THE APPLICATION OF RFID TECHNOLOGY IN AN AIRLINE COMPANY

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PLAGIARISM

I hereby declare that all information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work; otherwise I accept all legal responsibility.

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ABSTRACT

THE APPLICATION OF RFID TECHNOLOGY IN AN AIRLINE COMPANY

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The aviation industry grows day by day, as it grows the number of passenger and baggage increase relatively. The number of carried baggage increases the number of mishandled baggage. Each mishandled baggage causes cost and customer dissatisfaction for airline companies. Alternative and new solutions have been developed by airline companies in order to decrease the number of mishandled baggage. In this thesis, Radio Frequency Identification (RFID) technology was used to find owners of lost and unidentified baggage of Turkish Airlines. The RFID system is installed to the warehouses where the company stores lost baggage and RFID baggage cards are provided to passengers on request. Passenger information was captured rapidly and accurately with this system. At the same time, the warehouse and the volume of staff needed to remain the same in spite of the increase in the volume of passenger and baggage. Also, it was observed at the end of the project that there was a decrease in the compensation paid to the passengers for lost baggage.

Key words: RFID, aviation industry, airline, baggage, mishandled baggage

ÖZET

THE APPLICATION OF RFID TECHNOLOGY IN AN AIRLINE COMPANY

Eren, Gonca Gül

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Havacılık sektörü gün geçtikçe büyümekte taşınan yolcu ve bagaj sayısı da artmaktadır. Taşınan bagaj sayısındaki artış aksaklığa uğrayan bagaj sayısını da arttırmaktadır. Aksaklığa uğrayan her bagaj, havayolu şirketleri için maliyetlere ve yolcular için memnuniyetsizliğe neden olmaktadır. Bu nedenlerden dolayı, havayolu şirketleri aksaklığa uğrayan bagaj sayısını azaltmak için çeşitli yöntemler geliştirmektedir. Bu tezde Türk Havayolları firmasında kaybolmuş ve yolcu bilgileri üzerinde yer almayan bagajların sahiplerini bulmak için Radio Frequency Identification (RFID) teknoloji uygulaması yapılmıştır. Firmanın kayıp bagajları sakladığı depolara RFID sistemi kurularak, yolculara RFID bagaj kartları isteğe bağlı olarak temin edilmiştir. Bu sistem ile yolcu bilgilerine hızlı ve eksiksiz bir şekilde ulaşılmıştır. Aynı zamanda havalimanı içerisinde depo ve personel ihtiyacı, yolcu ve taşınan bagaj sayıları artmasına rağmen aynı kalmıştır. Ayrıca yolculara kayıp bagajları için ödenen tazminat giderlerinde azalma olduğu proje sonunda gözlemlenmiştir.

Anahtar Kelimeler: RFID, havacılık endüstrisi, havayolu, bagaj, kayıp bagaj

TEŞEKKÜRLER

Bu tezin araştırma ve yazım sürecindeki rehberliği ve destekleri için danışmanım Prof. Dr. İsmail Erol' e teşekkürlerimi sunarım.

Bu tezde anlatılan projenin hayata geçmesini sağlayan ve tez yazım aşamasında verdikleri tüm destekler için Türk Havayolları Genel Müdürü Sayın Bilal Ekşi'ye, Genel Müdür Yardımcısı Sayın Akif Konar'a, Yer İşletme Başkanı Sayın Ali Aykanat'a ve Bagaj Hizmetleri Yönetim Müdürü Ergün Altıyaprak'a sonsuz teşekkürlerimi sunuyorum.

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INTRODUCTION

RFID (Radio Frequency Identification) is the generic name given to technologies used to identify living things or objects with radio waves. RFID is a technology that works with radio frequencies that allows the monitoring of the movements of an object carrying a tag that is equipped with a microprocessor (Üstündağ, Tanyaş, 2008). RFID systems can make any of tagged things/entity mobile and communicate and intelligent over the organization's infrastructure (Curtin et al., 2007). RFID can provide an added value to companies by providing identification and traceability. It can obtain a wide range of location and property information through physically RFID labels and wirelessly searchable assets. (Curtin et al., 2007; Weinstein, 2005). Academics and practitioners well know that organizations can use RFID systems in order to achieve business value (Weinstein, 2005; Curtin et al., 2007).

RFID systems have advantages such as quick and simple access control, contactless, multiple object recognition, a wide line of sight, long distance accessibility, large memory, programmability, processability, low cost, and flexibility. The most important meaning of RFID technology is that physical objects can be transformed into software data created by the RFID system (Zhang, Ouyang, He, 2008). Using RFID technology may provide disadvantages as well as its advantages. These disadvantages are technical risks, non-compliance with RFID Standards, special materials requirements, the efficiency of alternative technologies, installation and implementation difficulties, privacy concerns, etc.(Tajima, 2007; Ladas, 2008).

RFID technology was used for the first time in World War II to identify aircraft in military aviation (Asif, Mandviwalla, 2005). The use of RFID from World War II to the present has met with many examples. And today RFID technologies are becoming increasingly widespread in the world and are used in many sectors. RFID has become an integral part of our lives and is used for hundreds of applications to increase productivity and convenience (Landt, 2005).

The spread of RFID technology has led to the emergence of a new field of academic research. There has been a significant increase in the number of articles published in RFID and a host of disciplines such as electronics engineering, information systems, computer science, and business strategy. Curtin et al. (2007) summarize several areas in which this new research flow can be expanded. Radio frequency identification (RFID) has become an important issue in the fields of production and logistics. It was used to increase the efficiency of the processes in the supply chain (Ngai, E., Moon, K. K., Riggins, F. J., & Yi, C. Y., 2008).

In Turkey, RFID activities in the aviation industry have primarily been aimed at increasing the efficiency of in-house business processes by ensuring the tracking and maintenance of cabin and emergency equipment counting and maintenance processes. Moreover, RFID systems have been also used to manage follow-up control processes of test equipment used during aircraft maintenance processes at tool and aircraft maintenance workplaces (http://www.rfid-turkiye.com).

Based on the detailed literature analysis, we maintain that RFID technology has been applied in various industries at developed and developing countries. In addition, some researches on the Aviation industry with respect to RFID applications show that a number of RFID projects have been implemented. On the other hand, new case studies on the application of RFID technology to different operations in the aviation industries from developing countries are considered to be useful for a better understanding of the issue.

To this end, the aim of this study is the application of RFID technology in an aviation company. Specifically, RFID applications in Turkish Airlines will be discussed in this study. Turkish Airlines was established in 1933 and is Turkey's largest network carrier company. The company has faced serious problems with the identification of owners of lost baggage for a long time. In this research, how Turkish Airlines uses RFID technology to solve this problem, the process steps and expected benefits of this project will be discussed. With the help of this technology, we argue that (1) the number of lost baggage will be reduced, (2) customer satisfaction is to be expected to increase, (3) the cost of lost baggage in an airline company is reduced, and (4) finally, ensuring the reliability of service in an airline company will increase the brand image.

The rest of the thesis is organized as follows: as technical information about RFID technology will be given in Chapter 2, the history of RFID technologies and the required background of this thesis are presented in Chapter 3. In Chapter 4, information about baggage operation in the aviation industry, Turkish Airlines, and Baggage Service Management Department will be explained. In Chapters 6, system methodology will be described. Turkish Airlines lost baggage problems and the application of RFID technology in Turkish Airlines will be presented in Chapter 7. Finally, in chapters 8 and 9, discussion and conclusions are demonstrated.

CHAPTER 2

RFID TECHNOLOGY

2.1 History of RFID

In the 1800s, works on the electromagnetic energy by Michael Faraday, James Clerk Maxwell, Heinrich Rudolf Hertz, Aleksandr Popov, and Guglielmo Marconi led to the development of RFID technology (Landt, 2005). In 1906, Ernst F.W. Alexanderson invented the first continuous wave (CW) radio equipment and showed the transmission of radio signals. This is considered the beginning of modern radio communication. Thus, it was assumed that radar technology was born in the early 20th century (Landt. 2005). The first usage of RFID technology was for military purposes in 1926, during The Second World War. Britain Air Forces utilized the RFID technology to identify aircraft of the enemy and allied forces (Asif, Mandviwalla, 2005).

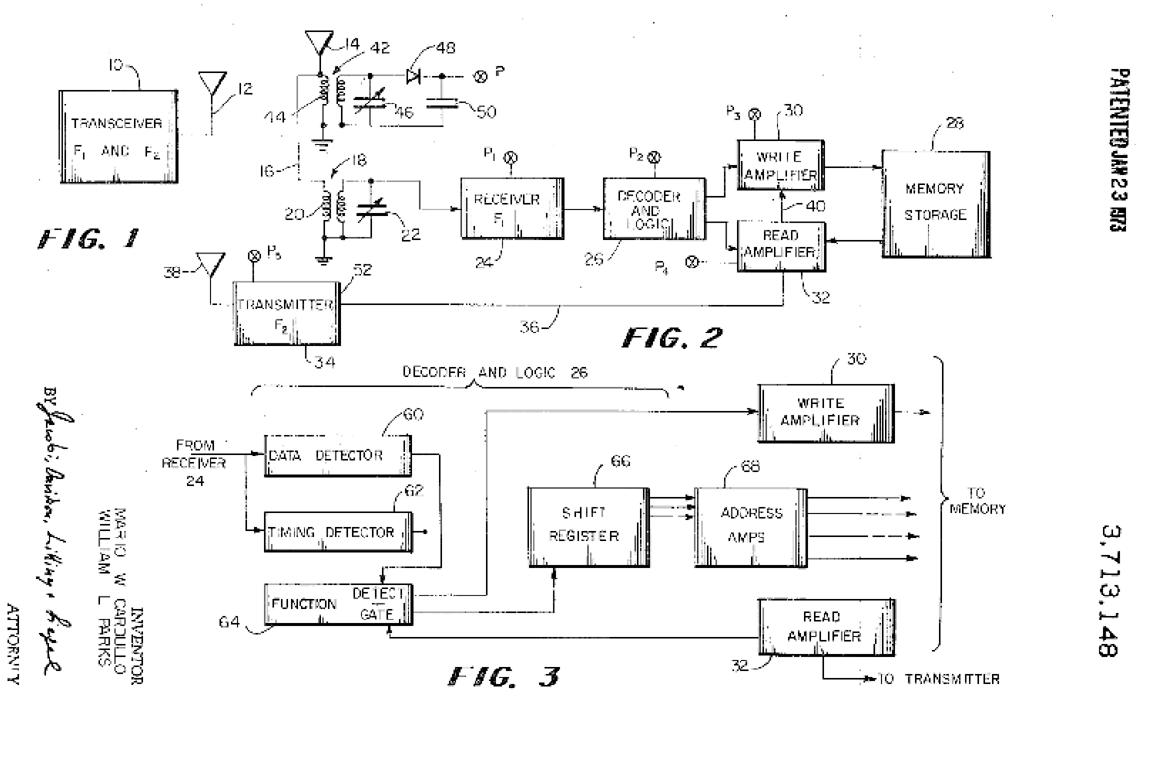
The article about the implementation of data communication over the radio frequency published by Stockman (1948) is considered as the one of the early studies the RFID-based technology. With the development of hardware and software technologies, RFID technology has begun to widespread rapidly in the 1950s. In 1958, Jack Kilby developed the first integrated circuit systems in Texas Instruments (Üstündağ, 2008).

According to Üstündağ (2008), the following researchers have made several inventions based on RFID such as the innovative work on electromagnetic theory by Harrington (1964), radio frequency remote control devices by Richardson (1963), radar communication by Rittenback

(1969), passive data transmission techniques by Vogelman (1968) and reader-receiver identification systems by Vinding (1967).

In the 1970s, developers, inventors, companies, academic institutions, and official laboratories worked actively on RFID and made remarkable progress (Landt, 2005). In the 1970s, RFID applications were not used as controls but rather for identification purposes (Üstündağ, 2008). The passive radio transponder with memory shown in Fig 1 was patented in 1973 by Mario Cardullo. This is considered as the true ancestor of modern RFID technology (https://patents.google.com/patent/US3713148).

Figure 1 Patent of RFID



Source: (https://patents.google.com/patent/US3713148)

In the 1980s, RFID applications have been spread over many areas. In the United States, the use of RFID in the 1980s was for transport, personnel access and, in a limited extent for animals, in Europe, they used mostly in short-range systems for animals, industrial and business applications (Landt, 2005). In some European countries such as Italy, France, Portugal, and Norway toll-collection devices are equipped with RFID (Üstündağ, 2008). And in 1984, the first commercial use of RFID was carried out by General Motors (Üstündağ, 2008).

The 1990s were an important decade for RFID. There have been many innovations especially in electronic tolls (Landt, 2005). The first toll-collection system, which was opened in Oklahoma in 1991, allowed the vehicles to pass through toll-collection lanes (Bazaatı S, 2012). With the development of integrated circuits in the 1990s, improvements have been made to RFID tags diminished to a single integrated circuit size (Landt, 2005).

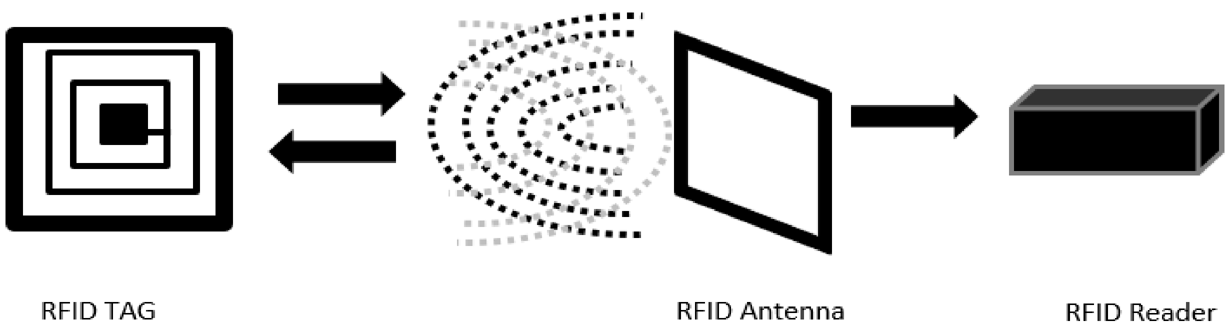
In the 2000s, RFID sizes and costs have been reduced. Thus, RFIDs could be integrated with many systems and consequently used in many sectors. An increasing number of engineers are involved in the implementation of RFID and system development is increasing over time (Landt, 2005).

2.2 Definition of RFID

RFID systems enable the production and collection of information without human impact or contribution. In recent years, RFID, which is one of the most widely used technologies for wireless communication, is being used in the industry. The area of usage is only limited to the imagination. All sectors can write data into the product that they want to follow product, carrier, cars, human, animal, etc. by attaching the appropriate apparatus and this information can read from ten centimeters to several hundred meters (Finkenzeller,2003).

RFID is an automatic identification and monitoring system provides data exchange via radio frequencies, using a microchip containing the object's information, and monitoring and analyzing it with an antenna connected to it and using a tag that can be integrated into objects. It is a technology that enables identification and communication with radio frequency via its components. As shown in Figure 2, RFID consists of three basic components: reader, tag and antenna. Information about objects with a tag placed on objects is sent to the reader in the form of a digital code using radio waves. The electromagnetic waves emitted by the reader reach the antenna of the RFID tag. These waves activate the microchip circuits in the tag and modulate the microchip waves and send them back to the reader via the antenna. The information that comes to the reader is converted into a digital form. The transponder on an attached or embedded radio frequency tag is activated by its wireless reader and tagged items become remotely read or data writable tag. (Das, 2002; ITAA, 2004, Want, 2004).

