RFID FOR BAGGAGE TRACKING

BUSINESS CASE
2017

IATA

SITA
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CONTENTS

1. EXECUTIVE SUMMARY

RFID holds the potential to save the aviation industry more than US$3 billion over the next seven years by improving baggage management and operations.

The performance of baggage operations has already dramatically improved over the last seven years. However, mishandling of bags remains a challenge and costs the industry US$2.3 billion every year. There also is a growing expectation from passengers to have access to baggage tracking information during their journey.

Both elements speak to an increase in the number of tracking points that enable airlines, airports and groundhandlers to take better decisions, improve their efficiency and level of service and as a result save costs.

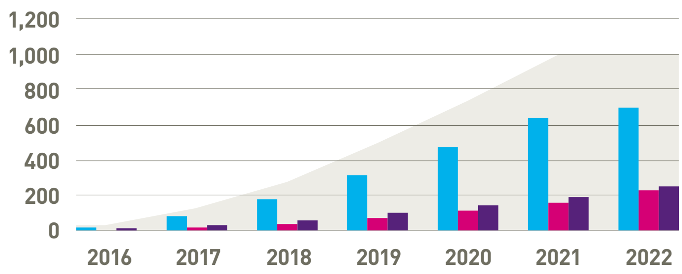
RFID looks like a technology of choice to fulfil this mission: it has high reading performance and relatively low infrastructure (capex) costs;

- Initial deployments of RFID show that bags are tracked at a more than 99% success rate, and translate into a drastic reduction of mishandled bags (25% or more).
- It allows higher automation, proactive care and reduced manual operations.
- It can be deployed for as little as US$0.1 per passenger on average while generating savings of more than US$0.2 per passenger.

With some big airlines and airports already introducing RFID technology and its compatibility with existing barcode technology, adoption of RFID across all airports could provide a positive return for airlines, both in cost and passenger satisfaction.

The savings are based on RFID being deployed in 722 airports (representing 95% of the total number of passengers) over a six-year period (2016 to 2021). The figures for 2016 take into account the RFID infrastructure already deployed. (See fig 1 for cost savings over seven years).

2016-2022: EXPECTED SAVINGS (US$ MILLION) LINKED TO THE ADOPTION OF RFID (fig.1)



Savings per area

Improve end to end tracking: More bag tracking leads to the reduction of mishandled bags and efficiency gains in baggage operations.

Improve aircraft loading/off-loading: Baggage is loaded/offloaded faster leading to fewer delayed flights.

Ease adoption of resolution 753: Deployment and operational costs linked with the addition of new tracking points are reduced.

Total savings

2. INTRODUCTION

2.1. BUSINESS CASE

This document is part of a joint initiative between IATA and SITA. It is also part of SITA's community initiative to improve baggage tracking for the air transport industry.

The white paper aims to provide the key figures and benefits any stakeholder should be considering for the deployment of RFID for baggage tracking. The benefits of RFID are already being recognized by industry players. Prominent among them is Delta Air Lines which is moving from bar-coded tags to RFID for all the 120 million bags which it handles annually.

Every year more than 3-billion bags are checked in at airports around the world – a staggering number that will continue to rise sharply over the next two decades.

Yet through the smart use of technology, only a small percentage of bags are mishandled each year. According to the SITA Baggage Report 2016, the rate of mishandled bags was 6.5 bags per thousand passengers in 2015, down 10.5% from the previous year, and down 65.3% cumulatively from 2007. However, no passenger wants to arrive at their destination without their personal belongings. And for airports and airlines each mishandled bag is an additional cost. Therefore the pressure remains on the industry to do even better, by further reducing the number of mishandled baggage while accommodating more bags every year.

The main drivers for the adoption of RFID (fig.2)

STAKEHOLDER	DESCRIPTION	HOW
Airlines	Improve the performance of baggage management	Increase loading/unloading performance. Improve quality in the collection of bag tracking messages.
Airports & airlines	Improve baggage operations	Increase baggage processing performance. Decrease need for manual processing.
Airports & airlines	Facilitate adoption of IATA's Resolution 753	Ease the deployment of new tracking capabilities.
Passengers	Improve passengers' experience	Richer tracking information Improve perception of baggage handling.

