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Exploratory analysis of Radio Frequency Identification implementation in Portuguese airports

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Master in Management

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BUSINESS
SCHOOL

Department of Marketing, Operations and Management

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I dedicate this work to my parents and friends, who are always there for me.

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Abstract

Cargo is an essential sector for the aviation industry representing 10-15% of the typical airlines business. During the pandemic, this sector was crucial to support the air carriers, representing one-third of the revenues (IATA, 2021a). Although passenger luggage mishandling has been the subject of various studies, little research has focused on improving the cargo side. RFID is a promising technology aiming to identify, locate and trace items.

This dissertation analyzes institutional and chain drivers, barriers, and success factors for RFID implementation in Portuguese Airports. This environment was chosen due to the sector growth since 2016 and its poor technological development (ANA, 2020). To collect information, five structural interviews were conducted.

The data analysis demonstrates that RFID implementation is driven by internal reasons: company and cargo services optimization. The complexity of the sector has differentiated barriers at the company and airport channel levels. Within the companies, restraints exist associated with the characteristics of the Portuguese business fabric and the partner reality (infrastructures, change resistance and financial conditions). In turn, airport adoption is constrained by the sector vision, the difficulty to manage various entities and the financial investment.

The research shows that a cargo is a complex and connected sector, highly affected by business partner behavior, especially in Portuguese airports, where the cargo contribution is undervalued. Therefore, a successful implementation depends on the trust and acceptance of the technology, the chain commitment, and securing the necessary infrastructure.

Keywords: air cargo, Portuguese airports, RFID implementation, successful factors, drivers, barriers

JEL Classification System

L93 – Air Transportation

O33 - Technological Change: Choices and Consequences • Diffusion Processes

Resumo

A carga é um setor essencial na aviação, representando 10-15% do negócio típico das companhias aéreas. Durante a pandemia, este setor foi crucial para apoiar as transportadoras, representando um terço das receitas (IATA, 2021a). Embora o manuseio incorreto de bagagens de passageiros tenha sido amplamente estudado, poucos estudos se concentraram na melhoria do setor da carga. RFID é uma tecnologia promissora que visa identificar, localizar e rastrear itens.

Esta dissertação analisa impulsionadores institucionais e da cadeia, barreiras e fatores de sucesso para a implementação de RFID nos aeroportos portugueses. Este ambiente foi escolhido devido ao crescimento do setor desde 2016 e ao seu fraco desenvolvimento tecnológico (ANA, 2020). Para recolher informação foram realizadas cinco entrevistas estruturais.

A análise dos dados demonstra que a implementação do RFID é impulsionada por motivos internos: otimização da empresa e dos serviços de carga. O setor apresenta barreiras diferenciadas ao nível da empresa e do aeroporto (cadeia). Nas empresas, as barreiras estão associadas às características do tecido empresarial português e à realidade dos parceiros (infraestruturas, resistência à mudança e condições financeiras). Adicionalmente, a adoção aeroportuária é condicionada pela visão do setor, pela dificuldade de gestão das diversas entidades e pelo investimento financeiro.

A pesquisa mostra que a carga é um setor complexo e interligado, altamente afetado pelo comportamento dos parceiros, especialmente nos aeroportos portugueses, onde a sua contribuição é subvalorizada. Portanto, uma implementação bem-sucedida depende da confiança e aceitação da tecnologia, do compromisso da cadeia e da garantia da infraestrutura necessária.

Palavras-chave: carga aérea, aeroportos portugueses, Implementação de RFID, fatores de êxito, impulsionares, barreiras

Sistema de Classificação JEL

L93 – Transporte aéreo

O33 – Mudança tecnológica: Escolhas e Consequências • Processo de difusão

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List of Abreviations

ANAC - Agência Nacional de Aviação Civil

AWB – Air Waybill

CRTs – Cargo Tonne Kilometers

DOS – Denial of services

e-AWB – electronic Air WayBill

EPC – Electronic Product Code

ERP - Entreprise Resource Planning

FRA – Frankfurt Airport

FTK - Freight Tonne Kilometres

HF – High Frequency

IATA – Air Transport Association

ISO – International Standards Organization

LF – Low Frequency

LH – Lufthansa

LIS – Humberto Delgado Airport ; Lisbon Airport

NFC – Near Field Communications

OPO – Francisco Sá Carneiro Airport; Porto Airport

RFID – Radio Frequency Identification

ROI – Return on investment

RPK – Revenue Passenger Kilometers

RTKs – Revenue Tonne-Kilometers

SLA – Service Level Agreement

TAP – TAP Air Portugal

UHF – Ultra-High Frequency

ULD – Unit Load Device

WMS – Warehouse Management System

Definitions

Revenue Tonne-Kilometers (RTKs): The revenue load in tonnes multiplied by the distance flown (British Airways, n.d.)

Revenue Passenger Kilometers (RPK): The number of revenue passenger carried multiplied by the distance flown (British Airways, n.d.)

Cargo Tonne Kilometers (CTRs): The number of revenue tonnes of cargo (freight and mail) multiplied by the distance flown (British Airways, n.d.)

Freight Tonne Kilometers (FTK): The number of revenue tonnes of freight multiplied by the distance flown

1. Introduction

The transportation of commodities by air stands out for the offered speed and reliability of the related processes. These characteristics make air cargo transportation essential for perishable goods, valuable cargo, the pharmaceutical industry, the high-tech industry and e-commerce (IATA, 2021). The sector is responsible for 1% of the global cargo traffic in value and represents 35% of the world trade (Boeing, 2020). In 2019 the sector transported approximately US$6.3 trillion worth of goods (IATA, 2020) and carried 60,9 million tonnes, while maritime transportation transported 11,9 billion tonnes (Boeing, 2020).

Over the past 30 years, the air cargo business has shown resilience despite the world circumstances: wars, terrorism, economic crises and pandemic. Before the covid-19 pandemic, cargo represented 10 to 15% of the airline business revenues although, the global situation changed the market needs and, in 2021, it represented one-third of the airline income (IATA, 2021a). The sector, between 1989 and 2019 grew an average of 4,1% per year (Boeing, 2020). From 2020 to 2025 is expected the global trade to grow by 4,7% and air carriage to expand by 4,1%. In addition, from 2019 to 2039, Revenue Tonne-Kilometers (RTKs) are expected to double from 264 billion in 2019 to 576 billion in 2039 due to increased demand in e-commerce and pharmaceuticals (Boeing, 2020).

The popularity of air carriage and the expected growth in demand affects the complexity of the processes, increasing the likelihood of irregularities. To protect the sector actors in case of anomalies, the International Air Transport Association (IATA) issued the Montreal Convention in 1999 that establishes that the air carrier is liable for the delay, damage or loss of load, being obliged to pay compensation for the damages caused to the clients (IATA, 1999). International air carriers have a minimum per kilo limit for financial compensation (e.g. €0.50 per kilo). However, the effects of anomalies go beyond the indemnification that the air carrier pays to the customer. The damage, delay or loss of cargo can result in a shortage of inventory, loss of sales and production stoppages and even breach of contracts. In addition, for some commodities, a long delay can lead to deterioration, spoil and loss of the market value (Dittman, 2015). Furthermore, for the air carriers, these occurrences also have a greater impact than the financial losses caused by the reimbursements. The anomalies increase the working hours of workers, raise the workforce cost, creates instability in the assistance processes on the ground, demands the creation of a specific department to deal with the clients' complaints, affects the brand image in the market and, in some cases, can lead to the loss of customers.

In air transport, the impact of irregularities is also visible on the passenger side. In 2018, 24.8 million bags were mishandled, representing an annual bill of US$ 2.4 billion (SITA, 2019). To mitigate

the impacts of mishandled baggage[1], IATA issued the “Resolution 753” that compel the passenger luggage tracking by the air carrier. The resolution intends to improve baggage handling operations and meet the growth of the passenger air transport industry (IATA, n.d.-a). In parallel, to comply with Resolution 753, IATA suggests the adoption of the RFID system in "Resolution on Radio Frequency Identification (RFID) in baggage" (IATA, 2019b).

The use of RFID for identification can be traced back to the late 1940s in World War II, when it was applied to distinguish between enemy warplanes and allied warplanes (Nguyen-Duy & Dinh-Duc, 2015). The benefits of this technology are discussed and analysed in different sectors, as seen in Vijayaraman and Osyk (2006) in the warehousing industry, Novotny et al. (2015) in retail, Valero et al. (2015) in construction and Kumari et al. (2015) in agro-food. However, the RFID adoption in air transportation remains in the early stage. On the cargo side, the RFID implementation is residual and, on the passenger side, the IATA recommendation only became effective in June 2018, fifteen years after the RFID big bang in the United States of America (US) triggered by the Walmart and the US Department of Defense (Reyes et al., 2016). Therefore, the present study aims to understand the aspects and factors that are delaying the adoption (in the company and the airport) and, the incentives and conditions that can trigger the implementation of RFID in air cargo transport, at the Portuguese airports. For that, the study takes into account the reality of the Portuguese business fabric and the conditions of the Portuguese airports. It encompasses three major actors – freight forwarders, ground handlers and air carriers – operating in the two main Portuguese Airports : Porto Airport (OPO) and Lisbon Airport (LIS).

In air transportation, the passenger side overshadows the cargo side, affecting the attractiveness of the sector and retrieving its potential. Passenger transport and handling is responsible for a higher business turnover. In 2019, the Revenue Passenger Kilometres (RPK) was 8680 billion, while the Cargo Tonne Kilometers (CRTs) were 254 billion (IATA, 2020). These differences are also reflected in the academic literature, which shows an imbalance between research aimed at passengers and research aimed at air cargo networks which can be explained partially by the complexity of the air cargo supply chain. The sector contains a plurality of stakeholders, with different goals and miscellaneous business models, encompassing passenger airlines, full-cargo airlines and integrators [2](Bombelli et al., 2020).

The change in consumer habits and the growth of e-commerce affect the way in which commodities need to be transported, demanding agility in service from companies and quicker

[1] Mishandled bags encompass loss/stolen bags, damaged/pilfered bags and delayed bags (SITA, 2019)

[2] Integrators are carriers that control the complete network of air and road deliveries. The best known integrators are UPS, FedEX, TNT and DHL (Malighetti et al., 2018).

transportation. Thereby a technology that enhances automation, improves the quality and management of data and, reduces irregularities can be essential to meet market development.

The research aims to enrich the academic literature on-air cargo transport. Additionally, it intends to raise awareness of the barriers to innovation in the Portuguese airport network and point out the conditions that the players believe should be met for successful implementation. Therefore, the research aims to answer the following research questions:

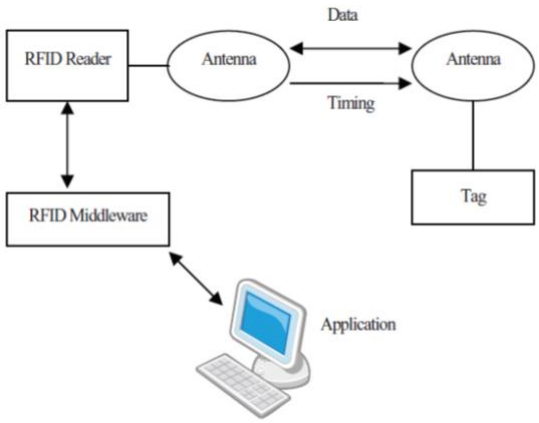
- RQ1: What are the benefits of the RFID implementation in the Portuguese air cargo sector.
- RQ2: What are the triggers for the implementation of RFID in the Portuguese air cargo sector.
- RQ3: What are the barriers to the implementation of RFID in the Portuguese air cargo sector.
- RQ4: What conditions must be met for the implementation of RFID in the Portuguese air cargo sector.

The dissertation is organized into five chapters. Chapter 2, the literature review, explores the particularities of the RFID system, the motivations that lead to the technology adoption, the advantages perceived with the technology adoption and, the barriers encountered during the system implementation stage and operation. Chapter 3 provides the research Methodology used during the study. Chapter 4 presents and analyzes the data collected: the perceived benefits of RFID for the air cargo sector, the factors that can trigger implementation, the players and airport barriers, and the conditions that must be met for a successful deployment in the network. Finally, Chapter 5 presents research remarks and observations, a conclusion, work limitations and potential future research.

2. Literature Review

2.1. The RFID system

The RFID system encompasses the tag, the reader, the antenna, the middleware and an application for the users (Mingxiu et al., 2012), represented in figure 2.1.



Source: Mingxiu et al. (2012)

Figure 2.1 – The RFID system structure

The tag is differentiated by a unique electronic product code (EPC) that allows the object identification when attached to it (Mingxiu et al., 2012). It is able to communicate with the reader and store information (Kumari et al., 2015). The reader has an antenna enclosed that allows the reception and broadcast of information through radio waves (Kumari et al., 2015). In some situations, the antenna is found outside the reader to provide increased flexibility and performance to the system, a common practice at on the systems deployed by Zebra Technologies. The antenna plays a key role in the communication between the tag and the reader (Wu et al., 2006) whereas the reader works as an intermediary between the tag and the middleware (Mingxiu et al.,2012). The middleware corresponds to a software that connects the reader with the captured data (Khaddar et al., 2011). It is composed of a set of components that manage the readers, deal with RFID events and information and link with end-user applications (Mitton et al., 2010). This section of the system controls the quality and usability of the data collected from the reader, to be later transferred to a back-end application (Khaddar et al., 2011). Lastly, the application corresponds to a software that presents the information collected from the middleware in a user format (Park & Eom, 2011).

The RFID flow is initiated when a tag is attached or embedded to an object. The EPC is saved in the chip tag herewith important product details (Khan et al., 2009). The reader, through the antenna, broadcasts radio waves to communicate with the tag. In turn, the antenna inbuilt in the tag receives the radio waves and broadcasts the information stored in the chip tag back to the

reader. The data collected from the tag is communicated to the middleware. Since the reader can compute multiple tags at once, it is necessary to process the information before uploading it to the user application. In the middleware, the information goes through filtering to extract the most important data, and logic as the aggregation of data and transformation. In the end, the data is displayed in back-end applications (Khaddar et al., 2011).

Below the components of RFID technology operation are presented.

2.1.1. The RFID Tag

The tag encompasses an integrated antenna and a microchip (Nguyen-Duy & Dinh-Duc, 2015). The antenna is responsible for the collection and broadcasting of the radio waves. The microchip (integrated circuit) is responsible for storage and data processing, modulating and demodulating radio waves and other specialized functions (Park & Eom, 2011). The tag is characterized in terms of power source, frequency and applicability (Khan et al., 2009) and, its cost varies depending on the frequency, amount of memory, antenna design and other requirements.

2.1.1.1. Power source

The way the tag is powered creates three categories: passive, semi-passive and active. The passive tag is non-powered, remaining "in silence" without broadcasting any radio wave until energized (Electronic Bag Tag sub-working group, 2018). Compared to battery-powered tags, the passive tag has a shorter communication range, a lower data transmission rate and a lower price (Zou et al., 2014). Depending on the frequency, the passive tag is used for animal recognition, asset identification, item tracking, logistics and health care (Sattlegger & Denk, 2014). Moreover, the absence of interrogating field (inactive mode) makes the passive tag the ideal option for air transportation (Electronic Bag Tag sub-working group, 2018). In the appendix A is detailed the passive tag operation procedures and working scope.

The semi-passive tag contains an internal battery yet, the component is not responsible for the communication with the reader. Similarly to the passive tag, the communication is initiated by the reader (Khan al., 2009; Khaddar et al., 2011). The presence of a battery increases the tag reading range[3] compared to passive tags with equivalent antennas (Zou et al., 2014). In return, the tag

[3] The tag reading range, also known as the read range, is the distance at which the RFID tag can return correct information to the reader (IATA, 2018).

lifespan is reduced, variating accordingly with the battery use (Kumari et al., 2015). In the appendix A is detailed the semi-passive tag operation procedures and the battery role. This class of tags are known for their capability to include various sensors, allowing the collection of information as temperature, humidity, pH, gas concentration (Kumari et al., 2015). Sensors are fundamental for the quality assurance, conservation, and safety of the tagged products. It helps the companies to meet the regulations, ensures the business viability and increases customer satisfaction. Its use is beneficial in the transport of perishable goods, pharmaceutical products, cold chains and areas where accessibility is reduced, dangerous or even prohibited (nuclear waste containment) (Strangfeld et al., 2019). Consequently, semi-passive tags are often used in scenarios where it is relevant to measure the environmental variables and share the information across the chain (Zou et al., 2014). They also present an advantage when there is no electromagnetic reader field and it is significant the collection of data (Jedermann & Lang, 2007). The semi-passive tags are evaluated as an effective trade-off among functionally, performance and cost, particularly for smart supply chain logistics (Zou et al., 2014). The sensors advantages are detailed at appendix A.