Figure 2 RFID System Components



In RFID systems, the connection can be made in two ways as electromagnetic or magnetic. Methods are being used depending on the application requirements such as label cost, size, reading speed and reading distance. Magnetic bonding is generally used in short distance access control applications. Electromagnetic bonding is the most common type of binding used in data communication between labels and readers. In this method, electromagnetic waves emitted by readers meet antennas and activate circuits in labels. The capacitor inside labels take energy from waves that generated by readers, microchips use this energy to send waves back to readers and readers convert new wave into digital data and finally reading processes are performed (Maraşlı, Çıbuk, 2015). RFID waves may interfere in application methods.

RFID systems are used in different applications according to the frequency type. There are four different frequencies where RFID systems work. The ranges at which these frequencies are defined are as follows (Finkenzeller, 2002):

- Low Frequency (LF, 30 kHz-300 kHz)
- High Frequency (HF, 3 MHz-30MHz)
- Ultra High Frequency (UHF, 300 MHz - 3 GHz)
- Microwave (> 3 GHz)

LF (Low Frequency) and HF (High Frequency) systems are preferred for applications that require a short distance reading range, while UHF (Ultra High Frequency) systems are included in applications that require further distance reading. UHF RFID systems are preferred in logistics and supply chain control systems. Table 1 shows the properties and application areas of RFID systems used in different frequency ranges (Bhuptani, Moradpour, 2005). As shown in Table 1, generally, there are four different frequency ranges used in RFID business solutions.

Table 1 Frequency of RFID

LF	Low Frequency	<135 KHz	Close Distance read access control card applications
HF	High Frequency	13.56 MHz	Near distance read input/control card applications
UHF	Ultra-High Frequency	430 MHz(Active) 860-930 MHz(Passive)	Production Tracking System, Warehouse Management System, Supply Chain Management applications
MW	Microwave	2.45GHz-5.8GHz	Instant Location Identification System

Source: (Bhuptani, Moradpour, 2005).

ISO 18000 series standards have been established for different RFID frequencies used globally (Üstündağ, 2008). There are seven standards in total ISO 18000 series, as indicated in below:

- ISO 18000-V1 Generic parameters for air interfaces for globally accepted frequencies
- ISO 18000-V2 Air interface for lower than 35 KHz
- ISO 18000-V3 Air interface for 13.56 MHz
- ISO 18000-V4 Air interface for 2.45 GHz
- ISO 18000-V5 Air interface for 5.8 GHz
- ISO 18000-V6 Air interface for 860 MHz to 930 MHz
- ISO 18000-V7 Air interface at 433.92 MHz

2.3 RFID Components

RFID consists of three basic components: tag, antenna, and reader. Detailed information about the mentioned components are provided in this section.

2.3.1 RFID Tags

Tags are components that store data. RFID tags can be read easily from any direction and angle without the need for touching and direct view. Tags are put on the top and inside of the object that needs to be defined. Tags have a protective layer for the protection of antennas and microchips. The purpose of the antenna on a tag is to read data embedded in a microchip inside tag and to establish the necessary communication with the system. The microchips in RFID tags have their own unique identification number. This is called a unique ID code. All kinds of data can be stored in this code. Therefore, we can write all kinds of information about the objects that wanted to be recognized and tracked. The memory capacities of RFID tags can be determined according to the application's needs. The name of objects, product code, etc. can be decoded by the memory capacity. High memory capacity is required when loading too much information about the object or when it is desired to continuously track objects or track information depending on the application. Tags can be designed physically in many ways. Plastic and paper tags are manufactured in different shapes, sizes, and packages according to needs. RFID tags have different designs and have many features such as power supply, carrier frequency, reading range, data storage capacity, memory type, size, working life and cost (Wamba, Lefebvre, Bendavid, 2008)

RFID tags are grouped into 3 different types according to the way of receiving energy. They are active, semi-active and passive. Active RFID tags receive energy needed for communication, reading, and writing, through readers, but the semi-active tags have their own power supply which switches off receiving power from the incoming signal. On the other hand, passive labels are also available. In this case, all energy required for communication takes over the reader.

An active tag is a label that allows product identification from a long distance. The battery inside labels allows the reader to operate independently from the power supply of the antenna. It can send signals itself directly to the reader without waiting. Active labels can be read from 1 meter to 100 meters and the antenna does not need to see any label. Its advantage over passive labels is that it can be read even more remotely, not being affected by metal and liquid, even if it is not visible by antennas. Reading distances are long, however, costs are higher than other tags. Active labels can also be inserted into valuable articles and devices that are in danger of theft. Thus, if the information is taken out of the designated area, alarm signals reach to the center of the system.

Semi-active tags supply power to their chips with the power supply they host on them, and they are dependent on the reader, such as passive labels, to communicate with the reader. They do not take action without being questioned. They provide communication at a longer distance than the passive label and their cost is higher than the passive label.

Passive tags don't have a power source on their own. They are passive in communicating with the reader first. Therefore, they are entirely dependent on the reader to activate and communicate their own chips. They receive the necessary energy from the reader via radio signals. This energy from the reader creates a voltage induction on the tag antenna to activate. The chip sends its information to readers through antennas. Since passive tags have low cost and are sufficient for many sectors, their use is high. The disadvantage of other labels is that they are affected by environmental conditions.

2.3.2 RFID Antennas

RFID antennas are components used to collect electromagnetic waves from a system and supply a system with the signals received from the electromagnetic waves around the environment and thus enhance the performance of wireless communication systems. Communication between tag and reader is done through antennas. When receiving or sending the antenna signal, the reader generates a signal and decodes a signal sent by tags. The antenna provides communication through radio waves between reader and chip, which translates information identifying objects into a format that can be understood by computers (Angeles, 2005). Antennas take radio waves and turn the reader's waves into the corresponding electronic product code in the form of the computer system (Angeles, 2005).

Antenna polarization determines how radio wave is emitted from the antenna and is directly related to the reading performance of the tag. Antennas are two types, the one with plane broadcasting and circular broadcasting antenna. The plane broadcasting antenna is concentrated in a single axis for maximum gain at the longest possible reading distance. The circular transmission antenna distributes the generated UHF energy evenly over longer distances. In this way, it is provided to read all labels in the environment with a circular direction spread.

2.3.3 RFID Reader

An RFID reader is a device that can read tag information by receiving a signal from the antenna on RFID tag, transmitting signals from the antenna on radio via radio frequency and providing the writing of new information to tag if necessary. The tag is detected by the reader when it enters the communication area of a reader. Some tags receive their energy from the signals sent by the reader through their antennae. The tag uses this energy to activate its own microchip. With this energy, the tag sends information to the reader by increasing and reducing the resistance.

RFID readers are divided into three types: fixed, handheld and mobile. Fixed readers can be mounted on walls or doors, have an external power supply, and usually contain multiple antennas. The antenna is located inside the hardware at the handheld terminals, usually connected to the IT infrastructure with the wireless network, the mobility is high and the battery is used as the power supply. Mobile readers include PCMCIA cards for laptop PCs, PDA can be featured, and some can be feature mobile phones. The basic features of RFID readers are the readings of the microchannel, which is also transmitted to the system.

RFID readers work on the reading capacities of many factors. These are frequency, the power of the chip, active and passive label, sensitivity of the antenna, whether liquid or metal in the environment.

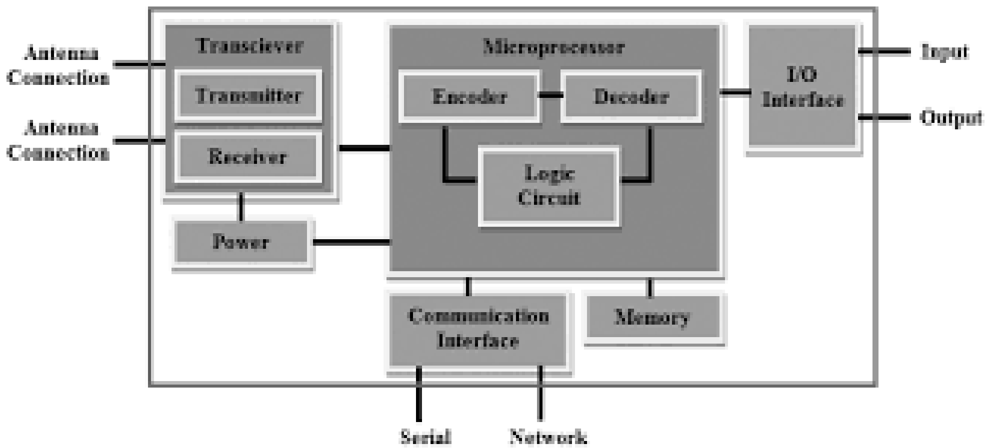
There are three basic commands that readers use for tag management. These are called select, inventory and access. The selection command determines which group labels should respond. With the inventory command, it is ensured that tags contained in a specific group are separated and the individual number information is recognized. Access command enables processing on a specific tag. With the four basic commands connected to the access command, different operations can be performed on the label.

- Read: Allows different data blocks within the label to be read.
- Write: Enables specific data to be written on the label.
- Kill: Makes the tag unusable.
- Encrypt (Lock): Encrypts the tag.

Besides these commands, it may be possible to read, write or delete information of labels with certain characteristics.

As shown in Figure 3 reader system consists of receiver, transmitter, memory, control processor, input/output (I / O) interfaces and antennas.

Figure 3 Reader System



Source: (Lahiri, 2005).

CHAPTER 3

LITERATURE REVIEW

The first work with RFID was published by Harry Stockman in October 1948, as "Communication By Means Of Reflected Power". In 1952, the article titled "Application of the Microwave Homodyne" was published by Vernon F. L. RFID technology has begun to expand rapidly in the 1950s, with the developments in an integrated circuit, microprocessor, memory chips and software technologies (Üstündağ, 2008). A brief history of RFID is given in Figure 4.

Figure 4 A Brief History of RFID

Decade	Development
1940-1950	Radar refined and used, major World War II development effort. RFID invented in 1948.
1950-1960	Early explorations of RFID technology, laboratory experiments.
1960-1970	Development of the theory of RFID. Start of applications field trials.
1970-1980	RFID development works increased tremendously. Tests of RFID are accelerated. Very early adopter implementations of RFID.
1980-1990	Commercial applications of RFID enter common use
1990-2000	Emergence of standards. RFID widely deployed. RFID becomes a part of everyday life.
2000-	RFID explosion continues.

Source: (Landt, 2005)

New developments by, Richardson R. (1961-1963), Harrington R.F. (1963-1964), Vinding J.P. (1967) and Vogelman J.H. (1968) in the 1960s provided the advent of RFID technology. In 1961 Richardson was published his work on radio frequency controlled devices in an article entitled "Remotely Activated Radio Frequency Powered Devices". In 1963- 1964, Harrington et al. were published two papers "Field measurements using active scatterers" and "Theory of loaded scatterers". These papers have been innovative studies of electromagnetic theory. Finding studied on the reader/receiver identification system and in 1967 he was published "Interrogator-Responder Identification System". In 1968 Vogelman has worked on passive data transmission techniques and the use of radar waves in his article, “Passive Data Transmission Techniques Utilizing Radar Waves”.

In 1975, Radio International of America (RCA) and Fairchild developed an electronic identification system and published the "Electronic ID System" (Datta, 2016). In 1977, RC Sterler developed an electronic plate for motor vehicles (Clench, 1975). Then RFID tags are used to monitor products or vehicles in some sectors. RFID, which started to be used in the monitoring of railway vehicles in the early 1980s, was used in the 1990s in America, Italy, France, Spain, Portugal and Norway for automatic payment systems on bridges and highways (Üstündağ, 2008). After the 1990s, RFID becomes part of everyday life and is widely used in many areas such as fee collection, animal labeling and personal identification (Datta, 2016). The spread of RFID technology has led to the emergence of a new field of academic research in many disciplines based on current research and there has been a significant increase in the number (Ngai, E., Moon, K. K., Riggins, F. J., & Yi, C. Y., 2008).

RFID has been the most rapidly developing technology within its applications for future business intelligence (Heinrich, 2005). The importance of RFID is increasing day by day and its usage areas are becoming larger such as healthcare industry (Ahsan, 20011), supply-chain management (Srivastava, 2004), airline baggage tracking, electronic security keys, toll-collection, and asset tracking, etc. (Angeles, 2005; Karkkainen, 2003; Srivastava, 2004).

Angeles (2005) and Karkkainen (2003) maintained that the capability of obtaining dynamic location and property information in real-time for tagged items including goods or people rapidly increased by using RFID technology. Violino (2005) research defined “internet of things” as a network that can enable cooperation or companies to track and view all product and goods in a supply chain concept and build many synchronized implementations. In his study, Srivastava (2004) argued that RFID technology showed dramatic growth and became the most attractive key development in recent years due to the last important developments in microprocessors.

In their review paper, Ngai et al. (2008) argued that researches have been published in animal detection, aviation, building management, construction, enterprise feedback control, fabric and clothing, health, food safety warranties, library service, logistics and supply chain management, mining, municipal solid waste management, museum, retailing category were examined. They grouped the literature into four main sections as displayed in Table 2.

Table 2 Classification of Literature

Classification	**References**
RFID technology	
Tags and antennae	Takaragi et al. (2001), Frisk et al. (2002), Biebl (2003), Keskilammi et al. (2003), Cabria et al. (2004), Chen and Hsu (2004), Heikkinen and Kivikoski (2004), Hirvonen et al. (2004), Keskilammi and Kivikoski (2004), Rasul (2004), Redinger et al. (2004), Tikhov and Won (2004), Cho et al. (2005), Curty et al. (2005), De Vita and Lannaccone (2005), Kwon and Lee (2005), Nikitin et al. (2005), O et al. (2005), Philipose et al. (2005), Rao et al. (2005), Ritamaki et al. (2005), Smith et al. (2005), Subramanian et al. (2005), Ukkonen et al. (2005), Usami and Ohki (2003)
Readers	Repo et al. (2005)
Communications infrastructure	Chlamtac et al. (1999), Deville et al. (2002), Ni et al. (2004), Gilbert et al. (2005), Yen et al. (2005)
RFID applications	
Animal detection	Artmann (1999), Wismans (1999), Streit et al. (2003)
Aviation	Wyld et al. (2005)

Building management	Sommerville and Craig (2005)
Construction	Jaseiskis and Ei-Misalami (2003), Yagi et al. (2005)
Enterprise feedback control	Kohn et al. (2005)
Fabric and clothing	Hum (2001)
Food	Hall and Hampl (2004), Vorst et al. (2004), Jones et al. (2005a)
Health	Venkatesan and Grauer (2004)
Library services	Hicks (1999), Kern (2004), Coyle (2005), Fabbi et al. (2005)
Logistics and SCM	Jansen and Krabs (1999), Angeles (2005), Twist (2005)
Mining	Ruff and Hession-Kunz (2001)
Museums	Hsi and Fait (2005)
Retailing	Ka¨ rkka¨ inen (2003), Jones et al. (2004a), Eckfeldt (2005), Jones et al. (2005b), Prater et al. (2005)
Waste management	Wa¨ ger et al. (2005)
Policy and security issues	
Privacy	Garfinkel et al. (2005), Gu¨ nther and Spiekermann (2005), Kelly and Erickson (2005), Ohkubo et al. (2005), Stajano (2005)
Security	Kang and Gandhi (2003), Knospe and Pohl (2004), Phillips et al. (2005), Shih et al. (2005)
Standardization	Jansen and Eradus (1999), Kampers et al. (1999)
Others	
General usage	Stanford (2003), Lapide (2004), Want (2004), Borriello (2005), Weinstein (2005)
General introduction/ review	Ferguson (2002), Rappold (2003), Jones et al. (2004b), Juban and Wyld (2004), McGinity (2004), Sangani (2004), Sheffi (2004), Goth (2005), Lai et al. (2005), Smith (2005)

Source: (Ngai et. al., 2008).