The success of tracking bags lies in deploying the right technology and infrastructure, that need to be robust, affordable and above all accurate. RFID can represent a great opportunity to meet these expectations by improving the performance of bag handling at the different stages of the bag journey.

2.2. PURPOSE OF THE DOCUMENT

This document exists in order to provide a common understanding of the benefits and application of RFID to baggage tracking.

It has been prepared by industry experts in order to demonstrate how to use the technology for best advantage and in a manner that is consistent for the aviation industry.

This document considers key functional processes of baggage management, and especially that of baggage tracking. Sortation is not considered as there is no proof yet that RFID can significantly improve this part of the baggage management process.

The technology, benefits, costs and savings associated with RFID are described in the different sections throughout the document.

The objectives of the document is to:

- Describe the technology and the benefits it can bring to the aviation industry in tracking bags more efficiently,
- Identify the key elements to be considered for a RFID deployment,
- Define the inputs and assumptions (in Appendix 1) used to estimate:
    - The costs associated with the introduction of RFID,
    - The savings RFID can generate in the context of baggage tracking.
- Provide high level financial statement (in Appendix 2) for RFID.

2.3. WHY RFID?

RFID (Radio Frequency Identification) is the use of radio-frequency electromagnetic fields to transfer data for the purposes of automatically identifying and tracking tags attached to bags. This technology allows a large number of identification and tracking tasks to be undertaken without human intervention.

The characteristics of RFID versus other technologies in the context of bag tracking are listed in the table below. RFID is to be understood as UHF RFID (Ultra High Frequency RFID) and it has been the standard for airline baggage RFID since 2005 as it has key advantages for bag tracking: line of sight, read speed, ruggedness, low cost.

RFID is not the solution to all identification needs, but by combining types of reader and information it is possible to meet most of the needs of baggage handling.

The one area where barcode could remain the best choice is in sortation, as this requires a high degree of singulation (i.e. knowing which particular label has been read at an exact point). Even in this case, it is still possible to singulate a read using just RFID readers, but the cost benefits of this over barcode are yet to be demonstrated when integration into the baggage handling system is considered.

Another possibility is to use RFID to reduce the chance of a no-read by combining RFID and barcode information.

Comparison between technologies (fig.3)

	RFID	1D BARCODE	2D BARCODE	BLUETOOTH	NFC
Line of sight	Not required	Required	Required	Not required	Not required
Range	<10m	<1m	<1m	>10m	<10cm
Singulation(1)	Yes	Yes	Yes	No	Yes
Cost of bag tags	Low	Very low	Very low	Medium	Low
Ruggedness	High	Low	Low	High	High
Read speed	High	Low	Low	High	Low
Bulk tag reading	Yes	No	No	Yes	No

(1)Singulation: Ability to read a tag without interfering with a tag nearby

2.4. BAG HANDLING

Baggage handling is a complex area of airport operations. On the surface it seems that taking a bag from a passenger at his point of departure and returning it to him at their destination should be a very easy task. However, there is much more being undertaken behind the scenes, such as:

- Identifying the bag and its flight
- Moving the bag through security
- Storing the bag until the flight is ready to be loaded
- Sorting the bag in the system to the correct loading location
- Ensuring the bag is on the right flight
- Ensuring that the passenger and bag are on the same flight in certain jurisdictions.

All the above steps are repeated for as many legs as the passenger flies, and at the end of the journey the bag has to be unloaded and placed on the right baggage reclaim carousel.

In order to achieve these steps, baggage messages are generated and sent between the airlines and all the airports the bag will pass through. These baggage information messages tell the systems what to do with the bag, and are linked to the bag via a 10-digit Licence Plate Number (LPN). This Licence Plate Number is encoded on the baggage label as a 1D barcode.