The active tag encloses an internal power source (battery), used to communicate with the reader and to power the others tags components (Khan et al., 2009). In the appendix A is detailed the active tag operation procedures and the battery role. They are the ideal solution when is required to read moving objects and to track cargo containers and vehicles (Nash II et al., 2016). It is frequently applied on metal surfaces and environments with water, on people tracking, tool collection, fleet management and logistic container tracking (Sattlegger & Denk, 2014).

2.1.1.2. Frequency

The tag is qualified, in terms of frequency, as low frequency (LF), high frequency (HF) and ultra-high frequency (UHF). Its selection is grounded on the requirements of a particular application (Nguyen-Duy & Dinh-Duc, 2015). The tags operating at a LF spectrum have a low reading range, with a slower read data, decreasing the number of tags read by minute (Kumari et al., 2015; Sattlegger & Denk, 2014). This class of tags are not appropriate for scenarios where encrypted communication is required. In turn, they have minimum interference in an environment that contains water and metal due to their long wavelengths (Unamate et al., 2018). Its features are ideal for security access, animal tracking (pet tagging, livestock identification), car immobilizers and waste management (Sattlegger & Denk, 2014). The characteristics of LF tags are further detailed in appendix B.

The HF tags operate mainly at 13.56 MHz due to the worldwide availability of the frequency and the popularity of smart cards based on RFID technology (Khaddar et al., 2011). Like the LF tags,

its performance is not affected when in contact with water and metal (Sattlegger & Denk, 2014). In contrast to LF tags, HF tags have a higher read distance, an enhanced data rate and an improved multi-tag reading capacity. (Khaddar et al., 2011; Sattlegger & Denk, 2014). Moreover, HF tags are applicable in public transportation, smart tickets, books, medical, assets/tools, passports and Near Field Communications (NFC) [4]applications (Sattlegger & Denk, 2014). The characteristics of HF tags are further detailed in appendix B.

The UHF tags operate between 860 – 960 MHz and sometimes at 2.45 GHz (Periyasamy & Dhanasekaram, 2015). In contrast with LF and HF, the UHF tags have a higher reading range, a higher data rate, a quicker multiple-item detection (Ching & Tai, 2009), and the capacity to read a higher number of tags simultaneously (Lauther, 2018). The UHF frequency can operate in different power sources: active and passive. The passive UHF tag is applied in retail, logistics, roll cages, asset/inventory management, medical/health care and access control (Sattlegger & Denk, 2014). Furthermore, their characteristics do not compromise the safety of the flight, making these the best choice for air transportation (IATA, 2007). Alternatively, the active UHF tags suit the needs of asset/inventory management, toll collection, logistics, container tracking and fleet management (Sattlegger & Denk, 2014). The characteristics of UHF tags are further detailed in appendix B.

Table 2.1.presents the characteristics of the different tag types based on tag frequency.

[4] The NFC corresponds to a specification of the RFID, being positioned in the HF passive technology (Sattlegger & Denk, 2014)

Table 2.1: Comparison of RFID tags based on frequency

Characteristics	Low frequency (LF)	High Frequency (HF)	Ultra-High Frequency (UHF)
Frequency Range	125 kHz and 134 kHz (Khaddar et al., 2011)	13.56 MHz (Khaddar et al., 2011)	860-960 MHz (Periyasamy & Dhanasekaram, 2015)
Read range and Data rate	Low reading range and data rate (Sattlegger & Denk, 2014)	Larger reading range and faster data rate than LF tags (Khaddar et al., 2011; Sattlegger & Denk, 2014)	Highest reading range and data rate(Ching & Tai, 2009)
Tag read capacity	Usually only single read (Unamate et al., 2018)	Improved multi tag reading(Khaddar et al., 2011; Sattlegger & Denk, 2014)	Highest multi-tag reading capacity (Lauther, 2018)
ISO Standards	ISO 11784, ISO 11785, ISO 14223, ISO 18000-2 (Sattlegger & Denk, 2014; Unamate et al., 2018)	ISO 18000-3, ISO 14443, ISO 15693 (Sattlegger & Denk, 2014; Unamate et al., 2018)	ISO 18000-6; ISO 18000-4 (Unamate et al., 2018)
Cost (Unamate et al., 2018)	Expensive	Depends on type of tag	Low cost (at high volumes) due to a simpler manufacturing process
Memory (Unamate et al., 2018)	Smaller memory than HF tags	Relatively high memory - 256 bits to 8 Kbytes	Smaller memory size compared to HF tags. Usually between 96 bits to 1 Kbits
Performance close to liquids and metals	Minimum interference (Unamate et al., 2018)	Reliable and accurate performance (Sattlegger & Denk, 2014)	Unless properly adapted, performance decrease (Unamate et al., 2018)
Applicability (Sattlegger & Denk, 2014)	Security access, animal tracking (pet tagging, livestock identification), car immobilizers and waste management	Public transportation, smart tickets, books, medical, assets/tools, passports and NFC applications	Retail, logistics, asset/inventory management, medical/health care, access control, tool collection, container tracking, fleet management

2.1.2. The Antenna

The antennas on the tag and the reader ensure the communication and the exchange of information in the system (Valero et al., 2015). A reader, using its antenna, broadcasts radio waves (Khaddar et al., 2011). Ergo, the tags within the reader range receive the radio waves in the antenna and respond, transmitting the information stored in the microchip to the reader (Khaddar et al., 2011). Furthermore, in the case of a passive tag, the received radio waves are transformed into electrical power by the antenna, "waking up" the device (Wu et al., 2006).

The component is sensitive to different aspects: type of reader, tag position and orientation and, the type of material of the object (Park & Eom, 2011); Therefore, the study of the antenna behaviour secures the system feasibility and performance. The alignment and configuration of reader antennas, ensuring that they do not interfere with each other whilst covering the entire field, is a fundamental and time-consuming activity (IATA, 2007). The characteristics of the antenna are further detailed in appendix C.

2.1.3. RFID reader

The reader links the tag to the system (Oliveira et al., 2018). The device is responsible for tag powering, communication starter, tag identification, data reading, data writing, interpretation of information and communication with the middleware (Park & Eom, 2011; Unamate et al., 2018). Their design has evolved and it is possible to make informed decisions, such as where the item should be and whether there is a need to report any information (IATA, 2007). Through the antenna, the reader broadcast and receives information in the shape of radio waves (Khaddar et al., 2011). The received signal is decoded, converted into digital information and transmitted to the middleware (Khaddar et al., 2011; Kumari et al. 2015; Oliveira et al., 2018). The reader features are further detailed in appendix D.

2.1.4. RFID Middleware and Software

The middleware corresponds to software or device that links the reader and the collected data with the company information systems. The device manages the readers and is responsible for the quality and usability of the information. The data stored in the tag microchip is collected by the reader and transmitted to the middleware (Khaddar et al., 2011). Typically, the reader gathers information from every tag that is within their reading range. Therefore, the material that arrives at the middleware is in a “raw” state and has to be treated. Afterwards, the device filters clean and formats the data to the

different applications (Kumari et al., 2015). The component allows the user to obtain cleaned and filtered data. It creates effective communication and the possibility to manage the system information (Kumari et al., 2015).

2.2. RFID Benefits

Studying the RFID system advantages is vital for its diffusion in the industry. For Lee and Jung (2016), the perception of the benefits is essential for RFID adoption. However, the gains obtained from the adoption are context-dependent and vary among companies.

Below the benefits are organized and presented.

2.2.1. Data management

Moving a tagged item produces records in real-time. Each entry is treated and combined into a reliable database for future use (DeVries, 2008; Chang et al., 2011). The collection of data over the chain enables asset tracking and inventory control which is important for operational efficiency. The organization and centralization of information in the system allow simpler and quicker access. In turn, the company transparency is enhanced, employee productivity increases (Vijayaraman & Osyk, 2006) and customer service improves. The client has access to accurate and detailed information (DeVries, 2008) and, the company, when queried by the client, provides a more reliable and quicker response (Kabadurmus et al., 2012). In Reyes et al. (2006), the accuracy and availability of information is cited as the greatest perceived improvement generated on the RFID implementation.

The data collected and processed can be a tool for decision-makers (Sharma et al., 2020). It supports inventory planning, reduces stockouts (Li & Visich, 2006) and enables a more reliable demand forecast (Chang et al., 2011). In Al-Kassab et al. (2013), the gathered data helped detect defective items, identify catching areas and understand customers' shopping paths in retail stores. The assessment helped the retailer to optimize the sales floor layout and improve their sales. In addition, feasible data can be used to cooperate with business partners, improving their connection (Li & Visich, 2006).

Some supply chain inefficiencies are attributed to the lack of shared information and a poor communication (Reyes et al., 2007). A closer connection among partners leads to a more efficient business. For example, the reverse chain logistics for reusable assets or recycling products is improved (Li & Visich, 2006). Moreover, the exchange of data strengthens the system benefits in inventory planning, forecasting and replenishment (Vijayaraman & Osyk, 2006; Li & Visich, 2006).

2.2.2. Asset management

The RFID technology is known for its tracking and trace capabilities. The attachment of a tag provides a unique identification of the item (Kumari et al., 2015) and an accurate trace as it moves through the chain (Vijayaraman & Osyk, 2006). The movements are recorded and stored in the RFID system, enhancing the safety and security in the supply chain (Li & Visich, 2006) and providing improved visibility of their various stages (Khaddar et al., 2011). He et al. (2010) identified the enhancement of cargo visibility as one of the three main benefits generated by the deployment of the technology. This improvement allowed access to cargo data in real-time (He et al., 2010). It is possible to know the location of the different items (Reyes et al., 2007), which and when was loaded, shipped and the arrival moment at the destination (Li & Visich, 2006). An effective traceability system increases the security and the customers' confidence (Kumari et al., 2015). In air passenger transportation, each luggage loaded in the aircraft is associated to a passenger. The access to information in real-time enables an automatic assignment of the baggage to the corresponding passenger, helping the air carriers to deal with security issues and luggage management (DeVries, 2008). In 2018, 24.8 million bags were recorded as mishandled worldwide (SITA, 2019). The RFID application helps the air carrier identify and rectify a problem before the client notices (DeVries, 2008). Additionally, this feature is vital for perishable commodities to meet safety and quality demands. In a cold chain, the accurate control of temperature assures the quality of the products, increasing their shelf-life and helps in the prediction of the items shelf-life. Furthermore, it supports the company to meet the requirements of regulatory bodies. In case of contamination during the carriage of food, the system identifies each potential package. Dole Food Company, after suspicion of products contamination with E. coli bacteria, began an initiative to recall the boxes that could be unsafe to consume (Kumari et al., 2015).

The effects of asset tracking are also visible on inventory management. The scan of multiple tags simultaneously allows the control of the inventory in real-time (Reyes et al., 2007), enhances the stock transparency, decreases the amount of needed inventory and reduces the out-of-stock situations (Vijayaraman & Osyk, 2006). At K-Mart, Target and BestBuy, RFID reduced the stock losses and placed the stock at an optimal level (Khan et al., 2009). Improved inventory management increases sales, enhances customer service and improves the company cash flow due to optimized inventory turns (Li & Visich, 2006). Inside the aircraft, the inspection of parts (slides, rafts, life vests, O2 Generators) is frequent for presence, expiration date and the need for inventory adjustment. The multi-tag reading capacity reduces the time required to verify the conditions of each item, allows accurate management of assets inside the aircraft and assures safety on board (IATA, 2018). Emirates saw a 97% and 98% reduction in the time needed to inspect emergency parts for the Airbus A380 and Boeing 777, respectively (Koonan, 2019).

Despise the benefits, the RFID impact on the management of the company assets is perceived differently. In Reyes et al. (2016), when compared with medium and large companies, small companies in the implementation stage present higher satisfaction levels on asset management.

2.2.3. Productivity and operations improvement

The RFID system is capable of multi-tag identification, at high speed, without human intervention or line of sight (Mingxiu et al., 2012; DeVries, 2008). These properties lead to an increase in process automation verified on Reyes et al. (2006) and Chang et al. (2011), leading to operational costs savings and reduced process errors.

The automatic acquisition of information accelerates the company processes (DeVries, 2008) and, the data entry errors diminish (Khaddar et al., 2011). On a distribution warehouse, 60% to 80% of labour are accountable for managing the entering goods (Li & Visich, 2006). The automation reduces or even eliminates the need for bar code scanning, manual counting and second verification (Vijayaram & Osyk, 2006; Chang et al., 2011). This way, the time required for every step is reduced (Chang et al., 2011). In a warehouse, the time needed on the unloading and loading process is lowered (Li & Visich, 2006) and, in the aircraft maintenance shop, the aircraft repairing time decrease (Chang et al., 2011). Moreover, the simulation developed at Cao et al. (2011) expects a reduction of 21% on the overall processing times with RFID, enabling the handling of 1.5 additional flights of cargo per day. Consequently, the level of resources is reduced by 17%, decreasing the operation costs. Giusti et al. (2019) found that the RFID implementation smoothed out data entry mistakes in cargo handling. The Unit Load Device (ULD) and truck consolidation errors were eliminated and, the items and pallet identification errors decreased. The reduction of human errors leads, during air cargo operations, to financial gains of 288,63€ per working day at Giusti et al. (2019).

The increase in automation minimizes human intervention, eliminates time-consuming activities (Reyes et al., 2016) and reduces human and labour errors (He et al., 2010; DeVries, 2008). In addition, the need for physical documentation decreases, diminishing paper-related issues (Sharma et al., 2020). The RFID system impacts the quantity of needed workforce (Kabadurmus et al., 2012), reducing the labour hours (He et al., 2010) and the financial costs (Khaddar et al., 2011). According to DeVries (2008), the system reduces the expenses with the workforce, time and energy to locate a piece of lost baggage in air passenger transportation.

The switch from Barcode to RFID improves the operations efficiency (Chang et al., 2011) and the effectiveness just as the supply chain efficiency (Vijayaraman & Osyk, 2006). In air cargo operations, the improvement in asset management due to the elimination of physical ULD counting, the reduction of ULD write-off, the exact identification of ULD quantities and a better ULD lifecycle management lead

to cost savings (Chang et al., 2011). During peak times, the performance of a barcode system can decrease. In air passenger transportation, this loss can lead to mishandling or rerouted bags. The multi-tag reading capacity avoids the decline of performance, maintaining the efficiency of the operations (DeVries, 2008). The adoption of RFID ends up positively affecting the company's performance and the quality and productivity of procedures. This effect is a conjugation of product tracking, automation, an increase of employee productivity, once the information is readily available, and greater control and flexibility of the items across the chain (Vijayaraman & Osyk, 2006).

2.2.4. Customer Service

The improvement in asset tracking, data management and operation, enhances the company customer service. The RFID system monitors each asset (item), improving the after-sale service (Reyes et al., 2007). In reverse logistics processes (recycling products and reusable assets), the company is able to focus on customer service rather than on transaction processes (Reyes et al., 2007). The products recall is managed quickly and effectively, increasing customer confidence (Li & Visich, 2006).

The collection of data during operations allows the companies to make informed decisions. In retail, the study of customer behaviour enables the management of the store based on the client's preferences, improving the customer service (Al-Kassab et al., 2013). The company approach can be moved from reactive to proactive (Chang et al., 2011), where the enterprise anticipates the problems and design a solution before the client notices it (DeVries, 2008). In logistic providers, the access to reliable information on the departure and arrival time of the goods increases the lead time accuracy, improves the decision-making process and raises customer satisfaction (Li & Visich, 2006). In air passenger transportation, the difficulty to match the baggage with the customer affects the client perception of the air carrier (DeVries, 2008). Furthermore, the response to customer inquiries is improved (Kabadurmus et al., 2012), having a high rating in Reyes et al. (2016).