In addition to the applications and benefits of RFID technology, studies have been carried out on the disadvantages as well. For example, the use of RFID technology may threaten the privacy rights of the person designated by EPIC (Electronic Privacy Information Center) in some circumstances (https://epic.org). Unauthorized access to the information obtained with RFID can pose a threat. Some methods can be used to obtain unauthorized information, for example, specially designed unauthorized RFID readers, unauthorized special designed RFID tags, systems can be blocked with specially developed RFID devices, RFID viruses and systems can be transmitted to the other systems and signal mixing methods can be used for system crashing (Henrici and Müller, 2004; Thompson et al., 2006). With the expansion of RFID technology, many studies have been carried out for information security. Garfinkel (2002) stated that the rights of consumers should be protected in the use of RFID technology and prepared a declaration on rights. Many studies have been carried out and new methods have been developed to ensure RFID data security (Juels et al. , 2003; Ayoade, 2006; Solanas et al. ,2007; Hui et al. ,2005; Munilla and Peinado, 2007; Chien and Chen, 2007; Henrici ve Müller, 2004).

Besides miscellaneous applications of RFID, its usage in the airline industry has been observed since 2003. It started after the meeting with Boeing and FAA (Federal Aviation Administration) to identify the needs in order to develop the industry further. After several research attempts, it has been realized that it is worth to put effort into RFID application for the aviation industry. Consequently, many companies achieved success in their implementations, and they have decided to put further applications of RFID systems into effect. However, it can be argued that there is still much to develop to operate RFID systems globally in airline industries, and regulations need to be studied (IATA; Guidance on Introducing RFID; 2013).

Furthermore, aircraft maintenance companies use the RFID system to eliminate the inaccuracy problems of inventory recording delays resulting from misuse in aircraft parts repair and to provide savings (Ngai, Cheung, Lam, Ng, 2014). Some aircraft maintenance and manufacturers (i.e. B787 Dreamliner), are planning to put RFID label onto key parts of their maintenance. Boeing Company, for example, is giving big efforts to improve business processes, trying to get increased data and sensing (O'Connor, 2005). The RFID technology has been used to identify the presence of aircraft emergency equipment to reduce the control process and reduce aircraft turnaround time. The RFID system was installed in the airplane cabin, aiming to save time by reducing the pre-flight check of emergency equipment via automatic equipment inspection (Škultéty, Stalmašeková, 2018).

Koldkjær (2016) reveals that the RFID implementation provides high visible status and lower mishandled baggage in some airports such as Denmark Aalborg International Airport, Lisbon Airport, Las Vegas' McCarran Airport, Milano Malpensa Airport, and Hong Kong International Airport. It also improves cost savings and automatic baggage scanning which increases the efficiency of baggage handling.

One of the examples from the industry that Delta Airlines Company implements RFID for baggage tracking. It is the first U.S. airline that provides its customers with accurate real-time luggage tracking information during travel. With scanners, status data are captured from RFID chips in the baggage tags (https://news.delta.com/delta-introduces-innovative-baggage-tracking-process).

In the following chapters, (1) first, the case company will be introduced, (2) system methodology and the problem will be identified, and (3) how RFID technologies will be implemented to remedy the problem will be discussed.

CHAPTER 4

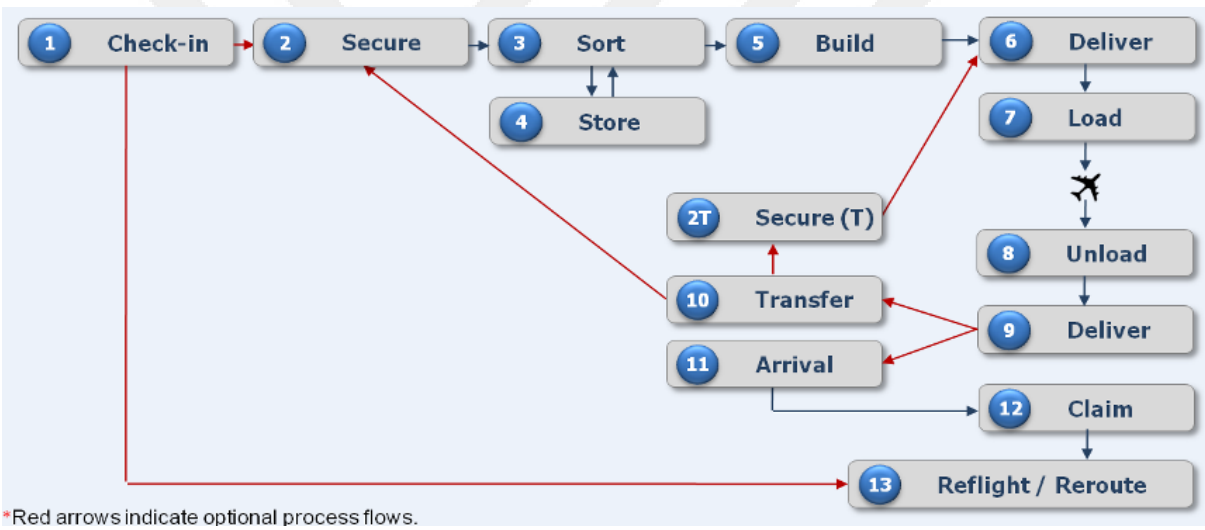
BAGGAGE OPERATION IN AVIATION INDUSTRY AND TURKISH AIRLINES

Air transportation has become one of the safest, most efficient and most comfortable ways of transportation due to the rapidly developing technological developments. Journeys to remote locations take place in a shorter period of time and provide both commercial and cultural advantages in terms of the interaction of cultures with each other. Due to its speed, comfort, and efficiency, travelers have preferred airway transportation. That is, the importance of air transportation has been increasing, and passenger transportation continues to grow steadily. Note that, in addition to the passengers, millions of baggage is also transported.

In the early days, aircraft were used for military and postal purposes. With the development of civil aviation, airports were established. By 1915, in the US and Europe, airports have been begun to open (Frey, 2014). The first airports were built according to the number of passengers carried due to the small size of the aircraft (Frey, 2014). With developing technology, aircraft types have grown and the number of passengers transported has increased. Initially, passengers were able to take their baggage to the plane, while baggage systems were needed due to growing planes and airports (Frey, 2014). In the course of time, the bag tag was created for each luggage. According to the destination which written on the bag tag, bag tags read by passengers were transported to the aircraft by hand. But these traditional methods were inadequate for developing modern aviation methods. Since the bringing of baggage from the airport to airplanes, from airplanes to airports again caused difficulties in big airports, automation systems were created including automatic baggage reading systems. This complex structure is expressed as a baggage handling system (Frey, 2014).

The baggage handling system is a system that generally transfers, sorts, delivers for outgoing passenger baggage to airside baggage areas in order to load into aircraft and transfer baggage from aircraft to baggage areas to deliver. As shown in Figure 5 the baggage handling system provides for conveying, screening and querying of arriving and departing baggage at the landside, terminal and airside of the airport. This system can also carry out incoming passenger baggage from the airplane and automatically direct the passenger to the baggage claim carousel.

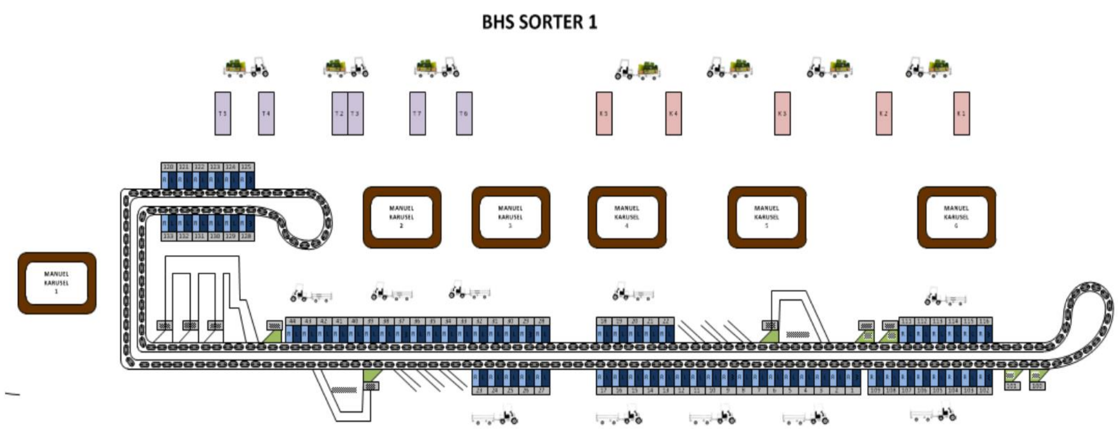
Figure 5 Baggage Flow Diagram



Source: IATA Handling Guidelines

In order to process baggage and take into the baggage handling system, each baggage needs to be recognized at the check-in stage. Airline companies are using bag tag, which is attached to the baggage. These bag tags contain a barcode. Bag tags indicate flight number, destination, flight date, and type of baggage. Those data sets are sent to a central database to be sent to the airline. After this stage, baggage moves to the sorting area to be loaded into the aircraft with the baggage handling system by conveyor belts. Conveyor belt in baggage sortation area is 13 kilometers long in Ataturk Airport. Baggage carried by the baggage transport system is sorted and conveyed to the allocated chutes for flight. Chutes are channels assigned to a single flight, baggage carts and containers are parked at in front of each chute channel to take baggage to aircraft. Baggage coming from different check-in counters conveys over a specific line until they reach their own chutes. A part of the baggage sortation system of Atatürk Airport is shown in Figure 6.

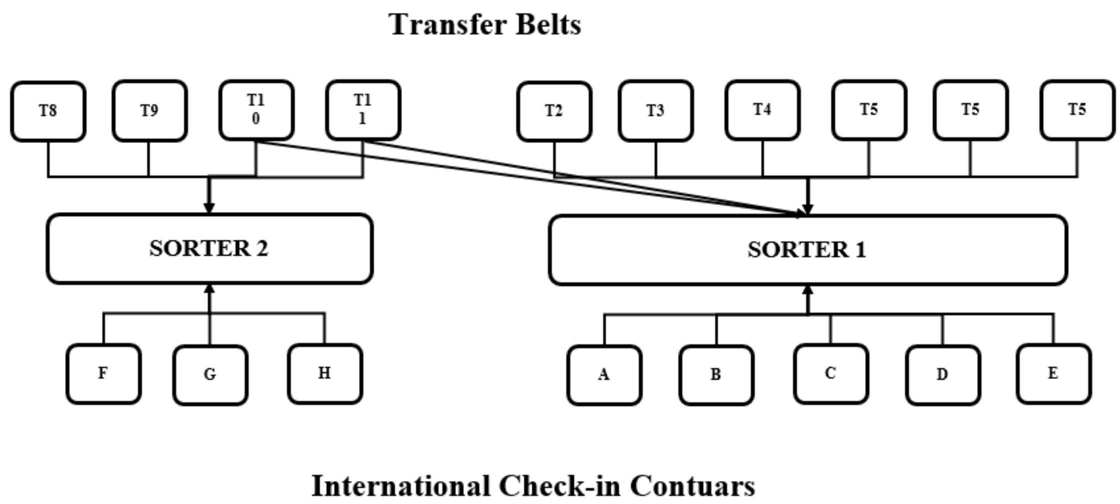
Figure 6 Atatürk Airport Part of the Sorting System



The baggage arriving in the baggage handling system area is guided to destination airplane by an automatic separation system and security control is provided through x-ray devices. From check-in to the chute is going through a security scan. A number of security levels from check-in to chute are controlled by passing through screen devices. Equipped with high tech machines that reduce error and insecurity weakness to zero, each baggage moves one by one towards chutes. According to flight information on bag tag, baggage reaches to the dedicated chute in the baggage handling system area.

At baggage handling system area baggage is loaded to baggage carts and containers. And vehicles pull those carts and containers by drivers who work in the baggage handling system area and deliver to the plane. Passenger and baggage are matched on system and baggage without passengers are not allowed to be loaded into aircraft by the system. Figure 7 shows the Ataturk Airport international baggage handling system area.

Figure 7 Atatürk Airport International Baggage Handling System Area



For incoming baggage, all processes are done in the opposite way of outgoing baggage. When airplanes arrive at the airport, baggage is unloaded, loaded to baggage carts then brought to the baggage handling system area. Baggage is put onto belts to deliver to passengers through the carousel. In the area of BHS, baggage is placed into a pre-determined carousel. With the help of belts, baggage arrives at the carousel on the arrival floor. Readers installed in the belts read barcodes from bag-tags and then send all baggage information to the system. Information for incoming baggage, the same way as outgoing baggage, barcodes are recorded in airline and airport systems.

If passengers have any problem with their baggage, they apply to the airlines' lost & found offices at the arrival area. At the lost & found offices, airlines staff creates a file for each person the World Tracer System. World Tracer System which offers airlines and ground handlers recording and tracing lost baggage is a global database. At present World, Tracer is used by more than 510 airlines and ground handlers at over 2 800 airports worldwide (https://www.sita.aero).

4.1 Turkish Airlines

The State Airlines Administration was founded on May 20, 1933, by Code no 2186 as the forefather of Turkish Airlines. Operating as a department of Turkey's Ministry of Defense, the administration later becomes part of The Ministry of Public works in 1935. The state airline administration takes on a new name in 1938, The State Airlines General Directorate, and comes under the auspices of The Ministry of Transport in 1939. The institution changes its name again in 1945 to The State Airlines Administration General Directorate. On May 21, 1955, it is decided that the company would become an incorporated company. As of March 1, 1956, the company starts serving as Turkish Airlines, Inc. (Turkish Airlines, 2019).

