless and maintaining a conservative analysis strategy, we will use the IATA results to our calculation with the following values for the simulation:

- Barcode reading problems: 9%,
- Failure in BSM messages: 10%.

Assuming that both kinds of failures in baggage handling operations, could be solved or reduce by the introduction of RFID technologies, we will use these values to estimate a quantity and cost calculation per year with mishandled baggage due to booth failures:

| | | | | |
|---|---|---|---|---|
| 109.011 mishandled bags | * | 9% | = | 9.811 mishandled bags per year due to barcode errors |
| € 7.764.844 per year due mishandled bags | * | 9% | = | € 698.836 per year due to barcode errors |
| 109.011 mishandled bags | * | 10% | = | 10.901 mishandled bags per year due to BSM failures |
| € 7.764.844 per year due mishandled bags | * | 10% | = | € 776.484 per year due to BSM failures |

[32] BSM – Baggage Sortation Message

resulting in the totals for both failures:

| | | | | |
|---|---|---|---|---|
| 9.811 bags due to barcode errors | + | 10.901 bags due to BSM failures | = | total of 20.712 bags per year |
| € 698.836 due to barcode errors | + | € 776.484 due to BSM failures | = | total of € 1.475.320 per year |

If we consider that only 60% of these costs will be solved by the RFID system, a first approach to the savings will result in:

| | | | | |
|---|---|---|---|---|
| total of € 1.475.320 per year | * | 60% | = | total of € 885.192 per year |

### 7.3. Costs simulation of a RFID baggage handling system

Supported by the RFID Business Case for Baggage Tagging paper (IATA 2007), the cost assessment will assume the following costs and quantities:

**Hardware required: RFID Equipment**

| | | | | |
|---|---|---|---|---|
| 100 RFID Tag Printers | * | € 1.800 per RFID Tag Printer | = | total of € 180.000 |
| 50 RFID Readers and Antennas | + | € 2.500 per RFID Reader and Antenna | = | total of € 125.000 |

In addition to the basic RFID equipments, supplementary investments will be required for integration and project management, estimated as follow:

- RFID equipments integration: € 300.000
- Project Management: € 100.000

**Software required: Track and Trace Application**

Also a baggage management system is required to report on the performance of the airport,

monitor service level agreements and to have a track and trace functionality. For such a system, our estimative will consider the following main figures:

- Project Development[33]: € 350.000
- Middleware[34]: € 100.000

**Consumables: RFID Tags**

Considering, as defined before, that Lisbon Airport will be handling 0,8 bags per passenger, that each RFID Tag, with small memory, will have a cost of € 0,015 and also assuming a fix volume of passengers handled during the next few years, the operational costs will be estimated based in:

| | | | | | | |
|---|---|---|---|---|---|---|
| Purchase of RFID Tags | = | 10.901.086 bags handled per year | * | € 0,015 | = | € 163.516 per year |

For other complementary operational costs, including maintenance costs, we will also assume a similar value of € 163.516 per year.

**Summary of Costs:**

To conclude the RFID Handling System costs analysis, we can summary the following main figures:

| | | | | |
|---|---|---|---|---|
| **Capital Expenditures** (RFID equipment and Track and Trace Application) | = | € 705.000 + € 450.000 | = | € 1.155.000 |
| **Main Operational Expenditures per year** (RFID Tags and other costs) | = | € 163.516 + € 163.516 | = | € 327.032 |

[33] Project Development includes user requirements analysis and identification, architecture and coding, integration, tests and validation

[34] Includes interfaces, servers and licences

## 7.4. Savings from RFID System

Based in the example previously prepared, we will now focus our attention in the three main figures in order to estimate the savings resulting from the RFID System implementation:

- Initial investment (capital expenditures) in the RFID Handling System, in a total of € 1.155.000,
- Main operational costs, special with the purchasing of RFID tags, required every year for the number o bags handled by the airport, in a total per year of € 327.032, and
- Perspective of reducing at least 60% of the mishandling bags caused by barcode errors or by BSM messages failure, with an estimated total cost of € 885.192 per year.