The adoption of the RFID system improves the company internal procedures and operations, resulting in improved customer service observed in Reyes et al. (2007). The technology impact on customer service is considered the highest perceived benefit to implementing RFID in companies with hands-on experience in the technology (Reyes et al., 2016). In Reyes et al. (2016), small companies consider a higher perceived benefit on customer service while large enterprises have the lowest outcome.

2.3. Implementation barriers and challenges

Barriers are aspects that may delay, restrict or even prevent the adoption of a technology. Proper identification of the difficulties associated with the implementation allows companies to take action

and correctly manage them. The adoption of measures reduces the risk of the implementation project and increases the possibility to get benefits with the technology deployment (Moretti et al., 2019). Below the challenges and barriers are organized and presented.

2.3.1. Implementation

The implementation of new technology is a challenging process. It removes the users from the comfort of the status quo, changes the routines and roles and is an expensive and time-consuming process (Klein & Knight, 2005). The satisfaction for the existing technologies and process performance eliminates the need to improve them and the urge to adopt new technology. Therefore, to be willing to initiate it, a company must expect significant gains from the adoption (Madlberger, 2009).

The preparation and support for the RFID implementation are crucial, especially during the construction phase (Sharma et al., 2020). The scarcity of case studies to support the implementation and the lack of know-how and expertise on RFID represent significant implementation barriers (Moretti et al., 2019; Costa et al., 2017). This situation requires the company to invest in training to use the technology efficiently (Sharma et al., 2020). IATA, to reassure a potential implementer and to support the RFID implementation, constituted a skilled team to help IATA partners and prepared several resources as guide for the RFID deployment, case studies, webinars and training materials (IATA, 2007). In a chain, the complexity of the process increases when the adoption of technology interferes with the individual objectives of the companies (Tsai et al., 2013). Furthermore, in some countries, the technology is not available in the market or the suppliers are difficult to be found. For example, in Bangladesh, RFID technology and accessories are not available neither in the local or nearby market and consequently, the companies are forced to import from the US, China, Taiwan and Malaysia. Moreover, even in cases where the vendor can supply the industry, there is a lack of after-sale services timely and accurately (Rahman et al.,2019). The difficulty in finding qualified suppliers of equipment for the RFID structure is classified in Moretti et al. (2019) as a decisive setback to the system implementation. Furthermore, RFID adoption requires a significant upfront investment that is more problematic when the potential implementer is located in a developing country where the organization basic needs are not covered by the budget (Rahman et al., 2019).

Despite the efforts and developments accomplished by EPCglobal and International Standards Organization (ISO), the RFID standards are still a concern (Kumari et al., 2015; Reyes et al., 2016). The lack of standardization is considered a major issue associated with the RFID implementation due to the high variety of tags (Nayak et al., 2015). In Moretti et al. (2019), the lack of standards and norms to be followed as a guideline for the system implementation are considered one of the major barriers.

2.3.2. Operation

The interest in RFID requires an analysis of the implementation environment to understand possible operational obstacles. The system performance can be jeopardized by the existence of obstructions between the tag and the reader (Sharma et al., 2020), the incorrect orientation of the tag (Kumari et al., 2015; Kabadurmus et al., 2012) and environmental factors as dust, moisture, extreme temperature, water and metal (Kumari et al., 2015). On air transportation, the attachment of tags on metal containers loaded in the aircrafts reduced the system accuracy (DeVries, 2008). Moreover, Kabadurmus et al. (2012) alert that the content of the package can also affect the system results.

The RFID system is known for its wireless properties. This characteristic may cause interference with other wireless systems (Nayak et al., 2015), collision by simultaneous radio transmission (Wu et al., 2006) and, interference between tags and readers (Kumari et al., 2015). A test performed in the air-cargo terminal detected continuous noises from cellular phones, Walkie Talkie and strong noises from wireless devices. In addition, the presence of two equidistant tags from the reader results in a simultaneous energization and a consequence response. In the case of readers placed at the warehouse doors, the approximation of a tag can generate records in both readers if it is inside the readers reading range, leading to the distortion of the collected data (Interviewee VII, Zebra).

In daily operations, the system requires a large number of tags, resulting in environmental issues as the devices are commonly designed for one application and are not biodegradable. Also, their disposable characteristics link the device with physical damage, particularly in the rough airport environment. The baggage handling can cause breakage or damage and, the static electricity created at the conveyor belt can destroy the antennas (DeVries, 2008). In addition, the easy remotion of the tag can compromise the system. The use of the RFID system in libraries concluded that tags are frequently removed from the books by the users (Rahman et al., 2019). Actions as this one leads companies to question the customer acceptance of the technology. For Vijayaraman and Osyk (2006), the lack of customer demand retrains the RFID implementation. For example, the poor customer acceptance forced Gillette and Benetton to remove RFID from their products (Smart et al., 2010). Furthermore, the perception of the technology can be transversal to the organization's employees: professionals that usually work with manual systems have difficulties in embracing the new technology, because, in some cases, the workers believe that the current manual system is as good as the RFID system (Rahman et al., 2019). A case study in the main difficulties of the RFID system implementation showed that the employee's resistance to new technologies represents a main influential variable (Moretti et al., 2019).

2.3.3. Technological characteristics and infrastructures

The implementation of the RFID system is a complex process that requires the change of the existing infrastructures (DeVries, 2008). However, in developing countries, the adoption can be hampered by the lack of basic resources. For instance, libraries in universities of Bangladesh report an instability of electricity that compromises the system performance (Rahman et al., 2019).

The preparation of the system infrastructures includes the system migration, the system integration, and the management of the collected data (Vijayaraman & Osyk, 2006). For Wu et al. (2006) due to the barcode popularity, the migration from the barcode system to RFID requires the parallel use of both technologies, increasing the infrastructures needs and the associated costs. On the other hand, Moretti et al. (2019) stated that the difficulty of migrating from the company barcode system to the RFID system is not demonstrated. In addition, the issues resulting from software interoperability and IT system integration can create reservations on prospect implementers (Sharma et al., 2020). However, in Moretti et al. (2019), the difficulty of integrating the RFID system with the company current management system (ERP, WMS) is not observed. Moreover, the technology is known for the generation of a high volume of data, thus, to eliminate the possible errors, the raw data goes through filtering and processing (Kumari et al., 2015), which requires the construction of new data structures for its management (Khaddar et al., 2011).

2.3.4. Costs and return on investment

The costs associated with RFID adoption have always been an attention point for this technology. For Smart et al. (2010), the technology costs are not limited to the cost of the tag. It encompasses development costs, initiation costs, switching costs, costs of capital, implementation costs, relational costs, and ethical costs.

The high costs associated with the RFID adoption prevented air carriers and airports from implementing the technology (Chang et al., 2011). The initial implementation costs (Reyes et al., 2007) and the expected future costs (Madlberger, 2009) negatively impact the adoption. The tag price is a crucial element that determines the feasibility of the deployment in air transportation (DeVries, 2008). Conversely, at Moretti et al. (2019), the costs are not observed as an implementation barrier. In this study, the technology costs are considered a significant difficulty for some respondents but not for others. For Moretti et al. (2019), the participant position is influenced by the sector in which it operates.

The adaptable characteristics of RFID result in systems for various aims and with different features. Consequently, when and what benefits are collected vary from system to system, complicating the

Return on Investment (ROI) calculation. In Moretti et al. (2019), the pitfall of calculating the ROI[5], the complexity in defining the strategic positive effect and the real gain for the customer and, the difficulty to connect the RFID implementation with the improvement of the company's indicators, form an expressive group of barriers (17.70% of expression) for the technology implementation.

2.3.5. Security, privacy and ethical issues

The increase in RFID popularity exposes risks of security and privacy. Through an illegal collection of information, the technology can be used for corporate espionage (Chien & Chen, 2007) and human tracking (Nayak et al., 2015). The fear of unauthorized tracking of products impacts the client's loyalty to the company. The addition of tags to men's shaver packages led to protests in 2003 against Gillette (Novotny et al., 2015). Moreover, the installation of spoof tags that provide wrong information or the launch of Denial of Service (DOS) can jeopardize the system (Chien & Chen, 2007), leading to privacy violations of customers, employees and external entities (Reyes et al., 2016).

The security of the information saved in the tag constitutes an implementation barrier (Costa et al., 2017). The study developed by Novotny et al. (2015) determined that customers have a strong desire to control who accesses their devices and when. To suppress the privacy impacts, retailers as Walmart, Target and Tesco shifted from item level to case and pallet level identification (DeVries, 2008). Furthermore, they applied simple measures as the "kill tag"[6] approach while security protocols were being developed (Nayak et al., 2015).

The European Union issued a recommendation on RFID Privacy, Data Protection and Security (Novotny et al., 2015) and, standards as EPC UHF Gen 2 Air Interface Protocol already including security measures to guarantee the system reliability and security (Chien & Chen, 2007). However, Novotny et al. (2015) demonstrated that customers do not have confidence in the legislation and do not trust those who have access to their data.

The breach of privacy can trigger ethical issues. In healthcare, the RFID tag is placed externally or internally (sub-dermal implant) for people identification and to closely monitor the patient health conditions. Hence, the illegal access to information brings a high risk for fraudsters to misuse sensitive medical data (Abugabah et al., 2020). Moreover, the system can be used to track and report the movements of people to legal authorities, decreasing the freedom in society (Abugabah et al., 2020). Additionally, there is the fear for the compulsory requirement of tags in humans as they are required to housepets (Novotny et al., 2015).

[5] The transformation of potential RFID benefits in ROI numbers can be complex. The indicator requires a lot of time to become positive and, the effects on ROI is only positive for the client and not interesting for other parts involved (Moretti et al., 2019).

[6] In the "Kill Tag" approach, the tag is electronically diactivated (Nayak et al., 2015).

The great advantage of RFID can also represent one of its biggest obstacles. The access to detailed data can delay the system implementation in sectors that collects and saves sensitive information. Developing effective security measures is crucial in a society that is beginning to understand the value of its personal data and the risks associated with its misuse.

2.4. Implementation drivers

The implementation drivers constitute the motivations that trigger the adoption of new technology in a company or a supply chain. The nature of triggers and their importance in the organization(s) influence a successful technological deployment. The reasons that lead to RFID implementation depend on the business case justification of each company (Vijayaraman & Osyk, 2006) and the region (Lee & Jung, 2016). This section discusses the implementation drivers, differentiated into internal factors and external factors.

2.4.1. Internal Drivers

The internal drivers of RFID implementation encompass three main factors: organizational, economic, and technological (Susanty et al., 2019). On the organizational side, some big companies want to be the trend and directly or indirectly influence their suppliers to adopt the technology (Tsai et al.,2013). In addition, the company size affects its ability to explore new technologies. This perception is due to the assumption that large companies have a superior financial position, the potential to generate economies of scale (Lee & Jung, 2016) and have more qualified human resources (Madlberger, 2009). The study conducted by Madlberger (2009) did not demonstrate the correlation between company size and RFID adoption although, Lee and Jung (2016) observe a connection between the two variables.

The company context can affect the adoption decision. The organization readiness (conjugation of financial with technological readiness) is a positive influence, especially in developing countries in East Asia and Southeast Asia (Lee & Jung, 2016). In addition, companies in uncertain moments are keener to implement inter-organizational technologies to improve the relationship with partners (Tsai et al., 2013). Furthermore, the management vision has a significant impact on the adoption phase, with top management leadership being decisive for its responsibility for the implementation process and strategic direction (Reyes et al., 2016). In terms of the company sector, the adoption level varies from one industry to another. The RFID characteristics suit best areas where it is necessary to monitor and trace items. (Rajabi et al.,2012; Chang et al., 2011). Moreover, Lee and Jung (2016) perceive the influence of industrial contexts in technology adoption, implying that the industrial context matters for the RFID introduction. Conversely, Reyes et al. (2016) prove that the industry does not influence the company stage of implementation.

Innovation as a means to improve the company internal condition is a powerful driver. The understanding of the RFID usefulness (perception that the technology enhances the company performance and efficiency) is according to Lee and Jung (2016) study, the most critical factor for adoption. The Asia-based air carrier explored at (He et al., 2010) mentions the need to improve the efficiency of the air cargo handling process as the trigger for the technology adoption. In Vijayaraman and Osyk (2006), better inventory visibility represents one of the most important reasons for RFID adoption. Madlberger (2009) considers that the main determinant of RFID adoption is the generation of internal benefits, while Lee and Jung (2016) consider it the second most influential. For Madlberger (2009), the perception of deployment benefit decreases the impact of the company size in the implementation decision. In turn, Reyes et al. (2016) conclude that small companies have a higher level of perceived benefits, despise the implementation stage. In return, the early adoption by small firms can provide a competitive advantage (Madlberger, 2009). Moreover, the urge for internal improvement is transversal for the supply chain. The cooperation of the various players generates greater productivity, leading some buyers to invest in the development of suppliers to collect tangible benefits (Tsai et al., 2013). The correlation between perceived inter-organizational benefits and RFID adoption is observed in Madlberger (2009).

The economic factor is a powerful determinant for the implementation of new technology. Madlberger (2009) refers that to deploy a new technology economic advantages must be expected. At Delta airlines, the main reason for the RFID implementation in 2004 was the financial benefits, as rectifying lost baggage and resolving related issues that cost the air carrier $100 million per year (DeVries, 2008). Moreover, in the implementation stage, the retailer Walmart expected significant savings due to better management of the company inventory (Vijayaraman & Osyk, 2006). Furthermore, the productivity enhancement, the reduced need for human intervention, quicker response time and, better customer service will lead to the company financial benefits (Reyes et al., 2016; Tsai et al.,2013).

The technological factor encompasses the RFID position on the market and the perceived technological gap. The perception of a performance gap influences the company to innovate (Madlberger, 2009). The dissatisfaction with the existing technologies triggers the search for an alternative solution (Madlberger, 2009). In the aerospace industry, it was verified that the poor performance was due to a lack of effective and efficient identification methods, leading to the adoption of automatic identification technologies. The deployment in air cargo resulted in increased visibility and a decrease in costs related to the air-cargo operations and asset management (Chang et al., 2011).

For the RFID implementation, the internal motivations are more significant to the technology adoption than the external motivation. In Reyes et al. (2016), is observed that a higher level of internal drivers is associated with a higher level of RFID adoption. Table 2.2 presents the RFID Internal Drivers.

Table 2.2: RFID Internal Drivers

Organizational Factors	> Company size: a better financial position, the potential to generate economies of scale and qualified human capital > Positioning factors on the industry: company under uncertainty moment, be a trend, influence their suppliers and competitive advantage > Organization readiness; > Management position and support to innovation > Internal improvement: better inventory management; asset tracking; greater supply chain efficiency; enhancement of labour and operations efficiency > Protection of the company business and elimination of counterfeiting .	(Lee & Jung, 2016); (Tsai et al.,2013); (Lee & Jung, 2016); (Reyes et al., 2016); (Reyes et al., 2016); (Reyes et al., 2016)
Economic factors	> Expectation of economic advantages > Savings due to a better management of the company inventory > Financial benefits: internal improvement, productivity enhancement, reduced need for human intervention, quicker response and better customer service ;	(Madlberger, 2009); (Vijayaraman & Osyk, 2006). (Reyes et al., 2016; Tsai et al.,2013)
Technological factors	> RFID position on the market: maturity, technological standardization; > Perceived performance gap and dissatisfaction with the existing technology	(Reyes et al., 2016); (Madlberger, 2009).

2.4.2. External drivers

The external drivers are, according to Susanty et al. (2019), divided into regulation pressure and customer's pressure. The regulation pressure can have origin in the government and regulatory companies or powerful enterprises (giant's). Normally, when the government is the source of the pressure, it means that the power is greater on the government side than on the market side. This behaviour is more relevant in Europe (Lee & Jung, 2016).

The use of RFID for baggage handling in the airports has been studied since 1999. Yet, the high costs associated with the adoption at that time prevented the technology implementation by airports/air carriers. After the September 11 attacks, the US Government's required the screening of

all bags for explosives. The government directives somehow changed the situation and the technology was applied due to the higher level of accuracy offered in comparison with the bar code system (Chang et al., 2011).

Concerning regulatory companies, IATA has been exploring the high number of mishandled bags in the air passenger transportation and their impact in the customer service. In June 2018, the Resolution 753 became effective. This directive requires an effective baggage tracking and for that is highly recommended the RFID deployment in the airports for baggage handling and associated processes (IATA, 2019b).