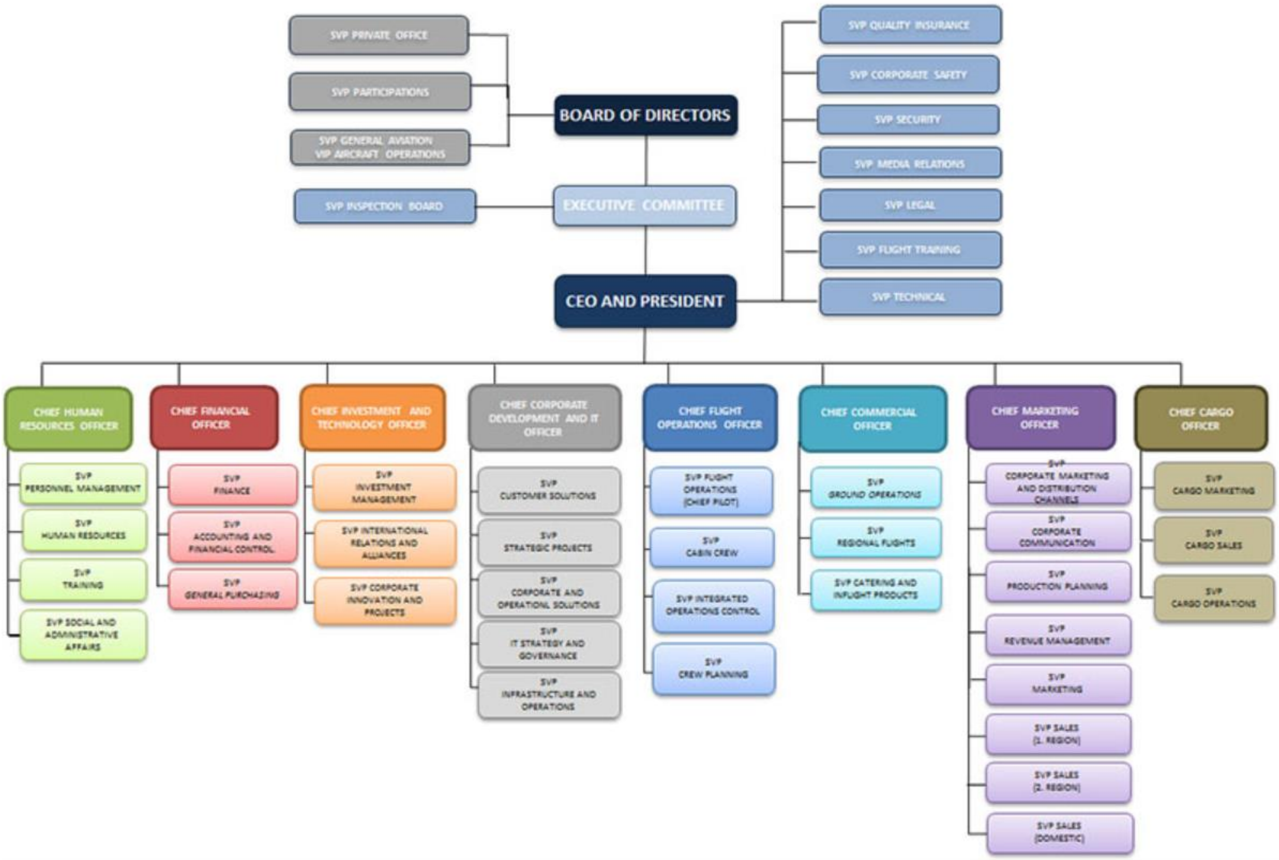
When the company was founded in 1933, it only had five aircraft. In 1936, the number of aircraft in the fleet was increased to eight, and seat capacity was increased to 64. Until 1945, the number of aircraft in the fleet went up to 52, and the seating capacity has risen to 845. With the increase of the fleet, destination number went from three up to 19 cities. Only in one year, the number of passengers has been dramatically changed from 18 000 to 37 000 from 1945 to 1946. In 1947, Turkish Airlines operated its first international flight as Ankara-Istanbul-Athens flight. In 1951, the fleet was consisting of 33 airplanes with 720 seats, and it began to fly to new destinations such as Nicosia, Beirut, and Cairo. In 1953, flight to Saudi Arabia was commenced in order to provide fast and comfortable transportation to citizens who wanted to perform the pilgrimage. In 1956, Turkish Airlines became a member of the IATA (International Air Transport Association), which was established to ensure cooperation among its members in terms of commercial, technical, business and economic fields and to prevent unfair competition. As of 1957, there were a total of 28 aircraft in the Turkish Airlines fleet, including 19 DC-3, in total seven-passenger aircraft and two cargo aircraft. At the same year, Turkish Airlines became a member of SITA (Telecommunications and Information Services). In 1958, five of Viscount 794 aircraft joined the fleet. A new era has been opened in the history of civil aviation by switching from piston engines to reactive motors. The number of passengers transported has doubled in 1956 and reached three hundred ninety-four thousand. In 1960, six F-27 aircraft joined the fleet. At the beginning of the journey, Turkish Airlines started with 24 staff and in 1973 became a giant family with a member of 4,437. In 1967, the number of passengers was 528 000, while in 1973 it reached 2.5 million. In

1974, three McDonnell Douglas DC-10s with double corridors and 345 seat capacity were added to the fleet and Turkish Airlines became the first airline in Europe to purchase this aircraft. In 1982, Turkish Airlines became an international airline with 27 aircraft, 3 000 909 seats, and 5 000 735 employees. In 1985, four Airbus A310s were added to the fleet, and far east and transatlantic flights have begun. By the end of 1993, Turkish Airlines increased its total destinations to 78, including 55 international and 23 domestic flights. In 2004, the number of carried passengers went beyond 12 million. In 2006, the 100th aircraft joined the fleet. In 2008, Turkish Airlines joined Star Alliance, which is a global airline company alliance. In 2012, the 200th aircraft joined the fleet. In the same year, by signing an agreement with IATA (International Air Transport Association) within the framework of regional education partnership, also the company achieved to be the first in Turkey and IATA approved its training center. Turkish Airlines started its journey with 5 aircraft in 1933 and today its fleet is consisting of 337 (passenger and cargo) aircraft. (https://www.turkishairlines.com).

The substantial growth it has achieved has put Turkish Airlines among the top airlines of the world. Reinforcing this prominent position and energy with its significant growth figures and innovative approach, Turkish Airlines has always put its signature under important successes in the sector. One of them is undoubtedly the largest aircraft order in Turkish Civil Aviation history, with a significant decision that the airline took in 2013. With this decision, the national carrier aimed to maintain the fleet average age over the coming years and push its quality of service. Counting the large scale of orders, and the aircraft whose rental period is due to come to end by the end of 2023, the fleet of the carrier including cargo aircraft expected to reach 500 aircraft (https://www.turkishairlines.com).

By innovations, Turkish Airlines service quality has been developed in order to increase passenger satisfaction to the highest level with trained and dedicated employees of Turkish Airlines. Family members who work with their passion in every step of the journey, play an important role in raising the global awareness of the brand with nearly thirty business areas within the partnership. The company organizational structure can be seen in Figure 8 (www.turkishairlines.com).

Figure 8 Turkish Airlines Organizational Chart



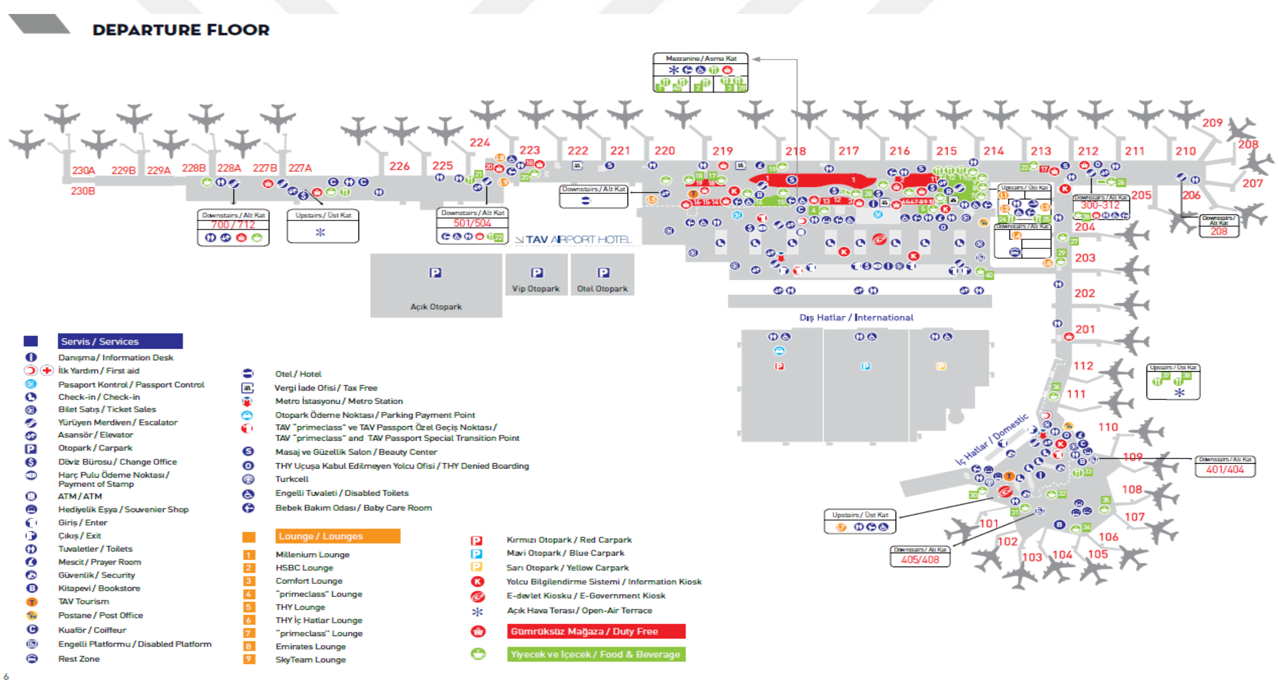
Source: www.turkishairlines.com

Turkish Airlines, which has opened its doors to its passengers, provides a flight to 300 destinations around the world which is the largest network in the world. The flag carrier that organizes flights to 120 countries totally is the first in the world ranking with this feature. Carrying 61.2 million passengers in 2015, Turkish Airlines carried 62.8 million passengers in 2016, 68.6 million in 2017 and 75.2 million in 2018 (www.turkishairlines.com).

Ataturk Airport (IATA: IST ICAO: LTBI)), formerly Yeşilköy Airport, the first time in Turkey in 1912 is where the initiation of civil air transport. In 1953, it was opened to international air traffic. In 1985, the name of modern Turkey's founder Ataturk name was given and changed to Ataturk Airport. The international airport, which was decided to be built in the Chicago

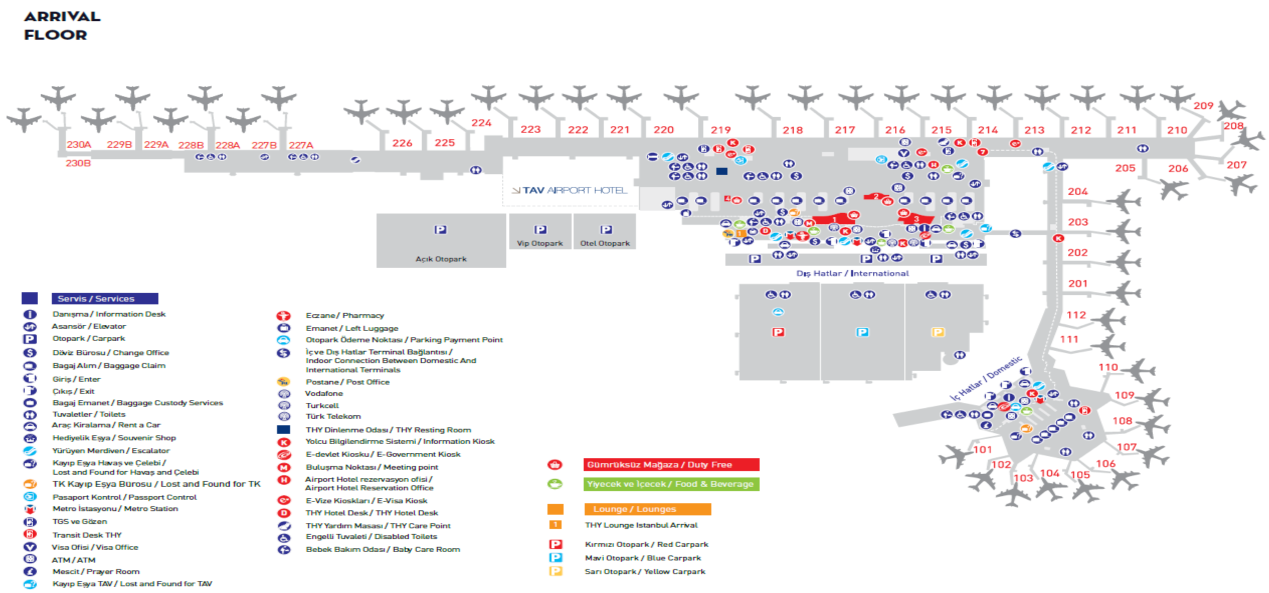
Convention, was completed in Yeşilköy, Istanbul and opened to international air traffic. The airport had a high standard runway, a modern passenger terminal, maintenance hangars, and electronic radio equipment. As shown in Figure 9 and Figure 10, the airport which was built in accordance with international standards has begun to bring thousands of points together. Ataturk Airport is the hub of Turkish Airlines and transfers the point of transfer passengers (http://www.ataturkairport.com).

Figure 9 Atatürk Airport Departure Floor



Source: http://www.tavhavalimanlari.com

Figure 10 Atatürk Airport Arrival Floor



Source: http://www.tavhavalimanlari.com

4.2 Miles & Smiles

Miles & Smiles is a loyalty program of Turkish Airlines. This project was launched in 2000. Miles & Smiles has been created to give its members a unique travel experience. It offers many benefits and privileges such as buying miles, transferring miles, activating miles that are out of date, and paying your ticket taxes in miles, depending on the membership status. It offers the possibility to participate in the world of Miles & Smiles, which can apply for membership with many channels and no charge. (https://www.turkishairlines.com).

Miles & Smiles membership is open to all passengers in any country where private passenger programs are free by law and Miles & Smiles is available; they may become members of the program if they comply with the rules on their personal status. Membership is not open to legal entities or other groups or associations. Miles & Smiles membership begins with the first activity of the person who wants to become a member, by completing the membership form and accepting general terms and conditions or using his / her temporary card. It was forbidden for more than one person to make a joint application or to make more than one application. Turkish Airlines is the only authorized body in the administration of personal Miles & Smiles accounts, calculation of the Miles and Smiles accounts, preparation and awarding of prize information, and Turkish Airlines records on performance evaluation in the program (https://www.turkishairlines.com).

If you are a Miles & Smiles membership, you can earn miles from the flights you have with Turkish Airlines and Star Alliance member airlines. With the miles you earn on the Miles & Smiles program, you can take advantage of a range of benefits, depending on your membership status. Miles & Smiles membership status cards are shown in Figure 11. In addition, you can earn miles from your credit card purchases at Shop & Miles, the most privileged store in the sky and more than a hundred program partners in different sectors, from accommodation to car rental, health to education and insurance. If you are a member of Miles & Smiles credit card, you can earn miles in all the shopping (https://www.turkishairlines.com).

Figure 11 Turkish Airlines Miles & Smiles Cards

Source: www.turkishairlines.com

4.3 Turkish Airlines Baggage Services Management

The Electronic Data Processing Center at Atatürk Airport was put into operation in 1985 and all bookings and lost baggage transactions were started to carry out electronically. In 1989, the Baggage Handling System was started to be used in order to provide fast baggage services. On 30 May 2012, Turkish Airlines has established the Baggage Services Management Department to monitor the baggage operation and to manage baggage problems (Turkish Airlines, 2019).

Turkish Airlines Baggage Services Management Department ‘s activities are control of the baggage reconciliation/delivery to passengers operation process to ensure that the passengers can travel together with their baggage, the systematic/operational development, planning and improvement activities, effective resolution of the customer complaints about baggage irregularities (loss & found items, damage, missing properties, late delivery), conducting of the necessary search, calculation of the compensations, and payments(Turkish Airlines, 2019).