# 8. Conclusions and Recommendations

## 8.1. Conclusions

With the ongoing activities in the field of RFID applications, running globally and successfully by so many representatives of the main air transport stakeholders, we can start to conclude that this technology will have an important role in the very near future of the freight and baggage handling systems and services through the efficiency improvement of the involved stakeholders, by the prevention of ground handling errors, tightening the control of the process and implementing new services along the End To End Chain.

The results of the work and analyse performed in both airports for the E-Cab project were clear about the adequacy of RFID technologies to the airport handling operations, with very positive results in the reduction of the mishandling bags actual rates, mainly the ones due to barcode errors or to baggage sorting messages failures.

But for efficiency maximization of improved freight and baggage services, it must be granted they are implemented at every check-point of the chain, starting at the departure, through the aircraft and finishing at the arrival airport.

The promising results of the E-Cab project, disclosed by the consortium during the final workshop where a demo was showed supported in the project mockup installed in Hamburg plant of Airbus, clearly had evidenced the benefits of RFID technologies introduction in control and monitoring of baggage and freight handled, including in the cargo compartment of the aircraft and closing this gap of the End To End Chain in air transportation.

The cost and benefits analysis carried out through the simulator developed during the

study and adopting a conservative case scenario, also allows us to conclude that the required financial efforts needed for the installation of a RFID baggage handling system, could reach a return of the investment in less than three years.

Despite the fact of the current price of a passive not reusable identification RFID Tag is still expensive, it is foreseen that with the global adoption of RFID technology, it shall decrease to the barcode level in a short period of time.

Nevertheless, it is also very clear that technology for itself is not the solution for the efficiency of the handling operations: the processes must always be careful analysed and improved, most of the times adopting small and simple organizational measures to eliminate or to reduce difficulties resulting of the mishandling bags.

The results achieved by the stakeholders, in particular the ones related with the activities leaded by IATA with the Simplifying the Business Project Team, are anticipating that RFID will soon be able to replace partial, or even totally, the actual fallible barcode systems.

Despite the fact that the Internet of Things – IoT concepts are actually straining the experts discussions all over the world and driving must of the ongoing ICT applied research projects, the actual stage in the state of the art is still requiring many efforts to reach an adequate level for a common market application.

## 8.2. Recommendations

As a final project statement and for further development, we would like to express the following main recommendations:

1. **The Internet of Things as a Vision for the Future**:

Due to the power of the Internet of Things concepts and to its actual stage of

development, it must be understand yet as a vision for a new paradigm in logistics, affecting in the near future all the E2EC, which means we need to be in a continuous alert condition during the developing of possible new applications and scenarios, with a special attention to systems integration.

2. **Development of Portuguese RFID applications for the New Lisbon Airport**:

As previously conclude and as IATA had been continuously announcing, RFID is a much promised technology in the future of baggage and freight handling operations.

With the New Lisbon Airport project, Portugal is facing a very challenging good opportunity, since it could represent one of the very few new good chances in Europe, in the next years, which with an adequate national strategy, can disclose the right momentum for the development of new and dedicate added value products and systems focus in air transportation sector.

According to the Portuguese Public Contracts Code[35], for projects over 25 million euros a budget of 1% must always be affected by the consortiums to research and development activities related with the project under proposal.

For the New Lisbon Airport project this will result in a budget of about 55 million euros, which are a very important source of funds for new research and development projects, including RFID technologies.

With the actual project scheduling and planning, it could be used first of all to develop smaller new RFID applications, using the actual infrastructures of Lisbon and Oporto Airports to test and validate the results. During a second phase the implementation of systems integration should be prepared, simulated and tested, using again the actual

[35] Portuguese law number 18 of 2008, published on the 29th of January

infrastructures, and preparing the proved developed solutions for industrialisation and a possible implementation in the New Lisbon Airport as well as a high added value Portuguese offer for the global market.

### 3. Portuguese RFID Support Centre

To increase knowledge and opportunities for RFID applications development, many European States had been establishing and supporting the implementation of independent infrastructures focus in RFID technologies and in the Internet of Things concepts.