In late 2003 the RFID big bang was observed in US. The interest of giant corporations such as Walmart and the U.S. Department of Defense (DOD) in the technology led to the creation of corporate directives to their suppliers (Reyes et al., 2016). The need to comply with the Walmart requirements was the major reason for the RFID pilot-testing or adoption in companies according to Vijayaraman and Osyk (2006). This behaviour can be explained by the companies fear of suffering retaliation, such as a reduction in orders. Entreprises want to safeguard their supplier position, preserve the relationship with the dominant retailer and ensure the business continuity (Tsai et al., 2013).

The influence of external pressure is notable in developing countries (Lee & Jung, 2016) and for some industries, it is essential for innovation and development. However, this trigger can reduce the perceived benefits and increase the expenses. This effect was observed on the companies that implemented RFID under the Walmart directives. Their urge to comply with the retailer requirements lead the company to use a “slap and ship” [7]strategy and inhibit the company to fully benefit the technology advantages (Vijayaraman & Osyk, 2006).

[7] In the "slap and ship" approach, the RFID tag is placed on a case or pallet right before being shipped from the supplier facility to the retailer facility.
This strategy is adopted when the technology is implemented strictly to meet the retailer’s requirements (Doug, n.d.)

3. Methodology

3.1. Research Design

This study explores the features of the shipment of goods by air in Portugal and the prospective implementation of the RFID system in the Portuguese airports. The research intends to understand:

- The benefits of the RFID implementation in the Portuguese air cargo sector.
- The triggers for the RFID implementation in the Portuguese air cargo sector.
- The barriers to RFID implementation in the Portuguese air cargo sector.
- The conditions that must be gathered for the implementation in the Portuguese air cargo sector.

To reply to these questions, it is required to combine the knowledge of the daily basis operation with the conditions of the Portuguese business fabric. For this, the chosen data collection approach, the interview, was divided into two phases. For the first phase, the interviews were designed to address airport players. The study intends to explore the perspectives and experiences of the interviewees (Moen & Middelthon, 2015). Using the interview, it is possible to gain a detailed insight on the research topic from the participant's point of view (Hennink et al., 2020). The method provides space for the participant to reflect and share their thoughts and knowledge. Hence, more information is extracted, allowing a deeper analysis (Moen & Middelthon, 2015). Subsequently to the content analysis, the second phase of interviews was carried out. This step was addressed to experts in RFID and air cargo transport and its main objective was to deepen the results obtained in the research regarding the RFID technology and its applicability in air cargo transport.

The Portuguese market was responsible for the transport of 139529,5 tonnes of cargo [8] in 2019 (Aviation Marketing Department, 2021). The data collection took place at LIS and OPO airports due to its size (medium size airport) and the substantial tonnes of cargo carried annually. LIS airport is the main Portuguese airport and TAP's hub. In 2019, it was responsible for transporting 89411,4 tonnes of cargo (about 64,06% of the cargo carried in Portugal). In turn, OPO airport is the second largest airport in Portugal and DHL's Road hub in Portugal. In 2019, it was responsible for transporting 39683,7 tonnes of cargo (about 28,44% of the cargo carried in Portugal). The recent market development makes these airports a good candidate to study the implementation conditions of the RFID system. Table 3.1 details the three main airports in Portugal based on tonnes of cargo transported in 2019 (Aviation Marketing Department, 2021).

[8] Data based on the airports managed by ANA Airports: Lisbon Airport (LIS), Porto Airport (OPO), Faro Airport (FAO), Beja Airport (BYJ), Madeira Airport (FNC), Porto Santo Airport (PXO), Ponta Delgada Airport (PDL), Horta Airport (HOR), Santa Maria Airport (SMX), Flores Airport (FLW)

Table 3.1: Three main airports in Portugal based on tonnes of cargo transported

Airport name	Tonnes of cargo transported	National expression (%)
LIS Airport	89441,4	64,08
OPO Airport	39683,7	28,44
Funchal Airport	3249,5	2,33

Source: Aviation Marketing Department (2021).

3.2. Data collection

The data analysed in the study was obtained through a qualitative approach, the interview. The first phase of interviews intended to obtain an in-depth understanding of the research topic, comprehending the context of each company and their perception of the airport environment and partners. For that, five individual structured interviews with nine open-ended questions were conducted. The appendix E presents the interviews structure.

The standard process of cargo transportation by air involves freight forwarders, handling companies, airports and air carriers. Each of them has a different business context, objectives, processes, and concerns. Therefore, the chain heterogeneity made vital the inclusion of each player in the data collection process. In addition, to answer the needs of the subject under analysis it was essential to include participants with a good knowledge of the operational aspect, a perception of the reality of the Portuguese business fabric and an understanding of the context of the Portuguese airport. The sample encompasses participants from all management positions from freight forwarders, air carrier and handling companies. Table 3.2 presents their characteristics.

Table 3.2: Participants of the first phase of interviews

Name	Position	Company
Interviewee I	International Business Director	ETE Logística (ETE) – Freight forwarder
Interviewee II	Head of RFID Competence Center – worked closely with Airbus in the creation of the RFID solution in the engines workshop	TAP Air Portugal (TAP) – Airline company
Interviewee III	Responsible for the cargo terminal at Porto	Groundforce – Ground handler
Interviewee IV	Sales consultant	Lufthansa Cargo (LH) – Airline company
Interviewee V	Airfreight Operations Supervisor	ETE – Freight Forwarder

For safety reasons, the interviews were conducted by video call. The chosen language was Portuguese and had a duration between 30 to 50 minutes. To ensure the integrity of the information, the conversations were recorded in audio with the permission of the participants. After the sessions, the interviews were verbatim transcribed and translated to English.

The second phase aimed to deepen the findings obtained in the interviews and clarify possible questions raised during the data analysis. The method followed a semi-structured form and, the questions were adapted to the participants' expertise. Table 3.3 presents the characteristics of the participants.

Table 3.3 : *Participants of the second phase of interviewees*

Name	Position	Company
Interviewee VI	Business Development	IDentPrint – Sistemas de Identificação e Impressão (IDentPrint)
Interviewee VII	EMEA Solution Sales Director	Zebra Technologies Europe Limited (Zebra)
Interviewee VIII	Operations	TAP Air Cargo

3.3. Method of analysis

The analysis of the interviews was carried out based on a thematic analysis. The method offers flexibility, enabling a rich, detailed and complete description of the data (Braun & Clarke, 2006). Braun and Clark (2006) describe this process as a method to identify, analyse and report patterns within data.

The coding process generated four key themes with Nvivo. Each was explored to understand the perceptions and concerns of prospective RFID implementation in the company and the airport. Table 3.4 presents the categories created in Nvivo and table 3.5 presents the interviews files.

Table 3.4: Categories created in Nvivo

Names	Files	References
Drivers	5	40
Barriers	5	72
Conditions to implementation	5	35
Benefits	5	64

Table 3.5: *interviews files in Nvivo*

Names	Codes	References
Interview_Interviewee I	47	163
Interview_Interviewee II	38	121
Interview_Interviewee III	32	69
Interview_Interviewee IV	58	204
Interview_Interviewee V	56	189

4. Findings and discussion

This chapter aims to expose and interpret the data obtained from the interviews. Through the chapter are explored: the perceived benefits of the technology, the implementation barriers for companies and the airport, the implementation drivers and the conditions that are vital for the implementation of RFID in Portuguese airports.

4.1. The drivers for the RFID implementation

The aspects that would lead the interviewees' companies to implement the technology and which factors were crucial to the implementation at TAP Maintenance and Engineering (TAP ME) were surveyed during the qualitative research. The research analyses classified the implementation drivers into two main groups: the internal drivers and the external drivers that are detailed in table 4.1.

Table 4.1: Drivers of the RFID implementation

Internal Drivers	External Drivers
> Internal improvement of the company; > Enhanced airport cargo services;	> Compulsory requirements; > Business Partners influence; > Customers;

4.1.1. Internal drivers

Internal drivers are defined as factors that generally are under the control of the organization, encompassing technological capacity, organizational culture, financial management and structures (Mdletye et al., 2014). The qualitative research labelled as internal drivers of the industry companies' the company internal improvement and the enhancement of the provided services. The table 4.2 details the internal drivers category.

Table 4.2: Category internal drivers in Nvivo

Internal Drivers	Files (5)	References (30)
Enhanced Airport Cargo Services	2	13
Internal improvement of the company	5	17

4.1.1.1. Internal improvement of the company

The company gains as a result of the RFID deployment are observed during the qualitative research as processes improvement and internal enterprise betterment. The enhancement of the existing processes is analysed as a result of the rise in efficiency, the boost on optimization, the decrease of errors and a more organized information. The RFID impact on the daily basis operation is not restricted to the company processes, being also considered for the chain operations.

The improvement of the internal processes at ETE is considered by Interviewee I (ETE) as the key driver for the RFID deployment on the company. For the interviewed the gain in efficiency, resulting from the process simplification, increase of automation and decrease of errors, is one of the most attractive aspects of the technology. Moreover, the technology allows the bundle of information that would be otherwise dispersed (Interviewee I, ETE).

The freight forward work demands a constant cargo location and status update. For further information on the cargo, the current system requires direct contact with the company´s partners which depends on the partner´s availability, the partner´s office hours and the easiness to contact the operation side. The centralisation of information brings to ETE (freight forwarder) a reduced searching time, an increased efficiency on communication with the company partners allowing a quicker and reliable response to the customer. The results stand in line with Reyes et al. (2016) who mentions an improved supply chain efficiency and the rise of labour and operations efficiency as a result of the RFID implementation. Similarly to Interviewee I (ETE), the prospective improvement of the internal process was the principal factor for the RFID deployment at TAP ME. Interviewee II (TAP) refers that the company needed to optimize the production area at the engine workshop, leading to a subsequent deployment. The RFID positive impact on the company is considered by Interviewee III (Groundforce) and Interviewee II (TAP) as an important trigger for the technology deployment. The equilibrium between the implementation costs and benefits was imperative for the RFID implementation at TAP ME (Interviewee II, TAP) and is considered one of the implementation triggers to Interviewee III (Groundforce). Interviewee II (TAP) adds that with the business case, the financial advantages of RFID and the positive effect on the company's processes became clear and "*the conditions to request the solution development was reunited*". These statements match with the study developed by Madlberger (2009) among manufacturers and retailers where is observed a positive impact between perceived internal benefits and RFID implementation.

The perception of RFID impacts on the company´s internal processes is classified as one of the most important triggers of the technology implementation. On the TAP ME scenario, the urge to boost the sector optimization was the trigger for the company research and development of a business case. Attached to the enhancement of the daily basis operations, it was also clear the financial advantages

of the technology deployment. The table 4.3 details the internal improvement of the company category.

Table 4.3: Category internal improvement of the company in Nvivo

Internal improvement of the company	**Files (5)**	**References (17)**
Process Improvement	2	4
Information	3	4
Organization of information	2	3
More information	1	1
Optimization	2	2
Decrease of errors	2	2
Financial	2	2
Non substantial additional costs	1	1
Efficiency	1	1
Customer Satisfaction	1	1
Benefits compensate the investment	1	1

4.1.1.2. Enhanced airport cargo services

In the 1980's, the European aviation was described as a non-competing market [9](van Asch et al., 2019). Since then, the market has suffered drastic changes, having an impact on the companies concerns and how the quality of the service is perceived.

A close and constant cargo monitoring is perceived across the air cargo sector as a positive outcome of the RFID implementation. For Interviewee V (ETE), the gain on cargo security, the enhancement of customer satisfaction and the possibility to do a full freight monitoring are mentioned as the most important aspects that would lead ETE to implement the technology. This focus stands in line with Oktaviani et al. (2018). The study highlights the interest of freight forwarders in accompanying the cargo in the different stages, ensuring its correct reception at the destination airport and the

[9] A non-competitive market is when the involved parties have the power to influence directly or indirectly the price. Usually, the system does not perform under perfect competition (Georgantzís & Attanasi, 2016)

protection of the client's interests. The technology benefits for cargo monitoring are also highlighted by Interviewee IV (LH). The interviewed refers that a technology that allows an easy cargo location across the chain is a surplus. Additionally, Interviewee V (ETE) refers that close monitoring of cargo is especially important when it requires a particular focus on security. Interviewee V (ETE) refers that some of the commodities that are freight by ETE demand, due to their characteristics, special attention, and the security guarantee during all transportation steps. For the interviewee, the RFID deployment would provide an enhanced trust and an increased tranquillity on the process once the transported commodity is easy to track and access to their location.

Even though air transportation provides the most secure way to transport valuable products, close monitoring brings tranquillity and reliability to all involved parts. Diamonds and Swiss watches are some of the most valuable commodities transported by the air carriers, demanding an additional concern to assure their arriving at the destination (IATA, n.d.-a). The RFID deployment reduces the mishandled cargo, improves the chain transparency and increases the service quality. The table 4.4 details the enhanced airport cargo services category.

Table 4.4: Category enhanced airport cargo services in Nvivo

Enhanced airport cargo services	**Files (2)**	**References (12)**
Full freight monitoring	2	6
Access to partners information	1	1
Easy cargo location	2	3
Cargo security	1	2
Cargo specificities	1	1

4.1.2. External drivers

External drivers are defined as outside forces that have an impact on the organization (Mdletye et al., 2014). According to Susanty et al. (2019), the external drivers can be divided into regulation pressure and customer's pressure although, through the qualitative research an additional influence was observed, the perspective of the partners. The table 4.5 details the external drivers category.

Table 4.5: Category external drivers in Nvivo

External Drivers	Files (5)	References (11)
Partners with experience	2	4
Compulsory requirement	1	2
Tendency to be mandatory	1	4
Customer's request	1	1

4.1.2.1. Compulsory requirements

Technological development and company innovation is a complex process due to the high level of resources and conditions it requires. Therefore, to stimulate innovation, some regulatory bodies can intervene in the implementation. According to Interviewee V (ETE), the Portuguese industrial fabric has limited resources, diminishing their willingness to innovate. On the other hand, the clients seek the lowest price possible, not having as main focus the service quality. For the interviewed, the only way to RFID be accepted across the community is through a compelling process by a regulatory organization, such as ANAC (Agência Nacional de Aviação Civil) and IATA. This pattern is described in Chang et al. (2011) where the US government, after 9/11, demanded the screening of all passenger luggages for explosives. This measure pushed the RFID implementation although, at the time, the technology costs were impacting the deployment willingness.

Currently, the RFID deployment is not mandatory in the air transportation industry. However, to comply with Resolution 753 that oblige the track of the passenger luggage, IATA recommends the RFID system adoption on " Resolution on Radio Frequency Identification (RFID) in baggage" (IATA, 2019b). This incentive increases the company's predisposition to implement the technology and creates the impression that the technology will be mandatory in the near future. Interviewee I (ETE) when questioned about their position on a possible RFID adoption refers:

"I would be in favour of the implementation because I believe that this type of technologies will end up implemented. If we do not implement it now, we will have to do in the future. Or is mandatory or, in the short run, the technology will be mandatory."

For some markets, the intervention of regulatory companies or pressure from the business partner can be decisive for the implementation of the RFID system. However, the adoption of these measures should be carefully considered to avoid a deployment where the technology benefits only a small part of the chain.

4.1.2.2. Business Partners influence

The experience of the business partners with the technology is classified simultaneously, during the research, as a driver and a barrier to the RFID implementation. The need to optimize the engine workshop production area led TAP ME to implement RFID in 2012. This technology was used at that time by Airbus in a different business area (Interviewee II, TAP). According to the interviewee, the RFID adoption at TAP ME was highly influenced by the partner´s use, even though in a different area. In 2012, Airbus showed high technical competencies on the technology, being later chosen to develop the solution at TAP ME. On the other hand, a business partner experience may negatively influence the company perspective. Interviewee III (Groundforce), when questioned about the technical feasibility at Groundforce, emphasised the low technology widespread among the industry and an unsuccessful experience of a partner in an RFID pilot test. Both points influenced the interviewee´s perspective on the technology benefits and applicability at the company.

The research showed a high correlation between the partner's past experience and the perceived benefits. During Interviewee II (TAP) interview's it was visible the positive perception about the RFID implementation. The interviewed described the implementation with a positive balance and a great perception of benefits. In turn, Interviewee III (Groundforce), during the interview presented a negative perception of RFID which can be influenced by the partners experience with the technology and the satisfaction with the current system. The partner's positive results with the technology can be noted as an important factor during the decision-making process. The different perceptions stand in line with Reyes et al. (2016) who expose the gradual increase of perceived benefits when the company moves from "not considering" the implementation, to "considering", to finally "implementing".