Turkish Airlines Baggage Services Management provides solutions to the system for operational problems by monitoring the matching operations for identification, labeling, dispatching and travel of the passenger's baggage during the operation of baggage services. In order to ensure passengers to travel with their baggage in the Istanbul station, the staff is able to take an operational decision or make sure to be taken by the handling company. Within the scope of baggage services, baggage activities of stations and suppliers outside of Istanbul station are being checked and measures are taken to prevent possible problems pro-actively. Managing to reduce disruptions in baggage operation across the network of Turkish Airlines. Continuously controlling operations, analyze operational data, prepare and publish necessary procedures and to ensure that necessary measures are taken. Passengers complaints and requests which are relating to baggage problems in Turkish Airlines come from several channels, which are examined and forward to related departments. All complaints and requests are evaluated and analyzed with related departments, airlines, and suppliers (Turkish Airlines, 2019).

Baggage Services Management Department consist of four departments:

1. Baggage Services Passenger - Relations Management Department: It manages the complaints process to ensure passenger satisfaction and creates customer feedback processes.
2. Baggage Services - Tracing Department: Lost baggage research and delivery processes are done. It manages lost baggage warehouses.
3. Baggage Services - Claim Department: Evaluates the demands of passengers and makes payment transactions within the framework of civil aviation rules.
4. Baggage Operation - Management Department: Managing the operational process of baggage services, providing support to ground handlers, provides administrative control and coordination.

Turkish Airlines Baggage Services, Management Department uses an in-house developed SW application which is called Bag Star to handled baggage irregularities. BagStar is connected to the World Tracer system to take and check passengers' data. All departments' staff use BagStar applications to connected passengers and solve their problems.

4.3.1 Instruction on Baggage Services Warehouse Management

The warehouses where lost baggage is kept are under Baggage Services Tracing Department. This department is responsible for tracing to find lost baggage. All baggage sent to Istanbul from other station passes through the registration, research, dispatch and delivery processes.

During the initial application of the passenger for lost baggage, the stations issue a form for Customs Declaration to declare that the lost baggage does not accommodate any item subject to customs, and to deputize Turkish Airlines authorized the person to examine and deliver the baggage when it arrives at the station later. After the passenger has signed it, the authorization form is retained. The passengers are given the initial necessity bags for their urgent needs by the authorized personnel of the station. In cases where the initial necessity bag does not cover the request of passengers, a payment is made for emergencies, and the Pre-Payment Form is prepared. A file is created in the World Tracer System (interline baggage regulation information provider) by the relevant stations for the passengers whose baggage has not arrived at the destination station. If the baggage problem could not be resolved within five calendar days, the file is lead to the Baggage Services Management Department by the mentioned stations (Turkish Airlines, 2019).

The lost baggage files the necessary investigation documents of which have been completed are investigated and resolved by the Baggage Services, Management Department within 21 business days at the latest. As a result of the research, the compensation is paid to the passenger whose baggage cannot be found according to upper and lower limits determined by Warsaw and Montreal Contract. By checking the payment documents that payment has been made, if there is a defect from the supplier or another airline, proration and recourse are performed. And then, the file is closed and sent to the archive (Turkish Airlines, 2019).

The Istanbul station is the central station and is a place where all lost baggage of the network is stored. In Istanbul Station, registration, search, dispatch and delivery processes of the remained unaccompanied baggage and some baggage processes from other stations are carried out.

All information and details related to baggage are investigated from the opened file in the World Tracer System and register to the Store Tracking Program of the company by a staff of Baggage Services Management Department. All lost baggage that is received with customs (international) and non-custom (domestic) flights to Istanbul Station is sealed for custom clearance in order to transfer to warehouses. The lost baggage which is stored in international lost baggage warehouses is delivered to Atatürk Airport Customs Directorate as attached to a cover letter periodically. The unclaimed baggage, the owners of which could not be found as a result of the search, are kept in domestic warehouses and are sold pursuant periodically in accordance. The amount for this transaction is put into the Company Trust Account (Turkish Airlines, 2019).

The untagged baggage remaining on the baggage claim conveyor belt in the arrival lounge is first subjected to physical check. In this checking process, if it is detected from the tag piece remaining on the baggage that the owner of the baggage is a transit passenger, the original tag of the passenger is produced and attached again. And then, this baggage is sent to relevant flight. If there are no tags, the file is opened on World Tracer System and the record is created on Store Tracing Application.

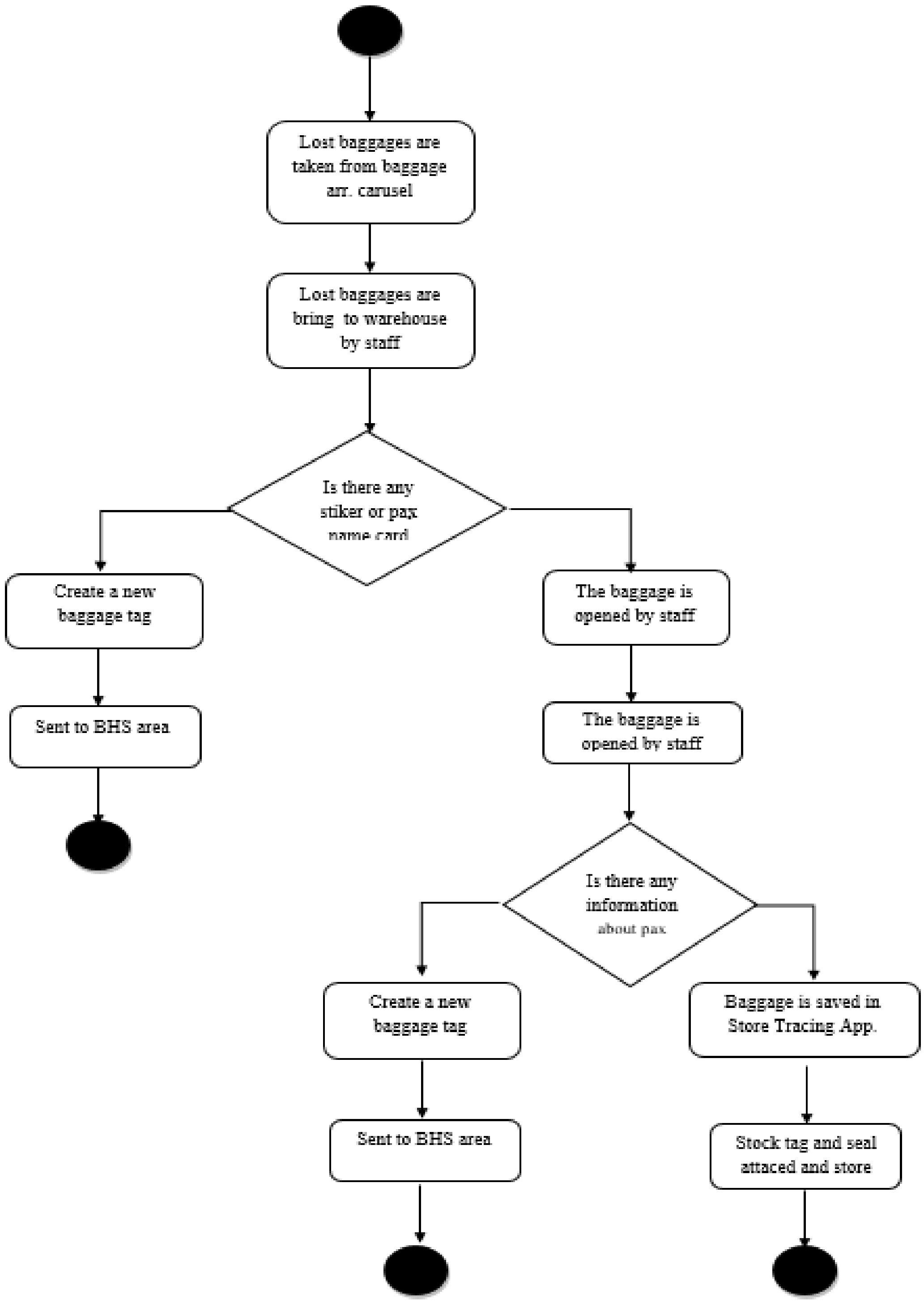
Dutiable baggage (containing a number of electronic devices, alcoholic beverages, cigarettes, etc.) is delivered to Ataturk Airport Customs Directorate with a form for Delivery of Baggage/Items to Customs/Safety Departments or kept in warehouses upon the request of Ataturk Airport Customs Directorate. If the baggage is delivered to passengers or requested by a passenger, the necessary transaction is performed upon informing Ataturk Airport Customs Directorate (Turkish Airlines, 2019).

The baggage concerning the police departments (hazardous materials, narcotics, etc.) is delivered to Ataturk Airport Directorate of Anti-Narcotic Crimes/Border Gates Department with a form for Delivery of Baggage/Items to Customs/Safety Departments or kept in warehouses upon the request of Border Gates Department. The baggage is delivered or forwarded after notifying Border Gates Department (Turkish Airlines, 2019).

When the owner of any of lost baggage contact detail is found, Baggage Service Management Department is contacted immediately to deliver baggage. The passenger is informed about the delivery, and the cargo firm that will deliver the baggage prepares the invoice. Besides, the necessary shipment information for relevant baggage is recorded in Store Tracing Program as well. Then, the relevant baggage is sealed and delivered to the logistics company together with their documents. If there is any baggage to be delivered to address remaining in the warehouse, their status is checked and the necessary shipment and storage transactions are carried out.

The process flow chart including registration and retention of lost baggage arrivals is indicated in Figure 12.

Figure 12 Lost Baggage Registration Process



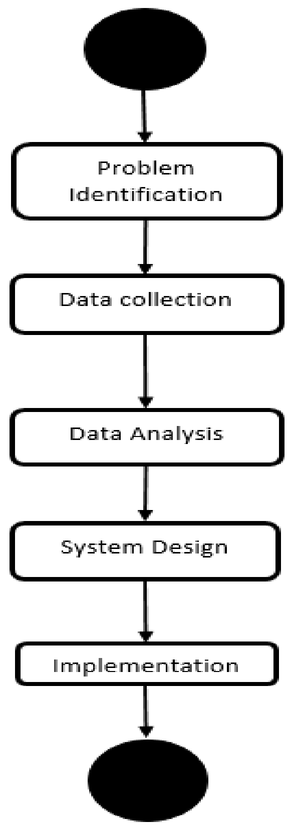
CHAPTER 5

SYSTEM METHODOLOGY

In order to streamline the existing systems and to provide a solution to operational problems, system methodology is necessary. Complicated systems have new challenges due to their intrinsic structures. System methodologies must have all the elements, which affect them in order to identify methods to have the solution for problems (Adams K., Mun J., 2005).

In this study, system methodology consists of system development phases and the methods to be used in these phases. System development phases are shown in Figure 13, in each state of which different methods are used. In this section, theoretical information about system development stages and methods will be given.

Figure 13 Stages in System Development

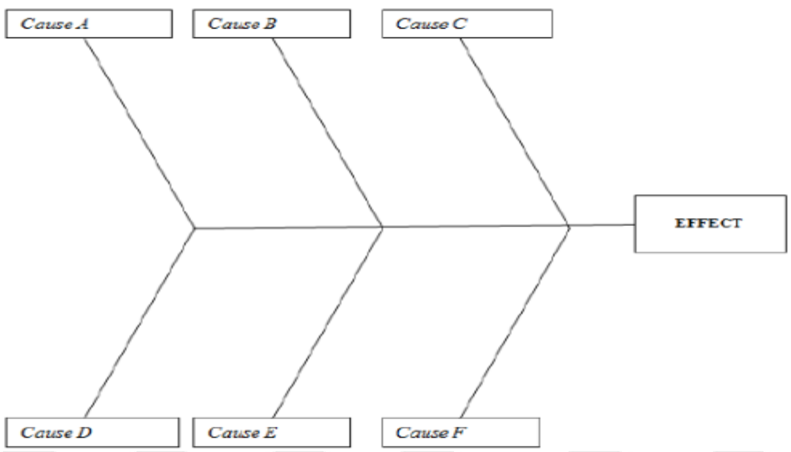


5.1 Problem Identification

Problem identification concept is important for having a wide range of interventions and creating different options. All actions are conducted in subsequent order within a framework, intended to identify the problems. At the beginning of problem identification, the first step should be clearly developed, and specify goals and objectives. And whole processes of the problem identification should be directly linked with these goals and objectives. The effect of the problem for reaching the goals should be clearly stated in the identification part (Dennis, A., Wixom, B. H., Roth, R. M., 2008).

The fishbone diagram (also called Ishikawa diagrams or cause-and-effect diagrams) is used to clearly identify all possible causes of a problem and the relationship between them. It is a technique that is created after the problem is determined and allows users to develop a general perspective for cases (Coccia, 2017). A typical fishbone diagram is shown in Figure 14.

Figure 14 Fishbone Diagram



Source: (Coccia, 2017).

5.2 Data Collection

Data collection can be explained as a process of collecting and measuring information from different areas. The data collection tools for research are common to entire study with all aspects. Methods and the approach in data collection may show difference based on discipline, the highlights on enabling precise and true collection remains the same. The author may discuss and evaluate the hypothesis and opinions based upon collected data. Most of the time, data collection is the first and most important phase of a research process (Dennis, A., Wixom, B. H., Roth, R. M., 2008).

5.3 Data Analysis

Data analysis is about the analysis of collected data based on the study objectives and goals. An analysis is highly important to lead for further studies and developments. Data Analysis consists of processes that are collecting, modeling data, transforming and in the purpose of reaching targeted goals and objectives. The results of data analysis lead to having suggested and supports the conclusion and decision-making processes. Before the analysis of data, there need to be cleaning, organizing and processing (Dennis, A., Wixom, B. H., Roth, R. M., 2008).

Research methods are classified into two groups as quantitative and qualitative methods. Quantitative research uses numerical data to describe relationships between events. Qualitative research, on the other hand, uses interview outputs as data to describe human behavior or experiences. Quantitative research that is a numerical research mechanism is derived from a number and often involves the collection of numbers that can be evaluated by statistical analysis (http://www.cles.org.uk). The key features of quantitative and qualitative methods are shown in Figure 15.

Figure 15 Key Features of Quantitative and Qualitative Methods

	Quantitative	**Qualitative**
Aim	The aim is to count things in an attempt to explain what is observed.	The aim is a complete, detailed description of what is observed.
Purpose	Generalizability, prediction, causal, explanations	Contextualization, interpretation, understanding perspectives
Tools	Researcher uses tools, such as survey, to collect numerical data.	Researcher is the data gathering instrument.
Data collection	Structured	Unstructured
Output	Data is in the form of numbers and statistics.	Data is in the form of words, pictures or objects.

Sample	Usually a large number of cases representing the population of interest. Randomly selected respondents.	Usually a small number of non-representative cases. Respondents selected on their experience.
Objective/ Subjective	Objective-seeks precise measurement & analysis	Subjective-individuals' interpretation of events is important
Researcher role	Researcher tends to remain objectively separated from the subject matter.	Researcher tends to become subjectively immersed in the subject matter.
Analysis	Statistical	Interpretive

Source: http://www.cles.org.uk.

5.4 System Design

Understanding requirements is a crucial point of the design phase and it states the system elements, security issues, and components, type of data, various interfaces, modules, and structure. The general structure of the design is developed to show how the system works and its all functions with technical requirements and components. In system design, there are stages which include the design of an application, databases, network, and interfaces. After completion of analyses steps then designing stages begins which builds the structure (Dennis, A., Wixom, B. H., Roth, R. M., 2008).

Unified Modeling Language (UML) of software and information systems is a standard language that allows showing the structure of the project (Dykman, 1998). By the development of software technology, the structure of projects became more complex. The coding for developing software is very complicated and organize becomes more difficult. Therefore, a standard language of modeling and analysis is needed. In order to simplify the phases of structure, unified modeling language is used. Hardware and software are intertwined in a period when large network systems are increasing.