Baggage handling systems do a fantastic job of reading this barcode and matching it to the information for the bag, allowing it to be processed. In fact, a well designed baggage system will mis-sort only 1 bag in 10,000. The overall baggage mishandling rate being around 6/1000, i.e. 60 times higher, this difference in mishandling is not linked with the baggage system itself, but with the rest of the airport processes.

Introducing RFID has a distinct advantage over barcodes, in that it allows information to be read outside of the baggage system, and ground handlers can be notified and take proactive action to put bags back on course for their intended flights. This is a particular advantage for bags that are being transferred from one flight to another.

2.5. CONTEXTUAL INFORMATION

2.5.1. Technologies

The RFID can be broken down in three main categories depending on the frequency band in which it operates:

- Low Frequency (LF),
- High Frequency (HF), and
- Ultra-High Frequency (UHF)

and two sub-categories under Ultra-High Frequency:

- Passive (using passive tags powered by RF signal from the reader), and
- Active (using battery powered tags).

UHF RFID is the technology of choice for baggage tracking. It has been selected due to the benefits it brings for item tracking as listed in its comparison with LF and HF (see fig.4).

UHF RFID with passive tags has the following key advantages that makes it suitable for bag tracking:

- High data transmission rates that allow reading multiple tags at one time.
- Passive UHF tags are easier and cheaper to manufacture.
- UHF frequency band is regulated by a single worldwide standard.

UHF RFID is more sensitive to interference, but many RFID manufacturers have found ways of designing tags, antennas and readers to keep reading performance high even in difficult environments (e.g. presence of metals or liquids).

UHF RFID is a good compromise between reading speed, distance, multiple tags handling and cost (see fig.4 below).

Comparison of low frequency, high frequency and ultra-high frequency RFID (fig.4)

	RFID			
Type	Low Frequency (LF)	High Frequency (HF)	Ultra-High Frequency (UHF)	
			Active (Battery Powered)	Passive (Powered by RF Energy)
Frequency	125 - 134 KHZ	13.56 MHZ	433 & 860- 960 MHZ	860- 960 MHZ
Range	<10cm	<1m	<100m	<10m
Interference	Low sensitivity	Moderate sensitivity	Higher sensitivity	
Data transfer	Low rate	Low rate	High rate	
Cost of tag	Moderate	Low	High	Low
Pros	+ Works well with liquids and metal + Meets global standards	+ NFC protocol + Meets global standards	+ Very long read range + High data transmission rate + Meets global standards	+ Good read range + Tags easier to manufacture + High data transmission rate + Meets global standards
Cons	- Very short read range - Low data transmission rate - Limited data capacity	- Short read range - Low data transmission rate	- High tag cost - Higher interference with liquids and metal	- Higher interference with liquids and metal

2.5.2. Standards and regulations

The UHF frequency band is regulated by two main international RFID standards bodies:

- ISO - International Organization for Standardization.
- EPCglobal - Electronics Product Code Global Incorporated.

The ISO RFID standards fall into a number of categories according to the aspect of RFID that they are addressing.

The ISO 18000 standard addresses the RFID air interface and associated protocols under the general title: Information technology — Radio frequency identification for item management.

The Part 6 of ISO 18000 deals more specifically with the UHF RFID and the parameters for air interface communications at 860 – 960 MHz.

EPCglobal aims at developing industry-driven standards for the Electronic Product Code (EPC) to support the use of Radio Frequency Identification (RFID).

The EPC standard used for the UHF air interface is Class1 Generation2 often referred to as EPCglobal Gen2.

EPCglobal Gen2 has been approved by the ISO for inclusion as amendment 18000-6C.

The EPC standard used to allow global visibility of items is EPC Information Services (EPCIS).

IATA through Recommended Practice (RP) 1740C, approved the use of tags and readers compliant with the ISO 18000-6C for the purpose of baggage handling.

2.5.3. Benefits and risks

Benefits

RFID is expected to generate a number of benefits in baggage handling, over barcodes (see fig.5 below).