4.1.2.3. Customers

A company´s major concern is the fulfilment of the market needs. Wherefore, the customer plays an important role in a company´s definition and direction. The customer impact on the RFID implementation is discussed from two distinct perspectives: the customer as a technological petitioner and, the company urges to boost customer satisfaction.

The technology adoption as a request from the customer is perceived by Interviewee IV (LH) as a key trigger for the RFID widespread. For the interviewee, the customer demand would create a

motivation that would lead to the system deployment. This statement responds to Tsai et al. (2013) who mention that the companies are living in an atmosphere where they are afraid of losing their position or suffering a reduction of orders if they do not adopt the RFID system.

The technology effect on customer satisfaction is mentioned by Interviewee V (ETE) as one of the main triggers for the RFID implementation at ETE. The technology benefit on the customer satisfaction is widely recognized in qualitative research, in particular by the freight forwarder. The higher consideration can be explained by their focus on the protection of the customer interest explained by Oktaviani et al. (2018). Moreover, even though their direct responsibility on the freight ends as soon as the cargo enters the airport warehouse, their position on the chain demands cargo monitoring across every process. If the cargo encounters an unforeseen situation, the freight forwarder is the one that communicates with the client. These intermediary roles can create a negative impression on the customer, even though their responsibilities ended at the beginning of the exportation process.

4.2. RFID Benefits

The positive impact on the air transportation industry, as a result of the RFID deployment, is perceived by the interviewees. The technology benefits can be clustered into seven categories: data management, asset management, productivity, improvement of chain processes and customer service. Table 4.6 details the benefits category.

Table 4.6: Category benefits in Nvivo

Benefits	**Files (5)**	**References (64)**
Data management	5	16
Asset management	5	19
Productivity	5	18
Improvement of chain processes	3	6
Customer Service	2	5

4.2.1 Data Management

Transportation by air requires a constant collection and share of data. The need for reliable information increases when it is necessary to share the data across the chain. For Interviewee IV (LH), the RFID system will provide more data and create equal access for all users:

"With RFID, every player would have access to the information. They would have access at the same time, at the same information regarding the transported cargo."

The ability to collect and easily access the chain data by all participants is seen as an advantage to Interviewee IV (LH). From an airport (chain) perspective, Interviewee I (ETE) refers that the collection, compilation and sharing of data is a very positive aspect. Interviewee V (ETE) adds that in the airport scenario, the exchange of information among the parties is not perceived as a concern but rather as an advantage.

The different entities placed at the airport have different needs and distinct data requirements fulfilled with the system. The freight forwarder wants to be aware of all cargo stages. The air carrier wants to know if the commodity arrived at the destination with an adequate transit time to air cargo. The handling company is interested to know when the goods arrive or leave the warehouse. In turn, the airport wants to know when the commodities are loaded on the plane and unloaded (Interviewee III, Groundforce). The availability and data accuracy offered by the RFID system is underpinned by Reyes et al. (2016). The study ranks these features as the greatest improvements for RFID implementers.

The easy access to the information gathered during the commodity shipment allows the creation of a reliable database (Interviewee IV, LH). Interviewee I (ETE) mentions that, with the technology, the data would be bundled. Therefore, the *"information would not be confusing and would not be lost"*. This perspective stands in line with Chang et al. (2011). The study refers that the availability of information allows real-time asset tracking and creates a reliable database. At TAP ME, the RFID, provided the tools to create a business unit inventory in a complex environment (Interviewee II, TAP):

"On a place of maintenance and engines installations there are different zones associated with different workshops thus [with RFID], it was possible to do the inventory of all Business Units in each zone."

A reliable inventory of business units brought positive outcomes to TAP ME. It optimizes the stock inventory, enhances the purchases planning's, diminishes the time to locate the business units, reduces the processes breaks due to lack of materials, enhances the reparation process, improves mechanical efficiency and increases customer satisfaction.

In addition, the access to the business partners information as hub's timings is perceived, by Interviewee IV (LH), as a great advantage. For the air carrier, the perception of how the different hubs are working helps to anticipate possible delays during the commodities transit. When the shipment relies on a connection flight, the loading on the connection airport is dependent on how early the flight arrives, the workforce availability to unload the previous flight and the load flow on the airport. The access to partners information allows the air carrier to predict if the shipment will proceed as planned.

Consequently, the communication with the client will be more accurate, increasing their trust in the air carrier service and satisfaction.

The access to information is considered by Interviewee V (ETE) as a driver of customer service. For the interviewee, the technology allows access to accurate information and gives the company the ability to provide a prompt answer to the client. Reyes et al. (2016) support this perspective by affirming that the management of data enables accurate communication among all parts. For an activity that involves various actors across the globe, a reliable database aligned with easy and global access plays a crucial role.

The adequate management of data is an advantage for air transportation. The positive impacts generated by the adoption of RFID are perceived at the company and chain levels. The RFID deployment in the sector brings a reliable database, global access to information, improved communication on the chain, package and asset trackability and, enhanced customer service. Table 4.7 details the data management category.

Table 4.7: Category data management in Nvivo

Data management	**Files (5)**	**References (16)**
Data Organization	1	3
More information	2	2
Inventory	1	2
Sharing of information	2	2
Access to partners information	2	2
Equality of access to information	1	1
Fulfilment of all entities needs	1	1
Easy access to information	1	1

4.2.2. Asset Management

For the air cargo sector, commodities are the main assets. To guarantee the flight safety it is necessary to follow strict rules and procedures. Wherefore, one of transportation companies' concerns is to understand if the cargo answers to all requirements. Interviewee V (ETE) refers that with the RFID, the

freight forwarder knows if the cargo is under the airport and the air carriers' requirements. If the cargo has documentation, if the documentation meets the destination requirements, if the commodities are classified with the correct customs status or if the cargo needs to be presented to the customs house (Interviewee VIII, TAP Air Cargo).

However, the safety of air transportation goes beyond the protection of the flight crew and the passengers during the flight. To maintain the reliability of air transportation, it is important to assure that the packages arrive at the destination, at the expected time and in good conditions. Therefore, the cargo location is a permanent concern. Reyes et al. (2016) refer that RFID enables the visualization of what was delivered, the destination, when and by whom. The opportunity to locate the freight and the possibility to have access to the exact location is considered by Interviewee IV (LH) as a surplus. The responsibility for the transport lies on the air carrier. However, their handling is executed by a ground handling company that represents the air carrier. In a scenario where the package is mishandled, the client, mediated by the freight forwarder, demands responsibilities to the air carrier. The application of RFID will allow faster detection of the package, reducing the search time and eliminating the situations where the air carrier communicates the loss or the carton mishandling to the client. The system protects the air carrier image on the market and prevents the company from financial losses on reimbursements and compensations.

In addition to the cargo localization, the system allows continuous cargo monitoring. For Interviewee V (ETE), this system revises the freight forwarder role in the chain. For the interviewed, the technology allows the anticipation of irregularities and a prompt resolution:

"We would be capable of cargo tracking and, if the package is not following the planned route, we would question: why is it there? Or, I would know if the cargo was loaded or wrongly loaded. My client would never be aware of a situation like this one".

For a freight forwarder, access to the cargo tracking brings a higher sense of security. This perception stands in line with Kumari et al. (2015), who highlight the increase in security and the enhancement of customer confidence due to the gain in traceability. In case of an unexpected situation, the time requested to solve the problem is reduced, increasing the company efficiency and customer satisfaction.

Besides the system application to trace the cargo, the RFID can be used to track different assets in the industry. The technology adoption at TAP ME focused on the workshop business units. According to Interviewee II (TAP), some processes were simplified due to the RFID adoption. The implementation reduced the complexity of the business unit search and facilitated their listing. The interviewed adds that the improvement of the existing processes simplified the mechanic's job.

The technology effects on the asset's management are perceived on the chain and company level. Applied to cargo, it brings security to everyone on board and the clients. Despise the item where the tag is attached, the technology enables continuous monitoring, supports the users on problems resolution and anticipation and, simplifies the tasks. In the end, the company is more efficient, the employees are happier and the customers are satisfied. Table 4.8 details the asset management category.

Table 4.8: Category asset management in Nvivo

Asset management	**Files (5)**	**References (19)**
Cargo monitoring	3	7
Quick item location	4	7
Security	2	4
Requeriment's control	1	1

4.2.2.1 Security and safety

The aviation industry works daily to guarantee the highest levels of safety, particularly on cargo transportation due to the night flights and the carriage of hazardous materials (Huerta, 2015). The cargo security, the passenger safety, and the airport security are the main concerns in the industry (Interviewee V, ETE). Across the literature, the topic of security is perceived by Vijayaraman and Osyk (2006), Al-kassab et al. (2013), Chien and Chen (2007) and Nayak et al. (2015) as a concern to the company that is studying the RFID implementation. Conversely, in air transport, the RFID is considered a tool to increase the security and safety at the airport and not a cause of insecurity.

Before the cargo acceptance, the freight forward, in combination with the air carrier, analyses the commodity characteristics and take the necessary measures to guarantee the safety of everyone around. Subsequently, during the acceptance, the cargo is submitted to the x-ray machine and, in some cases, the package can be opened for closer analysis. In terms of passenger luggage, the concern is the same. Interviewee VII (Zebra) shares his personal experience where he sat for 3 hours inside the aircraft because an extra suitcase was found on the plane. According to the interviewee the situation would have been solved in "5 minutes" if the RFID system were used by the airport. In addition, situations in which hazardous materials are left in the aircraft belly, compromising everyone's safety, can be

avoided. This perspective is endorsed by Li and Visich (2006) who noted that improving track and trace capabilities leads to greater security and protection in the supply chain.

In the case of carriage of hazardous materials, Huerta (2015) refers that improved and detailed communication between the ground team and the pilot would help the pilot make better decisions in case of an accident. In addition, the IATA (2018) suggests that RFID is used to revise the aircraft parts, ensuring safety on board with low time consumption to complete the task. Interviewee I (ETE) subscribes and refers that the technology can *"bring a lot of security, especially this year [2020] that everyone is paranoic with security*". In addition, the level of safety during the cargo handling would increase (Interviewee I, ETE):

"We would have more security during the cargo handling. After the tag reading, we know if the cargo is dangerous or not".

The capacity to save data and the easy access to information across the chain increases the level of safety on the cargo handling and during commodities transportation. In addition, constant cargo monitoring helps reduce the number of lost volumes, cargo mishandling and prevents commodities theft, fraud or injury (Vijayaraman & Osyk, 2006).

4.2.3. Productivity

The company efficiency and effectiveness have a direct impact on productivity (Vilayaraman & Osyk, 2006). The RFID implementation brings, according to Interviewee V (ETE), a higher level of efficiency and effectiveness. For the interviewed, this adoption outcome is perceived as a key decision factor. The technology´s impact on the existing procedures is also mentioned by Interviewee I (ETE) and Interviewee II (TAP). According to Interviewee I (ETE), *"the technology is crucial to facilitate the processes"* which is demonstrated on the RFID deployment at TAP ME. Interviewee II (TAP) refers that, after the implementation, a streamlining of the search and inventory process of the workshop business units was observed. The interviewee adds that the impact on the existing processes ended facilitating the mechanic's job. The correlation between the increase of automation with the improvement of the procedures is supported by Vilayaraman and Osyk (2006). Interviewee IV (LH) adds that the system brings a decrease in the number of irregularities, standing in line with Vilayaraman and Osyk (2006) and He et al. (2010). For Vilayaraman and Osyk (2006), the rise in automation reduces the number of irregularities. In turn, He et al. (2010) defends that it is a result of the processes streamlining. For Interviewee IV (LH), the decline in processes deficiencies influences the mishandled cargo, the transit time, the hub's timings, and customer satisfaction.

The rise in automation at the engine workshop converted manual activities into automated ones (e.g. inventory). Consequently, a decrease in the time required to complete those tasks is observed (Interviewee II, TAP). The reduction of the time required to repair the aircraft was expected by Airbus

and Boeing (Chang et al., 2011), being later observed at TAP ME. With RFID, the working time to repair the engine was reduced, resulting in financial benefits for the company (Interviewee II, TAP):

"After the implementation, there was a decrease on the time that the engine remained at the workshop, in 2/3 days. It seems like a short time, but we need to have in consideration that are a complex and expensive processes and, the reduction of time allows greater savings"

The economic advantages gathered with the implementation of the RFID system are discussed by Chang et al. (2011) and Giusti et al. (2019) as a result of the productivity rise.

The system impact on the companies' procedures is perceived as a strength. The simplification and the increase in speed of crucial tasks impact the workforce daily basis routines. Moreover, the rise in automation reduces the irregularities and increases the company profits. The effectiveness and efficiency generated with the technology increase the company productivity. Table 4.9 details productivity category.

Table 4.9: Category productivity in Nvivo

Productivity	**Files (5)**	**References (18)**
Process improvement	5	13
Quick item location	2	3
Reduction of irregularities	2	2
Process transparency	1	1
Employee work facilitation	1	1
Automation	1	2
Financial	2	2
Efficiency and effectiveness	1	1

4.2.4. Improvement of chain processes

The RFID effects on productivity are not restricted to each company. According to Interviewee I (ETE), the technology influences positively the process optimization, monitoring and transparency. The technology represents an important tool to optimize the processes that are not optimized (Interviewee I, ETE). The interviewee adds that the system simplifies the search for the lost cargo and baggage,

resulting in increased efficiency at the airport. This improvement is correlated with a higher level of connection between the chain players.

The technology allows better control of the various steps, proving the access to the several stages timings' (Interviewee III, Groundforce). For the interviewee, the system allows better control of the airport timings and procedures. This perspective stands in line with Li and Visich (2006), which states that a close connection among partners leads to a more efficient business. The chain overview is not limited to a facility. The technology allows access to data from different hubs' (Interviewee IV, LH). The accessibility to information despite the partner and their location, enhance the process transparency (Interviewee III, Groundforce). This interpretation matches with Moretti et al. (2019), DeVries (2008) and He et al. (2010) studies. These perceived benefits match with Mingxiu et al. (2012) that explores the transparency gains in the entire logistic process.

The system deployment increases the sharing of information, the process transparency and improves the communication between the users. These aspects positively impact collaboration, chain planning and relationships (Vi & Visich, 2006). The addition of automation to the pre-existing processes increases airport efficiency. In the end, the airport will present fewer irregularities and an increase in productivity. Table 4.10 details improvement of chain processes category.

Table 4.10: Category improvement of chain processes in Nvivo

Improvement of chain processes	**Files (3)**	**References (6)**
Increased process control	2	3
Processes optimization	1	2
Data management	1	1

4.2.5. Customer Service

The technology benefits on customer service are analysed from two perspectives: customer satisfaction and the company switch from a reactive to a proactive approach. The improvement of the customer service through the RFID deployment is defended by Interviewee V (ETE). The interviewed states that the information provided by the system gives a clear overview of the chain and allows transparent communication with the client:

"This system would bring efficiency and effectiveness in my cargo. At any time, I can say to my client if there is a problem or an obstacle with the cargo. I can justify where it is."

As freight forward, the storage of detailed information allows a closer relationship with the client. In a scenario of partial shipment, as a freight forwarder, Interviewee V (ETE) can say how many volumes were loaded, their characteristics (identification) and the expected time to arrive the remaining ones. The identification of the loaded volumes provides enough details to proceed with the customs clearance of the first shipment. For the importer, the access to detailed information about the arriving cargo enables better planning and, in some cases, can mean continuity of production. In a situation where the second shipment arrives close to the first one, it is possible to combine efforts and reduces the expenses to the final client. The correlation of easy access to detailed information with the enhancement of the company customer service is sustained by Reyes et al. (2007) and Li and Visich (2006). The paper analyses the contribution of improved internal procedures for better customer service. In turn, DeVries (2008) defend that the company gain in improved transparency, aligned to enhanced control and monitoring of operations results on the company switch from reactive to proactive. This change in the company position is indicated as a benefit by Interviewee V (ETE). As freight forwarder, their responsibility is to guarantee that the cargo arrives at the destination at their best time and best quality. Although during the processes, the shipment can face some obstacles that are easily solved by resorting to RFID help:

"We would be capable of cargo tracking. And if it is not following the planned route, we would question: Why is it there? Or I would understand if the cargo were loaded or wrongly loaded."