The Unified Modeling Language is divided into several views by Booch et al. (1999) because there is no specific line between the concept and the structure in the unified modeling language. The view is designated as a subset of unified modeling language diagram structures. One or two types of diagrams provide a representation of the concept in each view (Booch et al. 1999). Booch et. al (1999) divided into views three categories: structural classification, dynamic behavior, and model management. As shown in Figure 16, structural classification defines the components of the system and their relationships; dynamic behavior defines the behavior of a system over time, and model management refers to the organization of models in units (Booch et al. 1999).

Figure 16 UML Views and Diagrams

Major Area	View	Diagram	Main Concepts
Structual	Static view	Class diagram	Class, association, generalization, dependency, realization, interface
	Use case view	Use case diagram	Use case, actor, association, extend, include, use case generalization
	Implementation view	Component diagram	Component, interface, dependency, realization
	Deployment view	Deployment diagram	Node, component, dependency, location
Dynamic	State machine view	State chart diagram	State, event, transition, action
	Activity view	Activity diagram	State, activity, completion, transition, fork, join

	Interaction view	Sequence diagram	Interaction, object, message, activation
		Collaboration diagram	Collaboration, interaction, collaboration role, message
Model management	Model management view	Class diagram	Package, subsystem, model
Extensibility	All	all	Constraint, stereotype, tags values

Source: (Booch et al., 1999).

Unified modeling language (UML) consists of 9 different types of diagrams to display the software system from different angles (Booch et al. 1999).

- Class Diagram: Used to classify groups of software with a number of similar features and verbs.
- Object Diagram: An object is an instance of the class. In such diagrams, real objects are used instead of class.
- Statechart Diagram: Diagrams that show the state of real objects in any given time.
- Sequence Diagram: Class and Object diagrams model static information. Sequence diagrams are used to indicate such changing states.
- Activity Diagram: Show the execution behavior of a system. The state of an object may change over time by users or by internal functions of an object.
- Use Case Diagram: The behavior of software is examined by a user-based.
- Collaboration Diagram: In order for a system to achieve its purpose, all parts of the system must perform their work. These works are usually possible with a few parts working together. Collaboration diagrams show relationships.
- Component Diagram: Particularly in projects carried out by multiple developers, it is easier to separate the system into component parts.

- Deployment Diagram: A physical examination of a system is made with diagrams. For example, connections between computers, equipment, and all tools in the system are shown in the deployment diagram.

  In this study, an activity diagram is used to show the structure of the new system.

5.5 Implementation

This phase combines all the components and implements it to reach the objectives of the project. During implementation stage, there may be test processes running in order to check the availability of the system. And results of tests lead to see errors and correct points. According to results, tests are planned that includes test-related tasks such as test case generation, resource allocation for testing, testing criteria. It is the integration of systems within a framework, comes after understanding of complete system needs, functions and features. This stage is the final step to go alive for the project. Having successful test results take the project to run phases (Dennis, A., Wixom, B. H., Roth, R. M., 2008).

CHAPTER 6

THE APPLICATION OF RFID TECHNOLOGY IN AN AIRLINE COMPANY

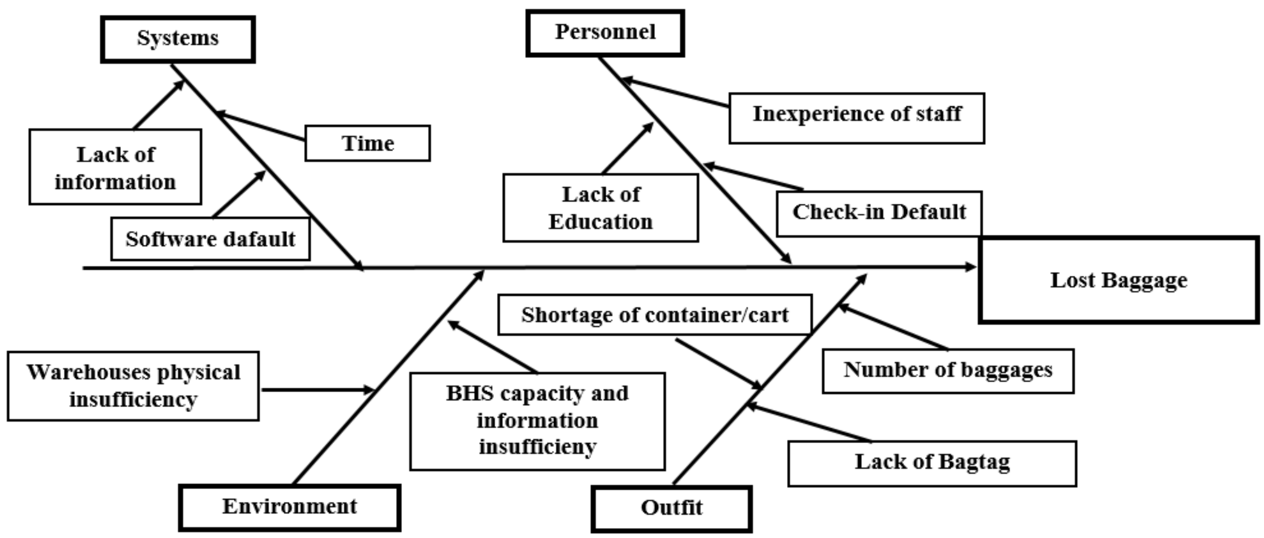
In this section, Turkish Airlines baggage problems are handled by using the system methodology described in Chapter 5. Detailed information with respect to the lost baggage problems, project assumptions, objectives, requirements, scopes and system models will be given about the new system developed for the solution of the problems. The RFID system, which is developed by adopting company data sets and workflow in order to solve Turkish Airlines, lost baggage problem, will also be explained using various diagrams and figures.

In the scope of the project, the fishbone diagram is used to depict the Turkish Airlines baggage problems. That is, the root causes of the company's baggage problems are identified. Using the quantitative research method, company data are collected, and current situation analysis is done. The system requirements are determined to design the framework. Then, the implementation stage is completed using a Unified Modeling Language (UML) diagram. Lastly, the hardware and software tests are carried out, and the project is taken alive.

6.1 Turkish Airlines Lost Baggage Problems

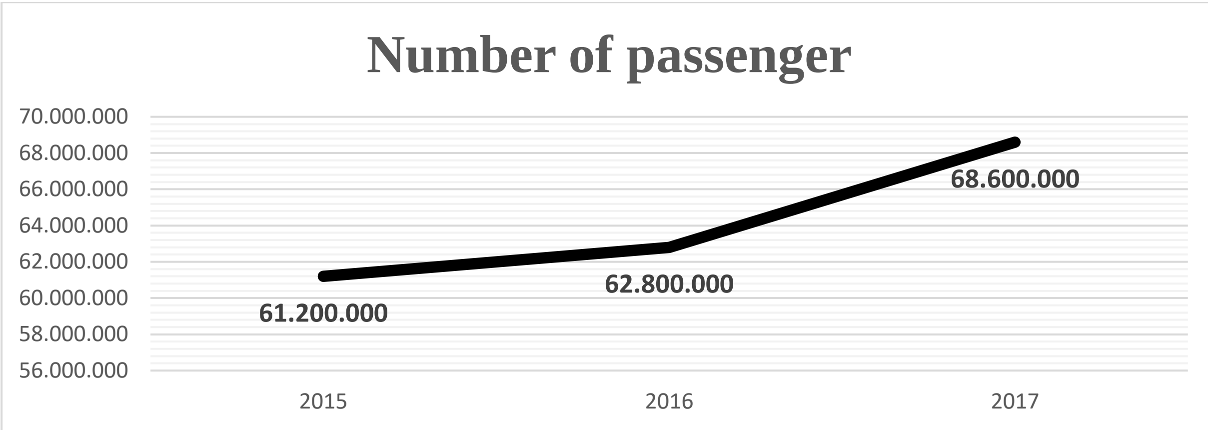
Many reasons can cause baggage problems at an airline company. For airline companies, the volume of the lost and damaged baggage has been causing a huge increase in cost, which results in major customer dissatisfaction. The complexity of the journey increases baggage losses. There are many causes of lost baggage: there are problems due to IT systems in part. Further, there may be problems due to several reasons. Note that the main reason why baggage owner cannot be detected is that they do not have correct passengers information. As it is shown in Figure 17, the lack of such information occurs due to several reasons.

Figure 17 Causes of Lost Baggage



As can be seen from Figure 18, the number of passengers indicates a dramatic increase, which is around 12 % between 2015 and 2017. With the higher number of passengers, the number of different destinations and the volume of baggage handling have also risen, which have also caused an increase in errors in baggage handling.

Figure 18 Turkish Airlines Number of Passengers



Source: www.turkishairlines.com

Note that Istanbul is the hub of the company and needs large areas for storage of the lost baggage. At Atatürk Airport, there are six different warehouse areas of approximately one thousand square meters. Warehouses are located in several independent places, three of which are at the international terminal and the rest are at the domestic terminal. Figure 19 shows the locations of warehouses in the international terminal.

Figure 19 Turkish Airlines Lost Baggage Warehouses

Table 3 demonstrates the number of baggage entered into the warehouses and stored there over the years due to the lack of information about the owners. The increase in the number of baggage entering the warehouses has also led to a lack of storage capacity over the years. Accordingly, due to insufficient capacity, new storage areas have been needed. Renting a new warehouse causes additional costs for the company. Also, the cost of new staff that will work in the warehouse and the equipment that should be in the warehouse are included as an addition to the rental cost.

Table 3 Number of Mishandled Baggage in Warehouses

Years	**Number of Baggage Arrivals to Warehouses**	**Number of Baggage owners not found**	**Number of Baggage owner found**
2015	32 049	12 965	19 084
2016	39 198	10 307	28 891
2017	72 259	12 183	60 076

Source: Turkish Airlines Store Tracing Application

A file is created for each complaint from passengers. As shown in Table 4, only lost baggage complaints are examined. In 2017, there was a 19% increase in the number of files opened compared to the previous year.

Table 4 Number of Lost Baggage Files

Years	Number of Open Files	Number of Close Files	Ratio
2015	10 002	9 258	%82
2016	43 594	42 966	%98.6
2017	51 930	51 166	%98.5

Source: Turkish Airlines BagStar Application

Note that due to the lost baggage, compensation payments have been made to the passengers. Higher number of lost baggage has also increased the amount of payment to the passengers. The average cost of lost baggage to the company is 800 US Dollars. That is to say, accurately identifying the owners of each lost baggage decreases the total cost for the company. Table 5 indicates that payments for lost baggage have decreased in 2015 compared to 2017. Despite the increasing number of passengers, the company wants to reduce these costs further.

Table 5 Lost Baggage Amount of Compensation ($)

Years	Number of Lost Paid Files	Amount of compensation ($)
2015	9 681	2 917 281
2016	43 618	2 740 130
2017	51 271	2 040 372

Source: Turkish Airlines BagStar Application

In the Baggage services tracing department, approximately 60 staff are employed. 7/24 shifting is applied in the warehouses and approximately 11 personnel take part in each shift. At the same time, approximately 16 staff in the Baggage Services Tracing Department officials are trying to find lost baggage during 8: 00-17: 00 working hours. An increased number of lost baggage causes more staff needs, which increases the cost of salary, food, and insurance.

Therefore, the company executives have decided that a new system should be developed in 2018 to further reduce the cost of the lost baggage. They also decided that RFID technology might be a good alternative to achieve that reduction.

6.2 Objectives of the Project

With this project, the company's identified lost baggage problems are aimed to be solved. The objectives of the project are listed below:

- To reduce the total payment made to the passengers due to the lost baggage compensation,
- To decrease the number of lost baggage at warehouses,
- To reduce the time spending on searching baggage and finding their owners,
- To reduce labor cost for searching baggage owners,
- To reduce the warehouse requirements for lost baggage handling,
- To increase the level of customer satisfaction,
- To expedite the delivery of lost baggage addressed to its owners,

6.3 The scope of the Project

In this subsection, the general structure of the system, hardware, and software relationship will be mentioned. In general, the scope of the system is as follows.

In order to identify the owner of lost baggage, the company needs to get the passenger contact information by using RFID baggage cards. When a cardholder's baggage encounters an irregularity and enters to lost baggage warehouses, the system can detect the RFID Baggage Card inside of baggage via RFID antennas. Thus, it can quickly identify the owner of baggage without having to go through long investigations.

In order to have Passenger – RFID Baggage Card matching, passengers need to register card number to the RFID Baggage Card Number field in Miles & Smiles account. RFID Baggage Card ID - passenger matched information is kept in Miles & Smiles systems. This paired information is sent to the RFID Baggage Recording System via web service.

When RFID reader detects baggage with an RFID card, it will send information to the Store Tracing System and RFID Baggage Recording System. There is a records pool, which the records detected in the RFID Baggage Recording System is displayed. Name, date, location, baggage card number, passenger name and surname, Miles & Smiles membership number, phone number, email and address information can be displayed in the system.

In the locations where no RFID readers are present, mobile readers detect RFID Baggage Card, and RFID information is sent Store Tracing System and RFID Baggage Recording System. If mobile readers are not connected to the Turkish Airlines network, detected RFID information is displayed and kept in a mobile application. When the mobile device is connected to the Turkish Airlines network, pre-stored RFID information is automatically sent to the RFID Baggage Recording System.

6.4 Assumptions

In order for this system to properly run, a series of assumptions must be made. These assumptions will contribute to increasing the accuracy and effectiveness of the system.

Basic assumptions of the proposed system application are stated as follows:

- The entrance of the lost baggage into the warehouses is done through a single door.
- RFID Baggage Cards must not be covered by metal because RFID cards cannot be detected by the readers.
- RFID Baggage Cards are used by the passenger who has sent/received.
- The passenger information in Miles & Smiles database is updated.

6.5 Requirements

All requirements have been determined to ensure the full functionality of the system. They are listed as follows:

6.5.1 Hardware Requirements

- Two antennas to be installed for each warehouse.
- A fixed reader to be installed in each entry of the warehouse.
- Three mobile readers that are linked with antennas, to be supplied for the detection of baggage in the warehouse.
- Devices to be used in the project should not be affected by radio frequency emitting devices such as mobile phones and cordless telephones.

- The reading distance of the antennas shall have circular polarization.
- The frequency and output power of the antennas will be in the UHF range and output power allowed by the international authorities.
- The operating conditions of the antennas and the reader must be between -20 ° C and + 50 ° C.
- The reader should be able to connect to the computer via Ethernet or serial port and all configurations and data transfers can be made via these ports.
- The reader must have anti-collision capability.
- The reader should be able to work in singular query and plural query modes.
- The system needs to be able to work with one and two antennas. When working with two antennas, the reader device must continue to read the cards even if one of the antennas is broken.
- Ports must be supporting circular antennas.
- Light and sound alert should be given by the reader when it detects an RFID card.
- RFID tags should be able to be recognized by the warning lights on which antenna port is detected.
- There must be an operating system embedded in the RFID reader. The control interface on the operating system must be able to be connected via the web.
- In case of a problem in energy or network infrastructure, 6 000 tags should be kept in reader memory.
- RFID cards must have a passive UHF RFID chip to be detected by UHF readers.
- The information in the RFID Baggage Card must be secured with encryption systems.
- The RFID Baggage Card should be read less than a second.
- The RFID Baggage Card must be made of PVC material.