The expected benefits for airlines and airports are listed below:

- Bag tags read more efficiently
- Shorter loading time
- Readers easier and cheaper to deploy
- Improve tracking capabilities

RFID is expected to generate a number of benefits in baggage handling, over barcodes (fig.5)

	RFID	BARCODES	COMMENTS
Speed and accuracy	Read rate >99%	Read rate <95%	RFID has a greater potential for speed and accuracy than barcodes
Capacity	96 bits minimum (for Electronic Product Code - EPC)	10 bits (for License Plate Number – LPN)	Bag tracking systems can benefit from the ability of RFID tags to hold more information
Durability	Higher durability	Can be easily damaged	
Information accrual	RFID tag is writable, information can be added at different stages of the bag journey	Bag label with printed barcode cannot be amended but only replaced	

Risk analysis

Below (see fig.6) is a description of the main risks identified as inherent to RFID adoption. These risks can be mitigated or avoided as described in the last column.

The main risks identified as inherent to RFID adoption (fig.6)

RISK	DESCRIPTION	STRATEGY
Cost of the RFID tags	The cost of RFID tags is based on volume and can be high especially for small scale deployments making it difficult to reach an acceptable Return on Investment (ROI)	**Mitigate** - The cost of the tags will decrease as RFID gain widespread acceptance (a number of major airports/airlines have already deployed RFID or are about to deploy RFID)
Interference with other elements in the reach of the reader	Data signals of one reader can collide with those of another reader Interference with stray bags or baggage carts parked in the read zone	**Avoid** - Initial setup with specialists to properly position the antennas

3. A LAYER MODEL OF RFID

With RFID, baggage processes and operations can be split in a number of layers, each layer being needed to complete the entire journey and each having different aims.

These layers are:

- Identity layer
- Passenger layer
- Security layer
- Handling layer
- Tracking layer

3.1. THE IDENTITY LAYER

This layer allows the management of identity in the baggage infrastructure. Messaging is a crucial element of all baggage operations and all baggage messages are defined in IATA Recommended Practice 1745. This recommended practice is currently being updated to include references to the unique identity of a bag. This identity can take several forms depending upon how airlines operate, and is sent as part of the baggage messages (BSM, BPM etc.) as the .M element.

The .M element can be provided by the airline Departure Control System (DCS), in which case it must be encoded in the RFID tag, or it may be read from the RFID tag as the Transponder ID (TID) of the tag, and sent to the DCS. This allows either the single use bag tag to be provided where the unique identity is encoded by the bag tag printer or multiple use bag tag to be used where the unique identity is read from the bag tag (more information about single use and multiple use bag tags is provided in section 4.1).

It is also possible to encode further baggage information onto the RFID bag tag. This can include the intended flights for the bag, and other flight relevant information. This means that in the rare instances that a bag cannot be matched to its message, the information can be read from the bag tag itself and processing can continue. The one area where this cannot be done is the reconciliation of the flight, as authority to load a bag has to always come from the most recent baggage message received.

3.2. THE PASSENGER LAYER

This layer concerns all the interaction with the passenger. This includes how the passenger obtains their baggage tags (as a product before their journey or as part of baggage acceptance), how the airline receives the baggage, how the passenger is informed about their baggage journey and how the bag is returned to the passenger.

How does a passenger's bag get an RFID tag?

Single use baggage tag

Single use baggage tags are typically encoded and printed as part of the on and near airport baggage processes. These processes make use of specialized baggage printers described in the next section to provide a baggage tag to the passenger.

Multiple use baggage tag

Multiple use baggage tags can be purchased by the passenger, be part of other sophisticated baggage tags such as the electronic baggage tag, or there may be an RFID inlay in the holder of a home printed baggage tag.

How does the airline know they can accept the bag?

RFID has a major role to play in simplifying the airport processes linked with the reception of a bag.

Single use baggage tag

With a single use RFID bag tag the passengers have to get a baggage tag before their bag can be accepted by the airline. The baggage tag will be associated to the passenger's journey at a counter or a kiosk, and relevant details will be recorded on the baggage tag. The baggage tag will then be attached to the bag, and the bag will be handed over to the airline.