As an intermediary, ETE has as aims, the reduction of customer concern. For Interviewee V (ETE), the system will allow a different approach to solving the problems without customer knowledge or intervention. The interviewed viewpoint resembles the incident lived by Dole Food Company. Due to the data collected with RFID, the company initiated a voluntary remotion of packaged salads due to suspected contamination of E. coli bacteria before any consumer report (Kumari et al., 2015).

The RFID adoption allows transparent communication with the client. Moreover, access to a detailed and reliable database builds a trustable relationship between the parties. In terms of solving problem, the technology provides broad access to information, optimizing the resolution process. The gathering of information helps in the anticipation of possible complications and the detection of irregularities. Additionally, the research demonstrates the concern for the RFID impact in the customer service is dependent on the player position in the chain. Table 4.11 details the customer service category.

Table 4.11: Category customer service in Nvivo

Customer Service	**Files (3)**	**References (6)**
Customer satisfaction	1	2
Resolution of mishandled cargo	1	2
From reactive to proactive	1	1

4.3. Barriers

The obstacles identified before and during the RFID implementation can delay or even impede the deployment. At the air transportation environment, the companies are compelled to cooperate with each other. Two distinctive sets of obstacles were explored during the interviews: the challenges to implement the technology in the interviewed company and the obstacles to deploy the technology in the chain. Table 4.12 details the barriers category.

Table 4.12: *Category barriers in Nvivo*

Barriers	**Files (5)**	**References (73)**
Company implementation barriers	5	43
Airport implementation barriers	5	30

4.3.1. Barriers to implement on the companies

4.3.1.1. The technological reluctance

The companies' reservations to implement a new technology can be influenced by the company internal vision on technological development, the existing technologies and, the technology widespread in the industry and the partners' perspectives.

The company level of technological advance is perceived by Interviewee V (ETE) both an incentive and barrier to RFID deployment. The interviewed refers that, if the company does not have a high technological development, it will be more reluctant to deploy a new system. In the freight forwarders context, Interviewee V (ETE) believes that there are large companies that would implement RFID without hesitation and, then, there are small freight forwarders that would not accept it so well. Instead, the small freight companies will focus on costs and the impact on the clients. This point of

view corroborates with Lee and Jung (2016). In the study, the company dimensions is considered a significant factor due to the higher capacity of a big-sized firm to discover new technologies.

Technology development is associated with the existing systems. Madlberger (2009) refers that the company likelihood to invest in a new system is influenced by their satisfaction with existing ones or their performance. This situation is perceived by Interviewee IV (LH). The interviewed refers that the current tracking systems, used by the airlines' companies, are reliable and provide a lot of information. Interviewee IV' perception may be influenced by their experience with LH cargo tracking. The system used by LH is one of the best among the airlines' companies operating in Portugal, considering the data accuracy, promptness on providing solutions when the shipment plan is modified and, reliability. The shared information is reliable, well detailed and the website is friendly-user. If the airline forecasts a possible irregularity on the drafted flight plan, LH presents upfront more than one option to complete the transportation. However, these features are not shared on most cargo tracking websites. In addition, the perception that a system suits the company's needs decreases the willingness to innovate. According to Interviewee III (Groundforce), the Groundforce needs are covered by the existing system. The interviewed adds that the number of metrics monitored is low and simple to record. Through this intervention, it is possible to perceive the influence of the process's complexity and the type of variables analysed by the company, on the final decision. This perspective is supported by Interviewee VI (IDentPrint). The interviewee refers that the RFID does not suit the needs of every process and, before the adoption, it is necessary to understand which the existing inefficiencies are.

The existing systems are narrow to specific areas. A detailed and transparent approach requires the intervention of the chain players. The current scarcity of RFID adoptions creates inefficiencies and decreases the technology propose (Interviewee IV, LH). The interviewed adds that once LH works with different handling companies worldwide, the technology becomes ineffective if most players do not use it. The absence of RFID on big players represents a crucial implementation barrier for LH. This perception is shared with Interviewee III (Groundforce), interpreting this low adoption as a signal that probably, the technology is not the best option.

The influence of the company business partner on the deployment decision point is based on the partner experience with the system, working as a barrier[10]. The negative perspective of Interviewee III (Groundforce) on the RFID adoption is influenced by a partner experience. The interviewed refers to past partner experimentation at Groundforce warehouse, where was implemented an antenna after the x-ray machine to control each exported package. Interviewee III (Groundforce) adds that after the test, the company CTT ended preferring another tracking system. The influence of the partner experience on possible implementers perspective is noted during the Interviewee III (Groundforce)

[10] In section 4.1.2.2. the partner experience is mentioned as an external driver to RFID implementation.

interview. This situation stands in line with the IATA approach. The organization believes that companies may be concerned about the developed business case result due to the lack of appealing implementation in the industry. To reassure a prospective implementer, and to support the technological innovation, IATA (2007), presents several implementations tools.

The company´s technological vision influences its openness to innovation. In addition, the company context, their controlling requirements, the procedures complexity, and their urge to analyse the data affects the company decision. An experience not well achieved by a partner and the implementation scarcity on the circle decreases the company willingness to adopt the RFID system. Table 4.13 details technological reluctance category.

Table 4.13: Category technological reluctance in Nvivo

Technological reluctance	**Files (4)**	**References (13)**
Existing technologies	2	4
Lack of technological widespread	1	3
Player's implementation	1	2
Companies' weak technological evolution	1	1
Partners perception of the technology	1	1
Resistance to change	1	1
Company dimension	1	1

4.3.1.2. Structural conditions´

The country conditions and the company structural conditions affect the RFID adoption decision. Air transportation connects different regions and countries around the world. Although, the various parts of the world present distinct contexts. For the Portuguese market, Luanda is one of the more significant exportation destinations. The country receives approximately 40% of the commodities exported from Portugal (Interviewee IV, LH). However, Interviewee IV (LH) enhances that Angola does not have the same resources as Europe, neither has the same business mentality. The interviewees add that besides the low financial capacities, the procedures are different, the security is scarce and, the companies do not treat the cargo with the same care. Interviewee I (ETE) supports this perspective, adding that not every country presents the same implementation capacity:

"Not every country will be capable of implementing the technology at the same time. Not every country is at the same stage and, that can be a big challenge. The truth is: the world is not all at the same speed. Some countries will implement sooner and, others will do later. And, there is other's that will need many years to be able to implement."

Both perspectives are in agreement with Rahman et al. (2019), which refers that in developing countries, the financial resources are, for the most part, scarce to essential products, making unrealistic the deployment of sophisticated technology.

In addition, the company´s circumstances and infrastructures represent an obstacle to RFID adoption. Interviewee III (Groundforce) refers that the most critical technical barrier to Groundforce is the existing infrastructure. The interviewee adds that currently the company daily basis operations are affected due to the poor infrastructure. This scenario is also verified at ETE, where the current infrastructure is considered by Interviewee I (ETE) as an internal barrier to deployment. The interviewee adds that the company´s (ETE) operational system is not ready to proceed with the technology adoption and, to avoid future problems, it must be submitted to modifications. This scenario stands in line with DeVries (2008). The study presents the delay observed during the RFID implementation for luggage in McCarran Airport due to the need to change various equipment's and create support infrastructures for the technology.

The high number of customers in countries with poor conditions may discourage RFID adoption. Although, the technology benefit is not restricted to the destination or departure airport. A future worldwide implementation may encompass the adoption of combined technologies such as RFID with a simpler one (e.g. Bar code, QR code), defended by Wu et al. (2006). Moreover, a careful analysis of the company infrastructures helps the prevention of future problems. Table 4.12 details the structural conditions category.

Table 4.14: Category structural conditions in Nvivo

Structural conditions	**Files (3)**	**References (13)**
Infrastructure	2	5
Countries readiness	1	4
Countries reality	2	4

4.3.1.3. Industry characteristics

The companies resort to air transportation when is necessary rapid shipping, the assurance of security or when the commodities are crucial for the business development. This mean of transportation is the

best option for merchandise with demanding needs. According to Interviewee IV (LH), RFID would bring benefits to cargo with a high market value, on sensitive load, on dangerous goods, on high-tech technology or on commodities that require a controlled temperature. Although, the interviewed adds that the Portuguese market sparse on this type of opportunities if compared to Europe, reducing the RFID potential in Portugal:

"If we think in Europe as an all, Europe has a much bigger potential than us. In Portugal, these industries only represent 10% of the total market".

In contrast, Interviewee V (ETE) believes that the features of the commodities handled by ETE incentivise RFID adoption. These perspectives demonstrate a connection between the type of commodities handled by a company and their eagerness to RFID deployment.

The cargo specifications increase their transportation costs and the client willingness to pay a more expensive service. At the Portugueses airports, the handled commodities are predominantly general cargo (Interviewee IV, LH). The addition of RFID technology increases transportation costs, which may not compensate in general cargo (Interviewee IV, LH). The interviewees add, that in this cargo the client may not be willing to invest once it cannot recover the surplus at the destination point. In turn, Interviewee IV (LH) believes that the Portuguese market does not have the capacity to financially support this technology and, the ones that do constitute a small percentage.

Changes in the industry in recent years have not contributed to the financial fitness of the sector. The rise in the number of competitors aligned with the quality of the service offered by them reduced substantially the tariff rates (Interviewee IV, LH). The interviewed adds that this transformation decreased the companies´ capabilities to support technological innovation. The consequences of the increase of competitors are also evidenced by Interviewee V (ETE). According to the interviewed, the client´s biggest concern is the price and not a better service:

"If the competition does not use the system and is efficient, the client will leave ETE and goes for a different forwarder."

The industrial fabric features influence the characteristics and value of the transported goods. The demanding features of the handled commodities increase the companies´ willingness to implement the RFID system. Although the company (shipper/consignee) unfavourable position on the market reduces its capacity to support additional costs, having as main focus the service price. The increase in the number of companies operating in the industry decreased their power and financial resources widening the access to more users. Table 4.15 details industry characteristics category.

Table 4.15: Category industry characteristics in Nvivo

Industry characteristics	Files (2)	References (9)
Small market niche	2	5
Great competition	2	2
Lack of financial capacities	1	1
Commodities low value	1	1

4.3.1.4. Costs

The RFID implementation requires financial investment during their lifespan. It starts with the idea generation and development, continues into the daily basis operation and maintenance and, it only ends when the technology is disabled. At the development stage, the company is concerned with creating the required infrastructures, forming one of the biggest project expenses (Smart et al., 2010). This statement stands in line with Interviewee IV (LH). For LH, the investment in the hub is one of the biggest barriers to the RFID implementation at the air carrier, especially under the circumstances that we are living on (Interviewee IV, LH).

After the implementation, the company must take into account the maintenance costs. Moretti et al. (2019) classify as maintenance costs, all expenses required to operate the system - tags, annual revision and system updates. For Interviewee V (ETE), the operational costs are the most influential barrier for implementation at ETE. The use of the RFID represents an additional expense that has to be shared with the client (Interviewee V, ETE). However, the interviewed believes that would not be well accepted. This perspective is sustained by Interviewee IV (LH). The interviewee highlights the impact of this investment on commodities with low market value and the company inability to recover the expense:

"Everything is about the commodity price. If their price is low, the client is not keen to support the investment because he would not be able to charge this cost on the destination."

The concern for the cost inflation and the impact on the final product price is also shared by Nayak et al. (2015).

The costs associated with the implementation are an important point in Portugal. The Portuguese business fabric is constituted mainly by small and medium-sized enterprises (99,9%) with a turnover smaller than €50 millions (Andrade, 2020). Although Interviewee I (ETE) believes that if the RFID adoption does not involve significant costs, the financial investment is not a barrier for the implementation. In terms of infrastructures expenses, even though are a big part of the

implementation expenses, Interviewee VI (IDentPrint) affirm that is lesser than the Bar code implementation costs with infrastructure. In addition, the influence of the technology on the product final costs is broadly observed especially on products with low market value. Table 4.16 details the costs category.

Table 4.16: Category costs in Nvivo

Costs	Files (2)	References (8)
Price concern	2	5
Financial investment	2	2
Operation costs	1	1

4.3.2. Implementation barriers on the Portuguese airports

The company's technological development is not standard. An environment that requires cooperation among several entities with different objectives and characteristics may trigger additional obstacles. The qualitative research allowed the analysis of three clusters of implementation barriers: the sector vision, the entities management, and the financial investment.

4.3.2.1 The sector vision

The industry innovation is influenced by the companies that encompass it, the people mindset and the customer demand. The cargo sector position in the industry defines the companies decisions and investments. According to Interviewee III (Groundforce), cargo transportation is the sector with less significance to the industry. The interviewee adds that, in opposition, the passenger side is the most important due to the high revenues generated by them. Interviewee IV (LH) also presents this view, mentioning that for Portway and Groundforce (ground handling companies operating in Portugal), the cargo is the less important side. The Groundforce Annual Report confirms both statements. In the year 2019, cargo handling was responsible for 10% of the total sales and services while passenger handling was accounted for 89% of the total sales and services at Groundforce (Groundforce, 2019). Interviewee III (Groundforce) refers that these numbers are reflected in the sector (companies) willingness to invest adding, that until the pandemic, the passenger side was the priority.

Aligned with the financial burden, the industry and management mindset is also an influencer of the sector vision. The innovation in the Portuguese airports is executed at a slow pace. Interviewee IV

(LH) mentions that the players' attachment to physical documentation is still strong, representing an obstacle to drive into digital:

"We (LH) implemented, nationwide the e-AWB (electronic Air WayBill) which allows the cargo transportation without physical AWB (Air WayBill). The implementation was very hard. The change of procedures and mentality is demanding. People are too attached to paper and, they believe that commodities transportation is impossible without physical documents."

Rahman et al. (2019) also examined this challenge in the paper. The study concluded that the use of manual procedures for a long time creates an aversion to automation. The user believes that the manual system is not worse than the new technology.

In air transportation, the riskier stages, in terms of cargo mishandling, are while the commodities are under the handling companies' responsibility. However, during the interviews, the handling company perspective was the most reticent on RFID implementation. According to Interviewee III (Groundforce), the current system measures the essential variables and, the company does not need to extend their points of analysis. Interviewee IV (LH) describes Groundforce view as a result of a deficient innovation mentality. The interviewed refers that the Portuguese handling companies' managers do not have an oriented mindset to technological investment.

The sector profitability affects the company openness to invest. In addition, it is understood a high attachment to the existing procedures and a reluctance to change. This attitude is not restricted to the associates, being observed as well at the medium management level. These aspects shape the companies vision and consequently the industry direction. Table 4.17 details the sector vision category.

Table 4.17: Category sector vision in Nvivo

Sector vision	**Files (3)**	**References (16)**
Industry mindset	2	5
Companies perspective of the sector	2	4
Management mindset	1	3
Willingness to invest on the sector	1	2
Resistance to change	1	1
Weak technological evolution	1	1

4.3.2.2. Management of entities

The RFID implementation at the airport requires cooperation between several organizations, located in different parts of the world and with distinct business models. This scenario brings out a challenge: the stakeholders coordination to one goal. Interviewee II (Interview) refers that the airport environment is particularly complex due to the high number of companies that contribute to the chain, increasing the implementation process intricacy. At TAP ME, the system deployment encompassed three stakeholders: Airbus, the TAP IT department and the engine workshop. In turn, the RFID implementation at the Portuguese airport's demands coordination among airports, the handling companies, the freight forwarders and the customs house (Interviewee V, ETE).

Considering his experience on the implementation at TAP ME, Interviewee II (TAP) highlights that, for a successful implementation, the companies that belong to the airport chain have to be aligned. For Interviewee V (ETE), the coordination of all entities with a common objective represents one of the biggest obstacles for the system implementation. The interviewee's perspective agrees with Tsai et al. (2013)**,** which analyses the increased complexity of the process due to a conflict of objectives between companies. To answer the issue "How can we involve all entities?", the interviewed suggests the intervention of a government entity or an organization as IATA and a compulsory requirement. This concern is transversal to Interviewee I (ETE) and Interviewee IV (LH). Although the articulation between all entities is mentioned as a challenging situation, the interviewees are confident that is possible.