6.5.2 Software Requirements

- Passenger contact information and RFID Baggage Card numbers of the passenger must be paired and saved.
- Multiple card information can be added for the same passenger.
- A web service must be provided to match the passenger-RFID Baggage Card number by a system.
- If there is a record that was previously opened for a passenger, double-entry should not occur. Additional cards must be added to the same registration of passengers. Miles & Smiles membership numbers that are unique to passengers must be entered during registration to prevent double registration.
- The RFID Baggage Card number identified by mobile readers in the warehouse entrances and antennas which are located in a warehouse should be automatically listed together with the contact information of a passenger is paired with in the system and the location where the card is identified. The information should be shared via a web service and other systems instantly.
- Hardware devices and location matching can be made and changed. Hand terminal and location matching must be possible. The status of the devices can be monitored instantly. Defective devices should be able to be displayed. In case of failure of a device, the fault information should be sent by email. When baggage with an RFID Baggage Card is read in both online and offline modes of devices, passenger information contained in tag must be listed on the screen. The user should be able to enter details of the record.
- The application should be able to read all RFID Baggage Card which is inside the baggage within three meters.
- The system should be able to cache information contained in the RFID tags where the network is not available it reads while offline.
- When connected to the hand terminal network, it should be able to forward passenger and location information it holds in the cache to RFID Baggage Recording System.
- When a hand terminal is detected with RFID Baggage Card, an audible signal must be issued and the frequency of acoustic warning should increase gradually as baggage arrives.

- When the passenger contact or address information is changed, this information will be sent to the relevant system via a web service. The device should be able to make necessary updates on the RFID Baggage Card chip in the first reading of the card with an update. The device should be able to keep this information in its memory while it is offline.

6.6 System Model

In this section, first, the infrastructure and details of the system are described. Then, the system model is provided based on the hardware and software infrastructure. Finally, the operation of the system, all the flows, and hardware integration to the system are discussed.

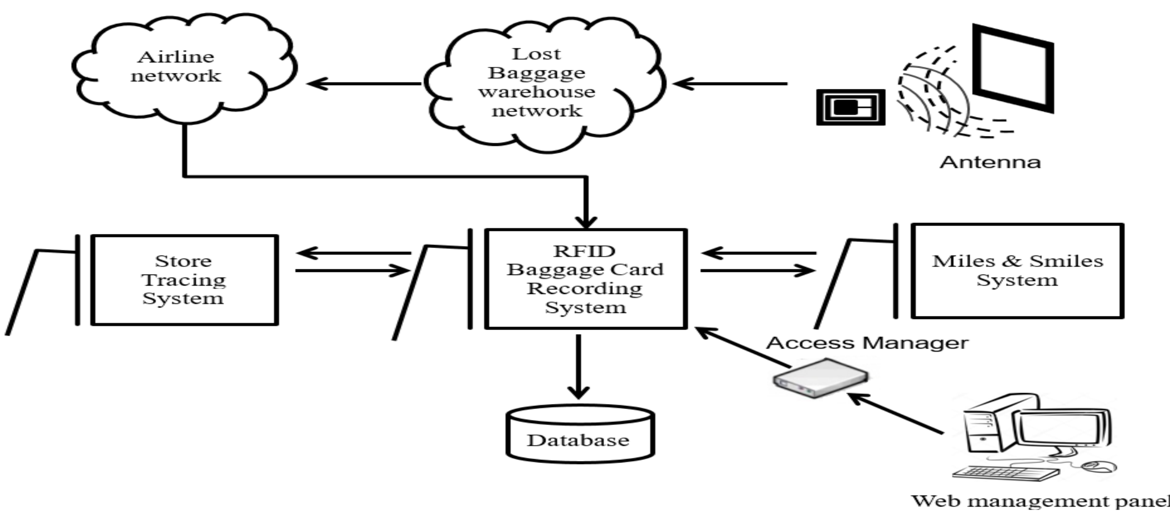
In-house company applications are required to reach and match data. In this project, integration between the three in-house company applications is used to run the system. While two of the three applications are used within the company, one new application has been created within the scope of this project. Three in-house systems, where the relationship between the systems will be described in detail later, are listed below.

- Miles & Smiles system: It is an in-house database where Miles & Smiles membership information is stored. The data stored this system is not shared with anybody except Turkish Airlines, and it is updated according to data recorded by the passenger.
- Turkish Airlines Store Tracing System: It is an in-house application where the information of each lost baggage that has entered the lost baggage warehouse is recorded. The system is used by the Turkish Airlines Baggage Services Management Department to identify, record and investigate of lost baggage. All details of lost baggage are recorded in this system. The staff working in the lost baggage warehouse can display the information of the lost baggage via this system.
- RFID Baggage Recording System: The system where each card number generated by the RFID baggage card manufacturer is defined and match to the Miles& Smiles membership information. This system is newly created as part of the RFID baggage card project. RFID

baggage card information is recorded to this system by certain staff who is working in the Turkish Airlines Baggage Service Management Department. The system enables matching RFID baggage card numbers with Miles & Smiles membership information and used for inter-system data flow.

Information about passengers should be linked to each system. Hardware needs to collect data and show the output of the system. As shown in Figure 20, a flow of data between databases is sometimes both in one direction and two directions.

Figure 20 General Architecture of System



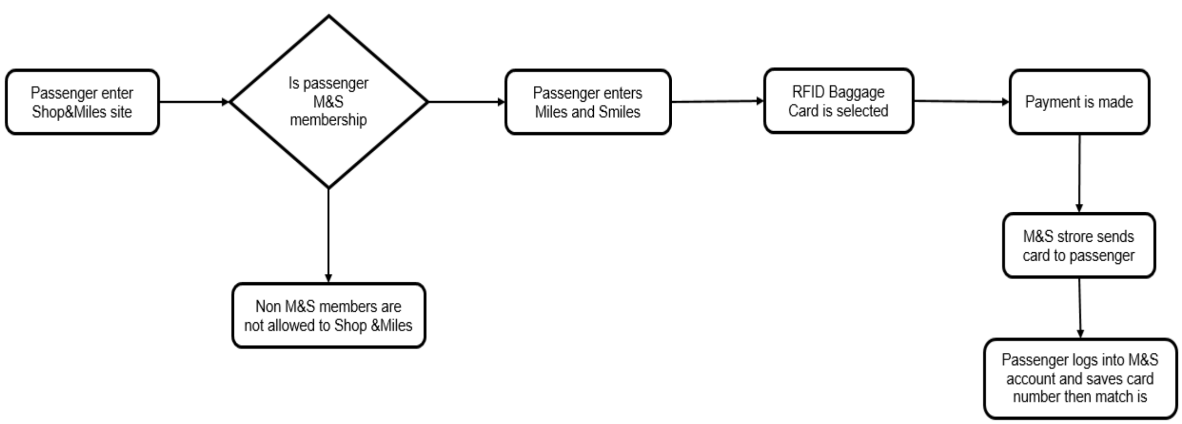
In the proposed system, data flow between applications must be ensured and these applications RFID Baggage Recording System, Turkish Airlines Store Tracing System are developed in Java programming language. MySQL database is used to store the personal information of passengers. It is developed to provide data flow between these programs, web services are generally a part of the software that enables different applications to communicate over the network and conduct their communication using a standard XML messaging system.

Moreover, an algorithm has been developed by the card manufacturer to define for unique Turkish Airlines RFID Baggage Card numbers. Card numbers that are specified for Turkish Airlines, are saved in the Turkish Airlines database.

As it is shown in Figure 21, RFID Baggage Cards are purchased from the Turkish Airlines Shop & Miles website. Purchased cards are printed in the name of the passenger and sent to passenger addresses. The card received by the passenger is identified in Miles &Smiles accounts. To use RFID Baggage Card, passengers need to register to the Miles & Smiles system first. After the card has been registered to the system, it will be able to be recognized. There are three steps for the identification of RFID baggage card as follows:

- Visit the "Personal Information" page from the Miles & Smiles account.
- Go to the "Baggage Card" section.
- Enter the 11-digit code card number.

Figure 21 RFID Baggage Card Registration Process



RFID Baggage Cards do not have an expiration date. In other words, they can be purchased once and can be used indefinitely. Positioning cards must be away from electronic devices and food items in baggage in order to ensure effective antenna coverage. Passenger information is not stored in RFID Baggage Card, which can be accessed only when the card is detected by antennas. It is basically available in the Turkish Airlines database and not shared with anyone. If any problem occurs about the baggage, this information is displayed in the Turkish Airlines Store Tracing System.

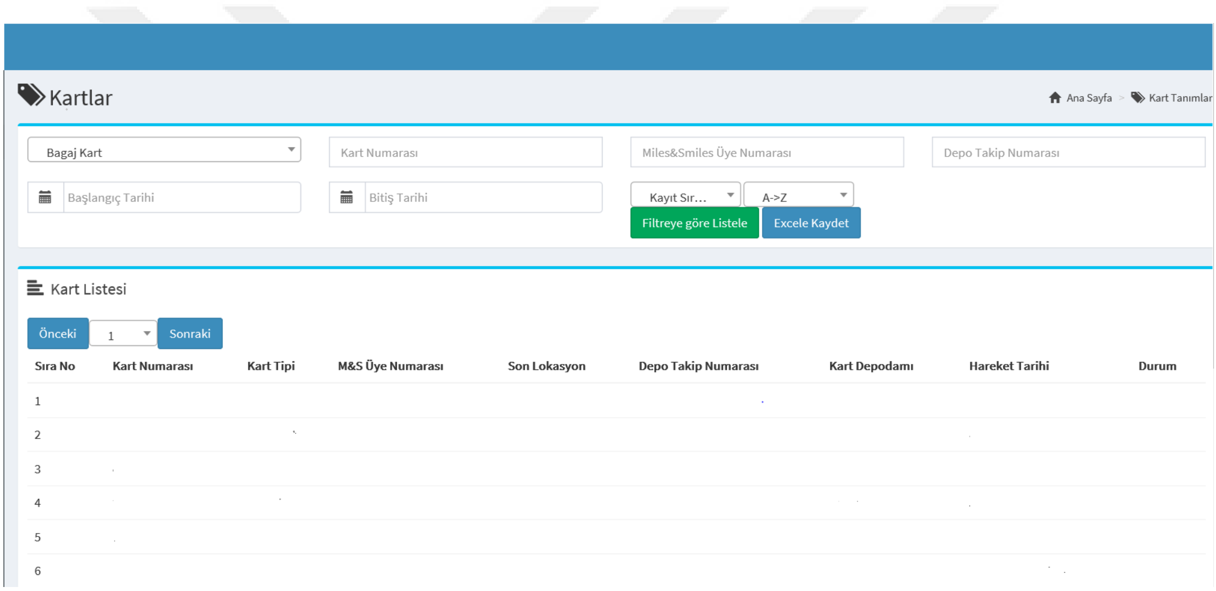
Card design and dimensions are similar to credit card dimensions (85, 60 mm x 53, 98 mm x 0, 76 mm). As illustrated in Figure 22, eleven unique digit-number is defined for each card and located on the card.

Figure 22 RFID Baggage Card

The RFID Baggage Cards which are purchased by the passengers are sent to passenger addresses by Turkish Airlines. Turkish Airlines orders RFID baggage cards from the manufacturer. An algorithm has been developed by the card manufacturer to define for unique Turkish Airlines RFID Baggage Card numbers. The produced cards are sent to Turkish Airlines and stored.

The return files that contain 11 digit card numbers are generated for each card by the card manufacturer. Then, return files have been transmitted to Turkish Airlines as a text file and RFID baggage cards numbers are imported to the RFID Baggage Card Recording System by Baggage Service Management Department staff. When the RFID baggage card is registered to the Miles & Smiles system by the passenger, the system sends the passenger information to the RFID Baggage Recording System. Thus, passenger information is displayed in the system. The interface of the application software is depicted in Figure 23. And, the RFID baggage card number, Miles & Smiles membership number, Store Tracing System number, the last location of the card, date, card status, and state are listed. If there are undetectable data, the field is empty. If RFID baggage card is detected in the warehouse, Miles & Smiles membership information is sent to Store Tracing System and displayed in the system.

Figure 23 RFID Baggage Card Recording System

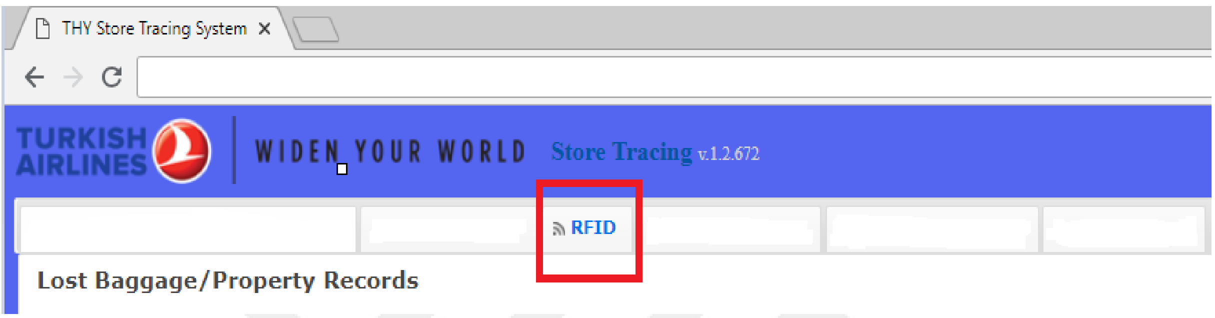


Turkish Airlines Store Tracing System is focused on registering, searching and shipping lost baggage. As it contributes to expediting the identification process of lost baggage, it accelerates the transportation process of lost baggage. Each lost baggage that enters the warehouse has recorded this system.

When lost baggage enters warehouses, staff open a file for lost baggage and record detail information about baggage. For each registered baggage, a unique number is assigned. If a passenger contact with Turkish Airlines Baggage Service Management Department, the staff can search for baggage on Store Tracing System.

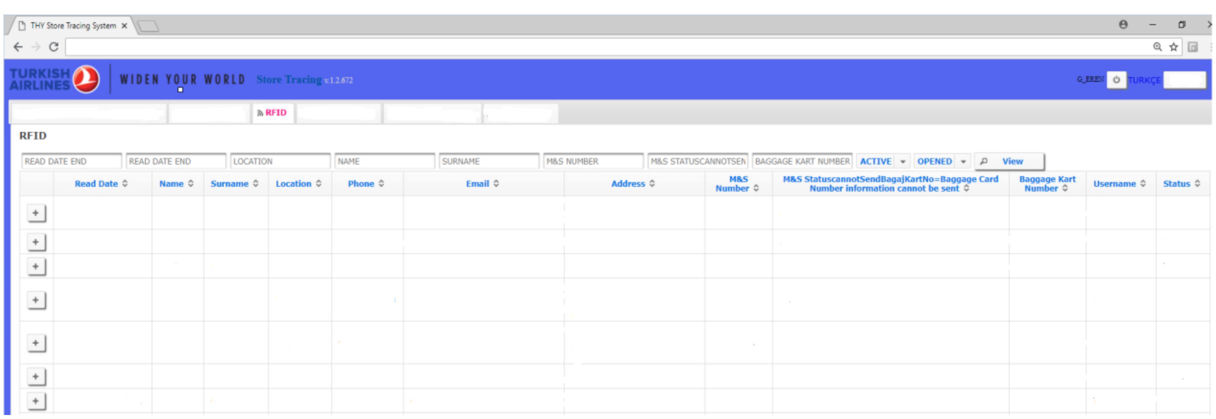
As can be seen in Figure 24, information about lost baggage which has an RFID baggage card can also be displayed on the Store Tracing System.