Multiple use baggage tag

With a multiple use RFID bag tag, the process can be done anywhere using a smartphone application.

The workflow with the smartphone application will typically be as follows:

1. The passenger registers for his flight and opens the application on his mobile device.
2. The passenger inputs requested details such as their Passenger Name Record (PNR) and completes the first part of his registration.
3. The application asks if the passenger will be taking a bag on the journey.
4. If it is the case, the passenger indicates the number of bags.
5. The passenger is then asked if the bags already have tags.
6. If it is the case the passenger is asked to scan the bag tags.
7. The application receives the unique identity for the bag and other information from the tags.
8. The application checks that the bag tags are acceptable to the airline for carriage and if it is the case the passenger is told to proceed to baggage drop.Where a passenger uses another channel, the fallback method to associate the baggage tag with the passenger journey will be to record the baggage tag details during bag acceptance at the point of handover of the bag from the passenger to the airline.

At all stages in the process the airlines are able to apply their business rules and logic (e.g. the number of bags that the passenger can take, etc). Elements such as the weight of the bag can be captured at baggage drop.

How are passengers informed about their bag journey?

The adoption of IATA's Resolution 753, which requires that bags are scanned at key points in their journey, will improve bag tracking and the level of information passengers can get about their bag.

This adoption implies that bags will be scanned at additional reading points, so moving from reading a printed tag that may generate inaccurate information about the bag to reading the information on an RFID tag with the latest information available should be a great benefit to the industry.

3.3. THE SECURITY LAYER

This layer is linked with security processes used to confirm that the bag that has been presented for travel contains nothing that could jeopardize the aircraft. This goes beyond the obvious threats of explosive devices to include things like dangerous goods that could harm the aircraft if they were carried incorrectly.

Many security processes are classified and therefore a generic version is presented below:

1. Use a screening machine to investigate the contents of the bag.
2. If the bag is deemed safe, allow it to continue.
3. If the bag is not safe, or part of a random quota, then pass it to a security agent for investigation.
4. Present the image of the bag and the area of concern to the security agent with the bag, to facilitate faster searching.
5. The security agent uses a variety of means to verify the bag is safe.
6. The bag is allowed to continue on its journey.
7. The method of screening and the result may be transmitted in baggage messages for further use in reconciliation systems.

In case a barcode is used to identify the bag, the security agent must manually identify the bag with a barcode. With RFID, a reader can automatically identify the bag and present the information to the security agent. Further information such as the intended flight for the bag can also be presented automatically.

RFID becomes very interesting with multiple use bag tags when the unique identity of the bag (stored in the .M of the messaging and sourced from the RFID tag) is combined with historical information regarding the bag. This allows the previous journeys of the bag to be seen, and it can be valuable information for risk based security screening.

The unique identity for the bag has a further role to play in terms of the IATA Remote Screening Concept. Under this concept the Universally Unique IDentifier (UUID) of the bag is used to identify the bag between security agencies, allowing screening information to be shared between them. This practice could significantly reduce airport Capex (Capital Expenditure) on screening equipment while increasing the effective use of the specialized security resources to address bags of interest.

RFID also allows the recording of the time of entry and exit into the security area in a simple manner, so that flights do not wait for bags that are under security screening and will not be processed in time for the outbound flight.

3.4. THE HANDLING LAYER

This is an area where RFID can offer a great benefit to the accuracy of bag processing. Handling is a source of two particular errors:

- Bag processed too late, or
- Bag taken to the wrong place

At the heart of handling are four processes:

- The baggage load process
- The baggage unload process
- The interline transfer process
- The online transfer process

The baggage load process

The baggage load process is where the bag is placed onto the correct aircraft. This is done either in bulk, through a containerized load, or through individual bags (loose load). In either case, it is relatively straightforward to use an RFID reader to check that bags being loaded are going into the right flight. In the case of loose load, this can be greatly automated through the use of a belt reader. This specialized RFID reader sits underneath the conveyor belt of a loose loader belt conveyor and reads each bag as it is loaded. This can achieve twice the load rate of a barcode reader. When combined with devices such as a ramp snake this advantage can be extended to containerized loads.