The RFID implementation requires the consideration of companies´ business models, hurdles and objectives. The high number of companies involved in the implementation, aligned with the need to coordinate all of them, with the same purpose is considered a barrier. This difficulty is mentioned by most of the interviewees however, it is also visible their confidence that can be overcome. Table 4.18 details management of entities category.

Table 4.18: Category management of entities in Nvivo

Management of entities	**Files (3)**	**References (16)**
Stakeholders coordination	4	6
High number of companies	2	2

4.3.2.3. Financial investment

The RFID implementation in the airport requires financial investment by all parties involves in the chain. A shortage of financial resources to invest in the interviewees' companies is noted during the research. In addition, this deficiency is also observed by the participants in the business partners.

For Interviewee IV (LH), this can be an implementation obstacle in the Portuguese airports. As mentioned in section 4.3.1.4, the investment in the hub is the main obstacle to LH (Interviewee IV, LH). The interviewee adds that the handling companies operating in Portugal are living precarious situation, with weak infrastructure, a small airport dock and a reduced workforce. The lack of financial resources leads Portway (the handling company responsible for the LH cargo in Portugal) to decline every investment required by LH even though the air carrier is one of Portway major client (Interviewee IV, LH). The interviewed adds that in Portugal, the airline industry faces huge security problems on a daily basis. To overcome this situation, LH required a bigger x-ray machine, with an increased capacity but, the request was denied due to lack of resources by the handling company. Rahman et al. (2019) analyze this reality. The article states that in a company with a lack of resources to buy essential products, the implementation of sophisticated technology may be unrealistic.

The RFID implementation, apart from the required financial investment, brings inherent costs. For Interviewee V (ETE), both aspects represent an obstacle for the technology implementation at the airports. For the interviewed, the industry is sensitive to the increase in costs. Moretii et al. (2019) refer that the additional costs are a concern weighted by the companies during the implementation stage. This argument is supported by Rahman et al. (2019). The paper mentions that albeit the technology widespread and maturity decreased the implementation costs, this point is still considered as one of the biggest challenges. Interviewee V (ETE) classifies this point as one of the two majors challenges on implementation.

The financial investment associated with the RFID implementation represents a barrier in the Portuguese airport. The concern for the increase in services costs, aligned with the lack of companies´ financial power creates an impediment for the sector development in Portugal. Table 4.19 details the financial investment category.

Table 4.19: Category financial investment in Nvivo

Financial investment	**Files (2)**	**References (6)**
Lack of financial conditions	1	4
Costs	1	2

4.4. Conditions to implementation

The RFID suffered an evolution since one of its first massive implementation in 2003 by Walmart. The continuous studies allowed the understanding of the technology benefits and barriers in diverse

environments. Consequently, was improved the RFID standards, technology security and, safeguarded user security.

To support the aviation sector and abet the RFID implementation in the industry, IATA created a working committee. The first RFID implementation in Europe (and third in the world) for baggage tracking occurred in 2008 at Milan Malpensa Airport. Thirteen years after, their use is not widespread. The research explored which conditions have to be met to trigger the implementation. Table 4.20 details the conditions to implementation category.

Table 4.20: Category conditions to implementation in Nvivo

Conditions to implementation	**Files (5)**	**References (35)**
Chain commitment	3	16
Company acceptance	4	10
Infrastructures	2	5
Implementation willingness	1	2
Confidence in the technology	1	2

4.4.1. Confidence in the technology

A successful long-term implementation requires the development of a business case. Interviewee VI (IDentPrint) classifies the technology as tricky, demanding several tests before the deployment. Interviewee IV (LH) refers that for the technology to be implemented, certain aspects have to be met. Each specificity has to be revised and, the technology must show proves of reliability and efficiency (Interviewee IV, LH). The interviewed adds that the technology should be approved by IATA and certified. Interviewee IV (LH), analysing from the partner's side, refers that to the technology be implemented by Groundforce or Portway, the company must be convicted that the RFID is important and indispensable. IATA, to answer the players' needs created various incentives: the recommendation practice (RP) 1740c[11], on-demand webinars and, business cases such as IATA End to End baggage (IATA, n.d.-b).

[11] In 1740C, IATA defines the standards for the application of RFID in the passenger luggage. The RP is updated to reflect the latest developments (IATA, n.d.-b).

Confidence in RFID represents an essential aspect for the enterprise. In aviation, the partner acceptance and the IATA approval has a high influence on the company decision and, in the consequent implementation. Table 4.21 details the confidence in the technology category.

Table 4.21: Category confidence in the technology in Nvivo

Confidence in the technology	Files (1)	References (2)
Technology maturity	1	1
The technology is essential and important	1	1

4.4.2. Company acceptance

The acceptance of new technology in a company influences how the benefits are perceived and their impact (Fries et al., 2010). At TAP ME implementation, the business case played a fundamental role in the acceptance process (Interviewee II, TAP). The research concluded that the generated benefits would be higher than the total costs. According to Vilayaraman and Osyk (2006), in some cases, this conclusion can be hard to observe once it requires the consideration of variables that are difficult to measure or quantify. In addition, the TAP ME business case allowed a clear benefits outlook, leading to a wider user acceptance (Interviewee II, TAP). The user non-acceptance or reluctance can compromise the system and the data credibility (Rahman et al., 2019).

The contribution of the user and its approval to RFID implementation is supported by Interviewee I (ETE). The international manager refers that apart from the user acceptance, the company must have a certain tendency to implement. This way, the management position plays an essential role once the decision power relies on them (Interviewee V, ETE). The perspective is reinforced by Interviewee II (TAP). For the interviewee, after a careful business case development, support from the management team is necessary to proceed with the solution deployment. Interviewee I (ETE) refers that the manager mindset influences the decision. The leader of the implementation must be confident and certain of the technology deployment on the company (Interviewee I, ETE). This perspective is shared by Interviewee III (Groundforce). The interviewed adds that to RFID be adopted, the parties involved must show willingness, and considering that the technology is an essential aspect to the company.

A successful innovation, change and transformation require an environment in which people are ready, willing and able to sustain change (Wiktorsson & Groth, 2011). The qualitative analysis observed a high influence of the involved parties' perception in the implementation. A clear outlook of the technology gains leads to user acceptance, contributing to the RFID integration in the company. Even though the user non-acceptance can boycott the system, the management team and the project leader

view, are crucial to the technology life span in the company and usefulness. Table 4.22 details the company acceptance category.

Table 4.22: Category company acceptance in Nvivo

Company acceptance	**Files (4)**	**References (10)**
Benefits perception	3	5
Benefits compensate the investment	2	2
Management support	2	2
User acceptance	1	1

4.4.3. Infrastructures

The lack of conditions in the company facilities is an obstacle for the implementation. During the research, the deficiency on infrastructures is labelled as an RFID implementation barrier. Wherefore, this point is relevant to be assured before the technology adoption.

Interviewee I (ETE) acknowledges that currently, ETE does not have the appropriate infrastructures to embrace the RFID system. The interviewed adds that early in the implementation should be ensured that the company has an adequate system to support the technology, adapted to its needs.

In addition to the technological infrastructures, according to Moretti et al. (2019), the lack of employees with technical knowledge represents a barrier to RFID deployment. Interviewee II (TAP) refers that to overcome the obstacle, the company has to be available to train their employees. Before the implementation, TAP did not have competencies in the RFID. Therefore, its deployment was supported entirely by Airbus, being the mechanics trained before the solution go-live. To bring higher technological independence to TAP, some of the IT department member's specialized in RFID, afterwards the adoption.

An adequate infrastructure in software, physical devices and, human capital is essential for RFID deployment. The lack of fitting digital support can compromise the total system (Interviewee I, ETE). In turn, the shortage of skilled human capital can create technical challenges in the long run (Rahman et al., 2019). Table 4.23 details the infrastructures category.

Table 4.23: Category infrastructures in Nvivo

Infrastructures	Files (2)	References (5)
Infrastructure	1	3
Company availability to train their employees	1	2

4.4.4. Chain commitment

The benefits produced by RFID increases with the number of users. A joint deployment of the system was considered during the qualitative research of great importance for the company decision-making.

For Interviewee IV (LH), the high number of players and the dependency between the several areas requires a "joint action" in the sector. Interviewee II (TAP) and Interviewee V (ETE) supports this perspective. The alignment and coordination between all entities are fundamental to guarantee a successful implementation, especially in this case, where the costs are divided among the implementers (Interviewee II, TAP). For Interviewee V (ETE), this project is only interesting if all parties are connected and perform accordingly with the requirements. The interviewed defends that the adoption cannot be segmented and must include all entities otherwise the technology absent at some stakeholders reduces the system efficiency. This perspective stands in line with Wu et al. (2006), which refers that to enhance the management efficiency the infrastructure must be established at every stage in the chain. Furthermore, Li and Visich (2006) highlights that when several organizations in the supply chain implement the technology produces greater benefits. For the IATA (2007), to have full benefits is not necessary a full-scale implementation. The IATA RFID Baggage Transition Plan states that for global benefits, implementing the technology is only important for 80 airports as it would cover 80% of all mishandled baggage. However, the implementation by some partners is recognized with greater importance than others. For LH, the RFID use by the big players is a relevant trigger, especially the closest ones to the company (Interviewee IV, LH).

The RFID adoption in the chain is not a simple process (Interviewee IV, LH). Interviewee IV (LH) believes that for the technology to be deployed, future users must share a common motivation. Conversely, Interviewee V (ETE) believes that the engagement of all entities is only possible through a compulsory requirement or the indication of a governmental or regulatory entity such as ANAC or IATA. The necessity for the intervention of a regulatory entity is, according to Interviewee V (ETE), justified by the characteristics of the cargo sector: various entities, spread around the world and, with different ways of thinking. In addition, Interviewee V (ETE) refers that nowadays the clients look for good service, paying the least possible. Wherefore, the mandatory requirement is the only way to the clients accept the technology. Interviewee IV (LH) shared a similar struggler when LH implemented the e-AWB. In the

beginning, the client's adherence was very low although, it suffered an exponential growth when the company started demanding a fee to the ones that did not use the e-AWB.

The low number of RFID users in the chain is an implementation barrier. To Interviewee IV (LH) the tag's objective is lost if the system is not used by a high number of users. In contrast, the partner implementation is a key condition for the company adoption, especially in those where the company works directly. Albeit, the intervention of a government entity may be required when the environment lacks customer demanding innovative services and the sector has a shortage of financial resources. Table 4.24 details the chain commitment category.

Table 4.24: Category chain commitment in Nvivo

Chain commitment	**Files (3)**	**References (16)**
Joint motivation	1	2
Indication from a governmental entity	1	4
Joint deployment	3	10
Existence of partners with the technology	1	1

5. Remarks and Conclusion

RFID appears to be a promising technology to be applied in air cargo transportation. When transporting goods by air, the players want to ensure that the commodities arrive at the destination, at the expected time and without compromising the passenger's safety and the integrity of the goods. The research shows that the participants acknowledge the positive impact of RFID on their operations.

This dissertation contributes with a practical overview of the characteristics and environment of the air cargo sector in Portugal. The study aims to understand the benefits, the triggers and barriers to the adoption of the RFID system in Portuguese airports (RQ1, RQ2, RQ3) and the necessary conditions for successful implementation (RQ4). The qualitative research demonstrated that the Portuguese airports' players recognize the RFID system benefits and perceive its implementation as a plus for their company and the airport processes.

The RFID system is a well-established technology. The technology is applied in different areas and its adoption is supported by IATA for the passenger side. Yet, their use in air cargo is residual. The methodology used - individual interviews - allowed a greater involvement of the interviewees and opened space for the participants to share their experiences and knowledge, enabling a deeper perception of the Portuguese context and the understanding of the critical aspects for the implementation.

The study reveals that the implementation of the RFID system in cargo is mainly encouraged by internal drivers. Business improvement and cargo service enhancement represent the main drivers of adoption. Even though external drivers are considered less significant for the RFID deployment, the analysis revealed these as decisive factors for implementation.

The conditions of the air cargo customers and the position of the sector in the industry, are seen as defining aspects of the sector willingness for innovation. At a company level, the characteristics of the customers (business partners, commodities specifications and financial position) and the characteristics of the partners (level of technological innovation, openness to invest and infrastructures) inhibit the implementation of the RFID system. These aspects end up creating barriers for the airport environment. The factor perceived with the greatest concern is the management of entities, followed by the sectorial vision and the financial capacity of airport players.

The investigation of the implementation triggers and barriers provides space to understand what conditions should be reunited for a successful implementation. The study highlights three elements: chain commitment, confidence and acceptance of the technology and infrastructures. The approach of these factors takes into account the concerns of the cargo players and the shortages of the Portuguese Airports.

Below some final conclusion and recommendations per research question are presented.

What are the benefits of the RFID implementation in the Portuguese air cargo sector?

The analysis demonstrates that the perceived benefits vary from player to player according to their concerns. The freight forwarder´s responsibility is to support the exporter/importer in the commodities transportation along the chain. Therefore, the freight forwarder highlights the RFID ability to monitor the freight at different stages and the impact on customer service. In turn, the ground handler is more focused on their warehouses (import and export). Their job starts when the commodities enter the warehouse and ends when they exit. The perceived advantages of the technology are narrowed for the impact on their own processes. Alternatively, the air carrier is the player with the higher responsibility in the chain. In most of the transport process, the airline is not in charge for the operation although, a problem in the chain is immediately attributed to the airline's responsibility, affecting its image in market. For this reason, the player recognises the RFID impact on their performance: commodities monitoring across the chain, hubs timings control, reduction of irregularities and facilitation of procedures such as items search. Additionally, from an airport network standpoint, an increase in automation and better management of data has positive impacts in the chain.

The investment in freight transportation is affected by the relevance of the passenger side in the revenues of hybrid companies[12]. However, as most cargo[13] is carried in the belly of a passenger aircraft and commodities are the first items loaded, the performance of the cargo operations impacts the passenger-side processes. Therefore, investment and improvement of the cargo procedures impact the number of flights delayed and increase passenger security[14].

What are the triggers for the implementation of RFID in the Portuguese air cargo sector?

The RFID system is perceived as an improvement tool. Internal motivations are considered as the most relevant reasons for RFID adoption, with a highlight for the technology impact on the organization and on the cargo services. In Reyes et al. (2016), a higher level of internal drivers is associated with a higher number of RFID adoptions. This insight together with the visible openness of the sector for RFID adoption leads to the conclusion that the implementation represents a great possibility in the Portuguese Airports. For this, it is indispensable to gather the critical conditions and promote the essential drivers.

Unlike internal drivers, the external ones are considered less important reasons for implementing RFID. However, the research demonstrated that external factors have an essential role in the

[12] Company that works with passenger and cargo.

[13] In 2017, the cargo transported in the aircraft belly corresponded to 61% of the FTK (Djibo, 2018)

[14] RFID system reduces the incorrect build-up of ULDs, palletising errors and late preparation in the warehouse that can delay the flight. In terms of security, the system eliminates the possibility of hidden dangerous goods.

Portuguese air cargo sector. The concern with customer conditions, the implementation at TAP ME encouraged by Airbus' experience with RFID, the influence of a partner experiment in the perception of technology and the need for joint implementation demonstrate that an external motivator can be the factor that lacks to trigger the deployment in Portuguese airports.

What are the barriers to the implementation of RFID in the Portuguese air cargo sector?

The Portuguese air cargo sector is demarked for its customers' characteristics and its relevance in the industry. The growth of the industry in Portugal has increased the number of players, crushing the price of the service and opening the air transportation to a more diversified business fabric. The Portuguese market is strong in general cargo that corresponds to commodities with low-profit margins, reorienting the concern from the quality to the price of the service. In addition, the export of goods by air from Portugal is common to countries with low financial capacity such as Angola and Brazil[15], making it difficult for the exporter to charge an additional cost to the commodities.

Along the chain, the sector shows undeveloped infrastructures that result in lower productivity and hesitation to redirect the companies towards a more digital approach. The reluctance of the freight forwarders to adopt e-AWB was mainly due to technological limitations. The inability to connect with the airlines' software impeded the freight forwards from transmitting the shipment data to airlines without a physical document. In addition, a difficulty to acknowledge the benefits and the idea that the e-AWB duplicates the work (need for physical documents apart from the digital ones) are also verified.