Figure 24 Store Tracing System RFID Tab



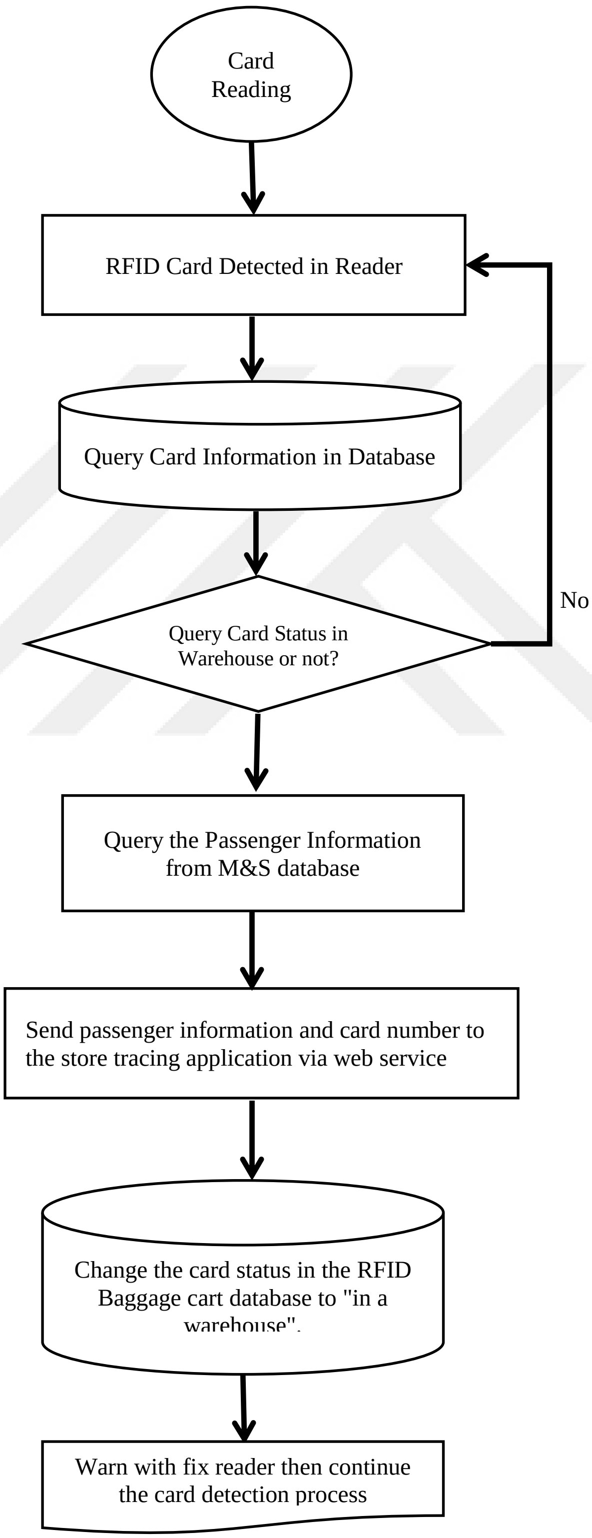
Besides that, a new tab is added to the Store Tracking System to display captured RFID information. From RFID tab, all history of lost baggage can be viewed at once. When lost baggage enters into the warehouses, all information about passenger can be displayed in RFID tab. As shown in Figure 25, this information is read date, passenger name, surname, phone number, email, address, Miles & Smiles membership number, location, RFID baggage card number, the status of the detected baggage card. In addition, the fast search feature allows the query of previously identified baggage.

Figure 25 Store Tracing System RFID Tab



The RFID baggage card reading process shown in Figure 26, begins with the RFID baggage card detection of the antennas. The signals detected by the antennas are sent to the readers. Then, the system checks card status from RFID Baggage Recording System. If baggage status is “at the warehouse", the system sends the query to Miles & Smiles system to transfer the passenger information. Miles & Smiles system sends passenger name, surname and contact details as a response of query. Once all the necessary input parameters have been received, passenger information and RFID Baggage Card are matched. If baggage status is “not at the warehouse", the card-reading process starts once again.

Figure 26 RFID Baggage Card Reading Process

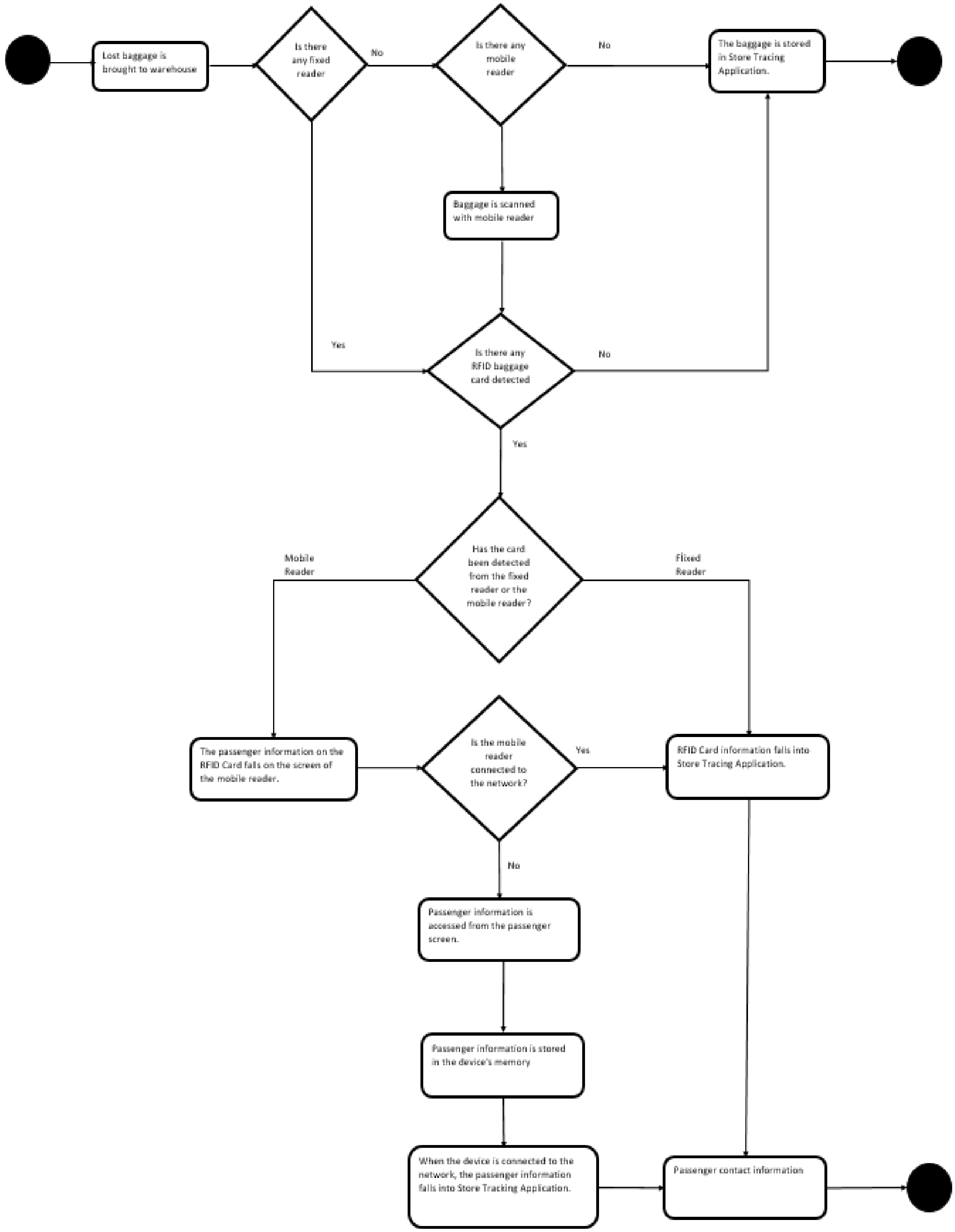


RFID readers and antennas are located at Turkish Airlines storage at Istanbul Atatürk Airport. Two antennas and one reader are placed at each warehouse. Further, three mobile readers linked to the RFID antenna are supplied. If the passenger's baggage, which has RFID Baggage Card, enters Turkish Airlines lost baggage warehouses, the RFID system warns that baggage has been entered into the warehouse. Then, RFID Baggage Card information detected by antennas is sent to readers. Finally, received data from readers are sent to the RFID Baggage Recording System. Then details of the passenger information are transferred from the Miles & Smiles database and listed on the Store Tracing System. Thus, the information about the lost baggage can be displayed by the staff who is working in the warehouse. Figure 27 shows the location of the antenna and readers at the lost baggage warehouse entrance at Atatürk Airport.

Figure 27 RFID Reader and Antennas Location

The Unified Modeling Language (UML) diagram shown in Figure 28 illustrates the identification and registration steps of the system.

Figure 28 UML Baggage Detecting and Recording Diagram



CHAPTER 7

DISCUSSION

A new project is designed based on the results taken from a fishbone diagram, and system methodology is developed to eliminate the root causes of the problem. The company data are analyzed by using a quantitative research method. The data collected with this method shows that the number of lost baggage and the compensation amount for the lost baggage paid to passengers is very high. The biggest factor in the high number of lost baggage is the lack of information about the baggage owners. This project is developed in order to reach the data of baggage owners. The unified modeling language diagram is used to provide data flow and integration of systems in the project.

The project, which is designed to locate lost baggage owners using RFID technology, was launched in 2018. As part of this project, 2 477 RFID Baggage Cards were distributed to Miles & Smiles membership. The number of lost baggage in warehouses identified by RFID technology was 321. The average cost of each lost baggage to the company is \$ 800 and the total gain of 321 pieces of baggage ensured by this project is \$ 25 680.

In the first phase of the project, the Miles & Smiles elite and elite plus members were distributed free of charge. Later, RFID Baggage Cards are sold on Shop & Miles website to all Miles & Smiles membership. We argue that the widespread use of RFID Baggage Cards and the learning curve effect on the project will increase the effectiveness of the project.

Note that there are several advantages of executing this project compare to the previous year: First of all, lack of passenger information, which is the most important reason that owners of lost baggage cannot be identified, could be solved by this project.

Secondly, as can be seen in Table 6, although the number of lost baggage in warehouses increased by 26% according to the previous year, the number of found baggage owners from warehouses increased by 28 %.

Table 6 Number of Mishandled Baggage in Warehouses

Years	**Number of Baggage Enters to Warehouses**	**Number of Baggage owners not found**	**Number of Baggage owner found**
2015	32 049	12 965	19 084
2016	39 198	10 307	28 891
2017	72 259	12 183	60 076
2018	90 872	13 794	77 078

Source: Turkish Airlines Store Tracing System

Thirdly, shorten the time of finding lost baggage owners has decreased the number of complaints. As shown in Table 7, passenger complaints about lost baggage are reduced, and the number of opening files is decreased by 5%.

Table 7 Number of Lost Baggage Files

Year	Number of Open Files	Number of Close Files	Ratio
2015	10 002	9 258	%82
2016	43 594	42 966	%98.6
2017	51 930	51 166	%98.5
2018	49 447	48 510	%98.1

Source: Turkish Airlines BagStar Application

Lastly, the decrease in the number of files also reduces the compensation payments made to the passengers. As shown in Table 8, the company has made a profit of $ 238.413 from the previous year on compensation for lost baggage. $ 25.680 of this amount is provided by the RFID Baggage Card project, which corresponds to about 10% of the total benefit.

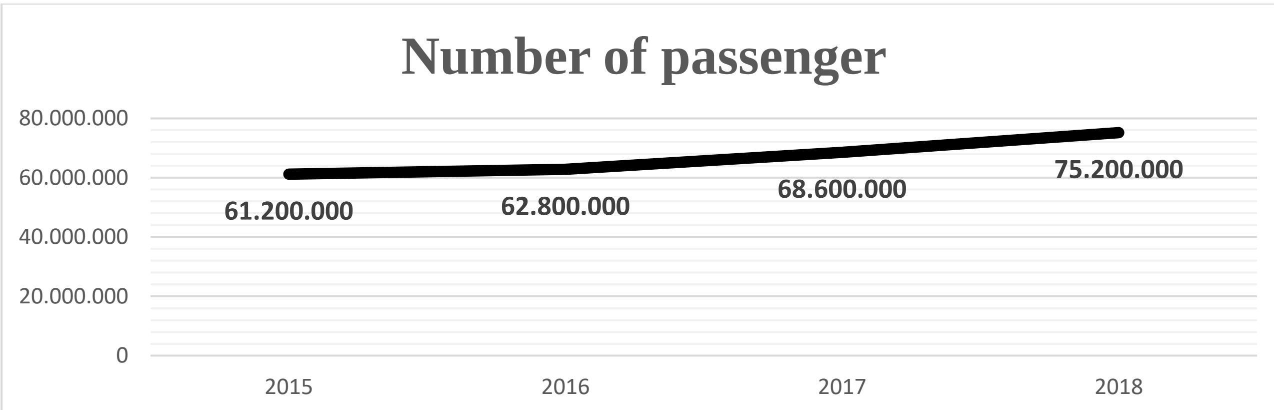
Table 8 Compensation Amount for Lost Baggage ($)

Year	Number of Lost Paid Files	Amount of compensation ($)
2015	9 681	2 917 281
2016	43 618	2 740 130
2017	51 271	2 040 372
2018	49 241	1 756 959

Source: Turkish Airlines BagStar Application

In 2018, as displayed in Figure 29, passenger traffic increased 9% compared to that of 2017. However, despite the rise in the number of passengers, note that no increase in the number of lost baggage has occurred. In addition, there has been no need for new personnel and new warehouse rental. Consequently, each goal and objectives that are targeted in this project achieved successfully.

Figure 29 Turkish Airlines Number of Passenger



Source: www.turkishairlines.com

CHAPTER 8

CONCLUSION

The goal of this research is to decrease the number of lost baggage and related costs, as well as increase customer satisfaction. This study also enables to identify owners of lost baggage and shorten identification time of lost baggage, this results in the reduction on compensation costs of lost baggage. Meanwhile, reducing the number of lost baggage in warehouses ensures the reduction of warehouse rental costs. It also contributes to reducing the number of staff working to find owners of lost baggage. This also gives the company overall cost savings and increases company reputation by ensuring reliable service. To achieve that, system methodology is used in this research, which consists of problem definition, data collection, data analysis, system design and implementation.

With this project, the second phase started at the same time. RFID Warehouse Cards project had been started and finished to make the warehouse baggage storing more systematically. To operate this phase, RFID cards need to be placed in all baggage, which is entered into the lost baggage warehouses. The second phase uses the same infrastructure that is installed in lost baggage warehouses. Each baggage that RFID card is placed is recorded into a system that makes it easy to find and manage the warehouse. In this way, it is ensured that lost baggage at the warehouses is identified, and counting procedures are made systematically.

The RFID system in this study was implemented at Ataturk Airport. However, the airline company moved to the new airport this year. The entire infrastructure of the system was examined and applied to the new airport. All tests and implementation phase were completed successfully.

For some time, the system has been running and integrated into the baggage operation of the airline company.

The future phase of this project is planned to be completed in 2019 at the new airport. With this phase, passengers will be informed after disembarkation from aircraft where their baggage will be delivered from which carousel via texting the baggage status to their phone notification.

Within the existing RFID infrastructure in the company, this application can also be used to track mishandled baggage from the mobile application. Note that using the new mobile application, passengers and the company will be able to communicate interactively.

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