Normally acting as a federating platform, these infrastructures are the right environment to develop and test new concepts and scenarios, and to disseminate the technologies and its applications.

The Informationsforum RFID and the RFID Support Center, both in Germany, RFID Nordic in Sweden, FILRFID/CNRFID in France, RFID Platform in Netherlands or RFIDsec in Denmark, are some good examples of the same strategy in different European Member States.

To strength the development of RFID applications in the European Union, the European Commission had lunch several initiatives during the last years.

According to Vivane Reding, European Union Commissioner for Information Society and Media, "RFID will form the basis of better and safer healthcare, drastically improved supply chain management, low cost environmental monitoring for a cleaner, more sustainable future. We need a pro-active European approach so that we can benefit from the advantages of RFID while giving citizens, consumers and businesses choice, transparency and control."

Following all the efforts lead by Commissioner Vivane Reding, the European Commission started, in 2009, to support RACE networkRFID[36], a European federating platform to the benefit of all European Stakeholders in the development, adoption and usage of RFID, involving 25 European organizations as contractual members, including all the RFID organizations mentioned before and Centro IBERLog in Portugal.

Unfortunately and despite all the efforts already spent in Portugal to lunch a similar infrastructure, this crucial goal was not possible to reach yet.

Nevertheless and keeping in mind the specific Portuguese conditions and our market dimension, we still consider that this RFID Support Centre, which should be established in a similar way as its partners of RACE networkRFID, will be essential to the implementation of a successful strategy for new RFID products development and for the right technology dissemination.

[36] www.race-networkrfid.eu

# References

AEA, ASSOCIATION OF EUROPEAN AIRLINES (2009), last time consulted on 09/12/18 in www.aea.be

ANA AEROPORTOS DE PORTUGAL SA (2009), ANA Annual Traffic Report 2008

EUROPEAN COMMISSION INTEGRATED PROJECT UNDER THE CONTRACT AIP5-CT-2006-030 815 (2009) – E-enable Cabin and Associated Logistics for Improved Passenger Services and Operational Efficiency (E-cab)

EUROPEAN COMMISSION THEMATIC NETWORK UNDER THE CALL CIP-ICT-PSP.2008.3.1 (2009), RACE networkRFID: Raising Awareness and Competitiveness on RFID in Europe, last time consulted on 10/01/28 in www.race-networkrfid.eu

INTERNATIONAL AIR TRANSPORT ASSOCIATION, IATA (2007), RFID Business Case for Baggage Tagging

INTERNATIONAL AIR TRANSPORT ASSOCIATION, IATA (2007), IATA Fact Sheet: Industry Statistics, update on 12/2009

INTERNATIONAL AIR TRANSPORT ASSOCIATION, IATA (2005), IATA Passenger and Freight Forecasts 2006-2010

INTERNATIONAL AIR TRANSPORT ASSOCIATION, IATA (2007), IATA RP1740C Standard

INTERNATIONAL AIR TRANSPORT ASSOCIATION, IATA (2007), RFID Business Case for Baggage Tagging

INTERNATIONAL AIR TRANSPORT ASSOCIATION, IATA (2007), RFID Trials for Baggage Tagging

MOODY'S INVESTORS SERVICE, INC. (2008), Moody's Global Corporate Finance Analysis – Ana Aeroportos de Portugal SA, November 2008, last time consulted on 09/12/21 in www.moodys.com

SOCIETE INTERNATIONALE DE TELECOMUNICATIONS AERONAUTIQUES, SITA (2007), The Baggage Report for 2006

SOCIETE INTERNATIONALE DE TELECOMUNICATIONS AERONAUTIQUES, SITA (2008), The Baggage Report for 2007

TEN HOMPEL, M. (2007), RFID: Towards the Internet of Things, Sensing the real world or the real Internet of Things

UNITED STATES THE US DEPARTMENT OF TRANSPORTATION (2008), U.S. Centennial of Flight Commission, last time consulted on 09/01/17 in www.dot.gov

WORKING GROUP RFID OF THE ETP EPOSS (2008), Internet of Things in 2020, Roadmap for the future