The sector is paper-bound and, up to now, some processes are impossible to complete without a physical document. The pandemic forced some companies to become more digital, although the forced transformation has shown that the sector has yet to have the appropriate infrastructure, resulting in time-consuming procedures that affect customer life.

In the chain, the ground handler executes most of the process that requires manipulation and processing of the load. Therefore, it is under the ground handler responsibility that a larger number of irregularities that affect overall performance may occur. However, the research observes that this player monitors a low number of variables and does a cursory analyse of data. This procedure creates a sense of satisfaction with the existing technologies, increasing the reluctance to RFID.

In Portuguese Airports, cargo transportation is considered a sector with less relevance for the players. For the ground handlers and the airlines, the revenues generated from the cargo are overshadowed by the passenger side, affecting its attractiveness for the industry. Moreover, the dimensions of maritime transportation, responsible for transporting about 89% of goods in Portugal in

[15] Angola and Brazil belong to the top five of the busiest routes of Portugal (IATA, 2019a).

2019 (PORDATA, 2020), redirect the focus of the freight forwarders from the air cargo. This context restricts the resources channelled for the sector, affecting the companies´ mindset, the willingness to invest and innovate, which end up defining the context of the Portuguese Airports.

The industry is composed of an extensive network at a national and international level. The growth in users of the RFID system increases the benefits generated by the technology. Therefore, in a scenario with a broad network, the alignment and management of all entities can be difficult. The airlines are the player that gains the most from the technology, although the most significant and impacting investment occurs with the ground handler. The resort to the Service Level Agreement (SLA) can help to share the costs through the chain. Similarly to the use of the x-ray machine (RXC), the service is invoiced to the various actors across the chain (ground handler - air carrier - freight forwarder) until is it finally charged to the exporter/importer. However, the substantial initial investment can hold back the deployment. The existing oligopoly in the Portuguese handling and their lack of resources reduces the possibility of airlines' companies enforcing the RFID implementation. Plus, the airlines' companies are not allowed to self-handling according to the European legislation, restraining their options. In addition, for airports where the management of entities is more complex due to financial reasons, apart from the hybrid system (bar code and RFID tags), the aircraft can have an integrated RFID reader to confirm that the commodities arrived and are at scale or take off.

What conditions must be met for the implementation of RFID in the Portuguese air cargo sector?

The focus on the passenger side, low turnover and the scarcity of financial resources to invest in the sector have generated a reluctance to invest in new cargo technologies. Thus, to adopt the RFID system, the players want to be sure of its benefits and be confident that the investment will bring gains.

The study demonstrates that the sector is sensitive to the decisions and changes made by competitors, therefore the lack of RFID adoption influences the player's openness and confidence in the technology. To overcome these constrain, I suggest that IATA can design a pilot deployment in collaboration with a major airport such as Frankfurt Airport (FRA), the hub of LH. A major airport is a relevant scale for many air carriers and a popular transit/destination scale for freight forwarders. Strategic implementation of the RFID system will provide a clear outlook of the technology benefits for air cargo transportation while affecting the performance of a large number of players. Albeit this approach has limited impact on the life of ground handlers, the improvement in performance affects the perception of other partners located elsewhere about the technology, as is shown in the partnership between TAP and Airbus. Moreover, closer contact with the RFID system creates greater awareness and influences positively the management team and the workforce.

The perception and quantification of the benefits of the technology for the company and the chain awaken players the will to invest in new infrastructures and human knowledge. To overcome the low

number of players with RFID, a strategy similar to the one used by LH to boost the e-AWB adhesion can be applied. Those who did not adhere to e-AWB have to pay LH an extra-fee for AWB. Since the influence of a single air carrier is limited in the airport environment, the initiative of the ground handlers in combination with the airlines' companies can positively impact the RFID adoption in the Portuguese airports. However, the research has shown that the players have no intentions of starting a high financial investment without chain commitment. The support and intervention of IATA or ANAC can stimulate the technology adoption in the Portuguese Airports since both organizations bring accreditation and a sense of security.

Existing research such as Cao et al. (2011) and Giusti et al. (2019) explores the benefits that can be generated from an RFID deployment in air transportation. In turn, this study allows us to understand the factors that are preventing the spread of a technology with proven benefits in Portugal and what can be done to successfully change this reality. As a sector with an extensive network, the first action of the air cargo players, should be the constitution of task forces divided by countries to understand the feasibility of the technology for each airport and its impact in the chain performance.

The developed study will help the airport players to devise strategies to overcome the obstacles and provide the necessary conditions for a successful implementation at the Portuguese airports and medium sized airports. Despise its contribution, the study presents limitations. The qualitative research was focused on a small number of participants and narrowed to the two biggest Portuguese airports (OPO and LIS airport). To better understand the results of this study, further research is needed determine the benefits, drivers, barriers and conditions to implementation in smaller Portuguese airports as Funchal Airport.

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Appendix

Appendix A – Passive, semi-passive and active tag

The passive tag can operate at low, high, ultrahigh or microwave frequency (Khaddar et al., 2011). To be powered, the passive tag relies on the electromagnetic field generated by the reader (Kumari et al., 2015). The radio waves broadcasted by the reader are collected in the tag antenna and converted into electrical power (Wu et al., 2006). The energy is conducted to operate the microchip, transmit the stored data to the reader and, energize other electronics components of the tag (Khan et al., 2009). The dependency of an external source of energy increases the device lifespan, operating until damage by tear and wear (Smiley, 2019). The passive tag is capable to work at near-field (magnetic/electrical coupling) and far-field (electromagnetic coupling – backscattering). The last is applied at the Ultra High Frequency (UHF), gaining market space due to their higher data rate and operating distance in contrast with near-field technologies (Zou et al., 2014).

The semi-passive tag, to communicate, resorts to the electromagnetic field broadcasted by the reader. The device remains inactive until being activated by the radio waves transmitted by the reader (Kumari et al., 2015). The semi-tag battery is not responsible for the communication with the reader. Instead, it supports additional components such as sensors and assists the powering process of the electronic circuit used to encode/decode/processing/memory. This feature reduces the quantity of energy that has to be collected to activate and operate the tag (Zou et al., 2014; Khan et al., 2009). The semi-passive tags are usually found under the ultra-high frequency (UHF), performing at 868/915 MHz and 2.4 GHz (Kumari et al., 2015). The enclosed battery and more hardware (compared to passive tag) increase the tag market value, being commonly employed on costly items (Urso et al., 2020).

Sensors are fundamental for the quality assurance, conservation, and safety of the tagged products. It helps the companies to meet the regulations, ensures the business viability and increases customer satisfaction. In the transportation of perishable good, the sensors help to prevent their deterioration or even their loss. The damaged products are easily detected and replaced with new ones, guarantying order quality and client satisfaction. For pharmaceutical goods, sensors are vital to ensure the quality of the product and do not compromise patient safety. The sensors allow the constant record of information and their storage for later analysis. They are of great use in areas where accessibility is reduced, dangerous or even prohibited (nuclear waste containment). In construction, the degradation of the infrastructure is usually challenging to detect at first sight. Wherefore the use of sensors helps in the early detection of anomalies, decreasing the repair costs and ensuring safety (Strangfeld et al., 2019).

The active tag, additionally to the antenna and the microchip, encompasses a power source and a transmitter. The built-in battery gives the tag the power to initiate the communication with the reader and allows the transmission of a continuous signal (Kumari et al., 2015; Khaddar et al., 2011). Moreover, the independent power source improves the device memory (Unamate et al., 2018) and increases the tag reading range, which can be extended by adding additional batteries (Urso et al., 2020). In turn, the battery reduces the tag life span, presenting a lower service life compared with the passive and semi-passive tags (Nash II et al., 2016). In contrast with passive tags, the active tags have more hardware that improves their performance and increases the market value (Urso et al., 2020). Due to the device high cost, the active tags are commonly applied on costly items (Khaddar et al., 2011).

Appendix B – Low, high and ultra-high frequency

The LF spectrum varies between 30 kHz and 300 kHz although, this frequency is only authorized to operate between 125 kHz and 134 kHz (Khaddar et al., 2011). The LF tags resort to magnetic coupling[16] to be powered and to transfer data to the reader. The tag read distance, data rate and environmental robustness are affected by the coupling form (Sattlegger & Denk, 2014). Therefore, tags that operate in the LF spectrum present a low reading range, with a slower read rate, decreasing the number of labels read by minute (Kumari et al. 2015; Sattlegger & Denk, 2014). The reader needs more time to receive and decode the broadcasted signal, reducing the tag applicability and usability (Kumari et al., 2015). The standards include ISO 11784/5, ISO 14223 for animal tracking and identification, ISO 18000-2 for item management (Sattlegger & Denk, 2014; Unamate et al., 2018).

HF tags resort to magnetic coupling to be powered and broadcast information to the reader (Sattlegger & Denk, 2014). Common standards include ISO 18000-3 for near field communication, ISO 14443 for proximity cards and ISO 15693 for item tracking and vicinity cards (Sattlegger & Denk, 2014; Unamate et al., 2018). Additionally, these tags are common in scenarios where is required an average data rate and read range (Nguyen-Duy & Dinh-Duc, 2015)

Inside the UHF tags class, the active tags have a better performance in terms of reading distance, are independent of external power source to operate and are more expensive than the passive tags (Sattlegger & Denk, 2014). In terms of standards, the ISO 18000-6 is the most common for passive UHF tags, while ISO 18000-4 2.45 GHz is the most common for active tags (Unamate et al., 2018).

[16] Magnetic coupling is a phenomenon that occurs when electromagnetic waves transmitted by the reader create a magnetic field that powers the tag (Oliveira et al., 2018; Li &Visich, 2006).

In contrast with LF and HF, the UHF tags rely on passive backscatter modulation (Ching & Tai, 2009). In the UHF spectrum, the tag performance varies when in contact with metal and water. The performance of UHF active tags does not degrade in metal-rich environments although, is not observed the same behaviour with UHF passive tags. Close to metal, the tag antenna characteristics can be disturbed, leading to the reflection of radio waves and decreasing the tag performance (Byondi & Chung, 2019). The UHF passive tags usually operate in environments with metallic objects, creating the need to find an alternative that serves well both in metal and non-metal situations (Omni-ID, 2009). To overcome this problem was initially suggested to create a space between the label and the metallic surface or the design of labels for metallic products (Park & Eom, 2011). Omni-ID (2009) suggests a plasmonic structure that impacts the oscillations within an electromagnetic field, capturing and holding the waves without interference. The proposed alternative suits environments rich in water and metal. Byondi and Chung (2019) presents a tag designed to operate in non-metal and metal contexts. Lui et al. (2020) introduce a new antenna design and structure where the tag produces a higher reading performance in metal than in free space. Moreover, Bouazza et al. (2020) developed a new antenna structure and design for metallic objects, which operates in different frequencies (Europe and America). The selection of a tag that performs well both in metallic and non-metallic environments reduces the need to fully assess the surrounding environment the tag will be in over its lifetime. In addition, this functionality increases the tag applicability in the industry and transportation (Omni-ID, 2009). Apart from the metal effects on the tag performance, the liquids in the surrounding environment can also interfere with the system operations. The tag signal is absorbed, reducing the reading range, the reading rate and the tag sensitivity (Yu & Qu, 2020). To remedy the drop in performance, the users have been applying some alternatives. When transporting liquids, the tag is attached to the neck of the bottle. The solution preserves the system performance although, it is only viable if the container remains in the standing position. An alternative solution is the label embedding into cork but, due to a demanding design, the cost of the manufacturing process would increase. (Sohrab et al., 2016). The need for a viable solution leads to the development of diverse solutions. Sohrab et al. (2016) propose a new tag design that offers improved performance in various scenarios (free space, paper bottle, glass bottle, plastic bottle). Periyasamy and Dhanasekaram, (2015) presents a new solution where, due to a higher emitting power, the radio waves can penetrate all sorts of metal and water with low conductivity. Additionally, Yu and Qu (2020) introduce a new antenna tag design developed based on the reasons that affect the device performance when in contact with metal or water. The continuous research on UHF tags creates solutions to overcome performance obstacles, increases the technology popularity and wider their application.

Appendix C – The antenna

In the tag, the size of the antenna is closely related to the read range. A larger size results in greater readability. Sometimes, to reduce the size of the tag, it is necessary to diminish the antenna dimensions, compromising the system performance (Byondi & Chung, 2019). In addition, as discussed in the previous section, contact with liquids and metallic products may affect the regular performance of the antennas (UHF passive tags). Moreover, Barge et al. (2019) determined a high impact of the food composition and its temperature in the reading range.

The polarization mismatch is observed when the direction of the electric field transmitted by an antenna does not match with the electric field received by another one (Omni-ID, 2009), reducing the system operation. Antennas are divided into two categories: circular polarized (CP)[17] and linear polarized (LP)[18]. A linear antenna should be adopted if the tag position is aligned with the antenna and the orientation of the tag is controllable (Armstrong, 2013; Omni-ID, 2009). In turn, if the tag orientation is not consistent or challenging to rely on, the circularly polarized antenna suits best the needs (Armstrong, 2013). The linear antennas are known for offering a better-read performance and accuracy (Omni-ID, 2009). In contrast, the circularly polarized antenna is highly effective if one or both RFID systems are in rotation and when the signal takes multiple diverse paths (multipath fading environment) from one station to another (Das et al., 2020). The application of a circularly polarized antenna is advised for a fixed installations transmitter or receiver while, linearly polarized antennas are suggested in the case of a mobile device (Szalay & Nagy, 2015).

Appendix D – The reader

Typically, the reader is comped of one or more antennas (Wong & Guo, 2014) and can be either an integral part of the reader or an external part (appending), connecting directly with the reader.

The readers choosing process requires an analysis of the surrounding environment and a clear definition of system objectives. The frequency of the radio waves that are received and broadcasted differ from region to region and are specific to the adopted system frequency (Wu et al., 2006). Moreover, as discussed in the previous section, the reader antenna can suffer some disturbances due to the materials in the encompassing environment, impacting the system performance. Conversely, for

[17] A circular polarized antenna emits corkscrew-shaped electromagnetic waves, which means the waves are emitted in two planes. They can operate in all directions without a substantial change in the radiation pattern (Khalaj-Amirhosseini & Farhoudi, 2019)

[18] In linear polarization, the electromagnetic waves are broadcasted on the antenna axis in a single plane, either vertical or horizontal (Huang, 2009).

the maximization of the system performance is vital the combination of the different sorts of readers (Periyasami & Dhanasekaran, 2015). Readers are classified into fixed readers and mobile readers. The fixed reader has an optimized performance and reading range (Oliveira et al., 2018), recording every tag in their reading range (IATA, 2007). Mobile readers, in turn, perform better when a specific item needs to be read and the device is close to the tag (Oliveira et al., 2018). Readers are typically limited to passive or active tags. The use of a hybrid reader allows the identification of the tag disregarding its classification (Wong & Guo, 2014).

Appendix E – Interview Structure

Question	Objective
What is the company position in terms of RFID implementation?	Understand the company implementation stage/position (a possibility, not adequate, considering, implemented and not implemented) and the implication on the perceived benefits, barriers and conditions.
> If the RFID system is not implemented: Which aspects would lead your company to implement the RFID system? > If the RFID system is implemented: Which aspects were significant for the RFID implementation?	Understand the triggers and the company motivation to implement the RFID system.
What is your opinion on RFID implementation?	Understand the perceived benefits of the technology for the airport and the company.
> If the RFID system is not implemented: From your perspective, which are the principal barriers to RFID implementation in your company? > If the RFID system is implemented: During the RFID deployment, which challenges did you encounter?	> Understand which barriers and obstacles can inhibit the RFID implementation in the company. > Understand the barriers and obstacles observed during the RFID implementation.
From your perspective, which are the RFID	The stakeholders' concerns (challenges and

implementation challenges/obstacles on the Portuguese airports?	obstacles) for the RFID implementation on the airport chain.
Which are the companies' conditions/criteria that would promote the RFID implementation?	Understand the aspects/points that a company must have to implement the RFID system.
Based on your company situation, under which conditions would your company be available for the RFID implementation?	Understand which conditions are missing; To perceive the aspects that are deficient on the Portuguese business fabric.
In a scenario where you are the one that decides about the RFID implementation on an airport, would you proceed with the implementation? Why?	Understand if the stakeholder believes that technology will suit the airport needs. Understand the reasons why the interviewee would not implement.