When a bag is being mis-loaded then the conveyor stops and an alarm sounds to inform the loader that there is a manual action needed to resolve the issue.

The baggage unload process

The baggage unload process is undertaken in two steps:

- Unloading the bags from the aircraft, and
- Deciding where to take the bags for the next stage of their journey - either into a transfer process or arrivals area.

One of the key decisions that is hard to make today is that of "quick" processing specific bags from one flight to another. These bags might be hard to find if loose loaded, and will be built into specific containers on the inbound flight. For a loose loaded flight, and using RFID, the same baggage conveyor belt can be set to stop for short connecting bags, allowing them to be easily identified and taken for processing. At a containerized transfer break, an RFID reader can read each bag automatically when placed onto the belt, identifying bags that are short connecting and also bags loaded to transfer by accident.

The interline transfer process

Interline transfer takes place between two airlines who have an interline transfer agreement. This agreement allows for the protection of the passenger during their connection, and for the handling of the bag between the carriers. The key decision here is whether the passenger will be able to make their connection or not. If the passenger is rebooked onto a later flight because they cannot make the connection, then the bag must also be rescheduled onto the new flight. This allows the passenger and the bag to travel together. These bags often require manual intervention to place reflight labels onto the bag, and thus need to be identified and separated from the normal flow of baggage. RFID can make this identification process more efficient.

The online transfer process

Online transfers are when a passenger transfers on the same operating carrier between flights. In these instances, the operating carrier has more control over how the bag is handled, and may be able to change the routing of the bag without undertaking a relabeling of the bag. Bags can therefore be reflighted, or even rushed (where the bag travels without the passenger to the final destination) automatically. The issue that can arise here is that if the bag is not identified correctly it will go to a manual process that can result in the bag being sent to the wrong build location. RFID, with a higher rate of correct first read, reduces this problem.

3.5. THE TRACKING LAYER

What is tracking?

At the simplest level tracking is the recording of an event at a specific time.

The IATA's Resolution 753 focuses on four events. These are:

- The handover of the bag from the passenger to the airline
- The loading of the bag on the aircraft
- The unloading of the bag to a transfer process
- The unloading of the bag to an arrivals process

These events are chosen in Resolution 753 because they form the minimum set of points allowed to record every bag as it enters or leaves the airport. With this information alone though, there is little that can be done. In order to turn the raw tracking data into actionable and useful information, it is necessary to match the raw data to the baggage message. This allows verification against a planned journey, interaction with the passenger and exception handling to be introduced, driving better baggage performance.

Tracking can be achieved through RFID in both fixed and mobile modes – e.g. either at specific places with fixed readers or at mobile places with handheld readers. Matching the RFID baggage identification to the baggage messages is achieved through the .M element of the message.

A LAYER MODEL OF RFID (continued)

The uses of tracking information

There are many ways in which having tracking information can profoundly change the operation and performance of baggage processes at airports.

Here are a few examples:

Improving the customer relationship

Accurate and timely information is essential to building confidence between the passenger and airline with regards to their bag being correctly handled. RFID-enabled airports typically have more read points, and more accurate reads, than non-RFID airports, resulting in more detail and more accurate information to support the passenger journey.

Reduce mishandling

The use of RFID increases the availability of information to support the operation. While RFID will not on its own reduce mishandling, it will enable more opportunities to decide if a bag needs a proactive intervention to complete its journey correctly.

Recovery from irregular operations

Irregular operations occur at most airports at some point. This can result in thousands of bags being left in large storage areas, and these need to be identified and processed. Bags are seldom organized when they are placed in storage, and so sorting the bags takes time. Handheld RFID readers allow specific bags or groups of bags to be quickly identified and taken for processing.

Recovering mishandling costs

By having greater detail and information on the location of bags, it is possible to determine what went wrong, when and where. This allows the costs of mishandling to be recovered through the proration process, ensuring that those airlines that have mishandling issues are paying for the resulting passenger claims, rather than simply sharing the costs with their interline partners.

4. COMPONENTS AND TOOLS

4.1. BAG TAGS

Single use bag tag

Paper bag tag commonly used for barcodes remains unchanged for RFID, the only difference is the RFID inlay inserted to convert it into RFID bag tag.

The RFID bag tag has to conform to IATA's Resolution 740 and IATA Recommended Practice 1740A to be used in the common use printers at an airport.

Processing a bag with an RFID bag tag is transparent to the tools and processes in place to manage existing paper bag tags, and RFID processing capabilities can be added over time, to improve key areas of baggage handling.

This RFID bag tag is also known as the single use bag tag. A new label needs to be attached to the bag each time a passenger starts a new journey.

Multiple use bag tag

An alternative to the single use bag tag is the multiple use or permanent bag tag.

This multiple use tag is attached to a bag and reusable for each new journey.

Different types of the multiple use bag tag exist including:

- Standalone RFID bag tag attached to the luggage
- Part of a more sophisticated electronic tag attached to the luggage or embedded in the luggage itself.
- RFID inlay in the holder of a home printed bag tag.

4.2. PRINTERS

The existing printers at the check-in counters or at the self-service kiosks can be upgraded with RFID modules so that they can encode the RFID bag labels.

The RFID printer can encode the License Plate Number (same as the one used with barcode on paper bag tags) and any other data to be processed as part of the bag tracking processes.

IATA Recommended Practice 1740C defines how data should be encoded into the RFID bag tag.

4.3. READERS

RFID readers can be introduced at different stages of the baggage journey for optimum baggage tracking and compliance with IATA's Resolution 753.

The reader consists of:

- A Radio Frequency element used to interrogate bag tags via Radio Frequency to get identity and data written on the RFID bag tags, and
- A control unit to manage the reader, aggregate the information collected from the bag tags and transmit it for further processing to data handling and bag management systems.

Fixed RFID readers

Mounted in tracking areas, such as

- Bag drop
- Sortation
- On top of conveyors in check-in, make-up, arrivals, or transfer areas
- On belt used to load/unload the aircraft

These readers provide the reading capabilities taking into account the specific environmental conditions that could apply to each area.

Handheld RFID readers

Being mobile and relying on batteries, these readers are complementary to fixed readers and used in general for manual processing in specific areas.

Initial setup is a key service to be considered before deploying RFID readers to make sure other elements in the proximity of each reader will not interfere with it and readers will not interfere with each other.

The readers have to be compatible with EPC Gen2 - ISO 18000 6C RFID tags.

4.4. DATA HANDLING

RFID readers can collect huge amount of information, and an intermediate layer is required to filter and structure the events collected through the readers introducing data gathering rules, and passing the structured information to the baggage management applications.

This layer may also introduce handling logic for bag tags that allows information not useful for bag tracking to be discarded (e.g. discard non relevant tag for a bag with two tags), or allow to reconcile information through interfaces with other applications like Departure Control System (e.g. gather source messages to generate processed messages for the bag tags read).

Application Level Events (ALE), the standard defined by EPCglobal, can be used as reference framework to describe the data gathering rules and the way data conversion is handled.

4.5. BAG MANAGEMENT APPLICATIONS

The integration with the RFID bag management applications has to be considered as part of any RFID deployment for bags.

The identity layer described previously should provide standard interfaces for a seamless integration with airlines or inter-airlines bag management systems.

5. APPENDIX 1 - INPUTS AND ASSUMPTIONS

5.1. INPUTS

5.1.1. Airports

Data from the Airports Council International (ACI) gives the number of passengers for all commercial airports operating in the world.

The split between airport tiers is as follows - ref 2014 (fig.7)

TIER	PASSENGERS PER AIRPORT	NUMBER OF AIRPORTS	NUMBER OF PASSENGERS (MILLION)	CUMULATIVE (%)
1	> 25 million	67	2,932	44%
2	> 10 million	97	1,589	67%
3	> 5 million	119	870	80%
4	> 1 million	439	995	95%
4	< 1 million	1,650	338	100%
	Total	**2,372**	**6,724**	

Airport passengers in the table are arriving and departing passengers, including transfer passengers.

The total number of airport passengers is different from the total airline passengers shown in section fig.8 below (airport passengers are counted at arrival and at departure while airlines count them once).

5.1.2 Baggage performance

The number of passengers is increasing rapidly year over year.

The latest estimates by IATA show that passenger numbers have grown by almost 5% per year from 2006 to 2015 to reach 3.55 billion passengers in 2015 (see fig.8 below).

There is no sign that this growth will slow as IATA's expectation is that by 2034 passenger numbers will have doubled to 7 billion.

It is difficult to obtain exact information on the total number of checked bags, but the number of bags follows the passenger trend.

SITA estimates that more than 3.5 billion bags were checked in 2015.

5.1.2.1 Baggage mishandling

The number of bags mishandled is collected by SITA and is shown below (see fig.9 below, source SITA's Baggage Report 2016).

This number of bags mishandled represents about half a percent of the total number of bags handled in 2015, with decreasing trend year over year.

Total passengers per year (fig.8)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total passengers (billion)	2.28	2.48	2.51	2.48	2.68	2.82	2.98	3.13	3.33	3.55

Mishandled bags per year (fig.9)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total bags mishandled (billion)	35.5	46.9	36.9	28.2	32.3	25.3	26.3	21.8	24.3	23.1

APPENDIX 1 – INPUTS AND ASSUMPTIONS (continued)

Type of mishandling

The statistics in 2015 show the following split for mishandling:

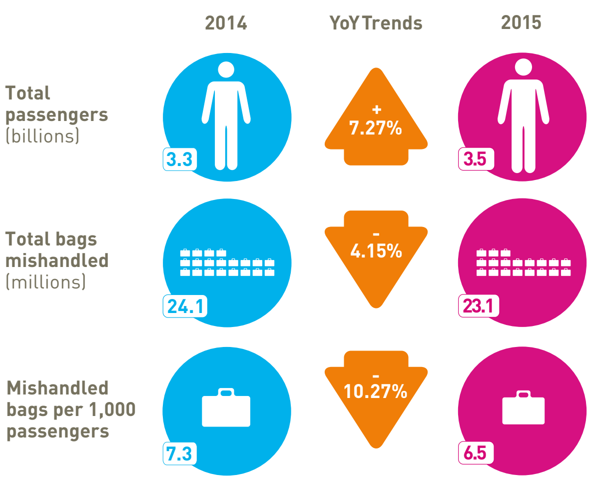
- Delayed bags accounted for 79% of all mishandled bags,
- Damaged or pilfered bags represented 15%, and
- Lost or stolen bags comprised 6%.

Reasons for mishandling (see fig.11)

- The largest cause of mishandling takes place during transfer, representing 45% of bags mishandled (e.g. bags not reaching a connecting flight).
- The second cause for baggage mishandling, at 19%, is linked with errors at the acquisition level such as:
  - Ticketing errors (wrong flight number on a tag)
  - Bag switch (bag tag on another passenger's bag)
  - Security (e.g. delay at security screening causing a bag to miss its flight).
- The third cause representing 16% of bags mishandled is due to failure to load the bag at the originating airport. Examples are:
  - Late check-in,
  - Last minute gate change,
  - Bag tag has not been read properly when it is sorted causing the bag to be processed manually.
- The other causes of delayed bags are:
  - Unexpected delays in the airport, at customs, due to specific weather conditions,
  - Space-weight restriction (not enough space in an aircraft for all bags),
  - Loading error (like bag in the wrong aircraft, bag in the wrong area and not loaded correctly at transfer),
  - Arrival mishandling (e.g. bag not presented to claim area in a timely manner),
  - Tagging error (mainly linked with damaged tag on a bag or inaccurate information on the bag tag).

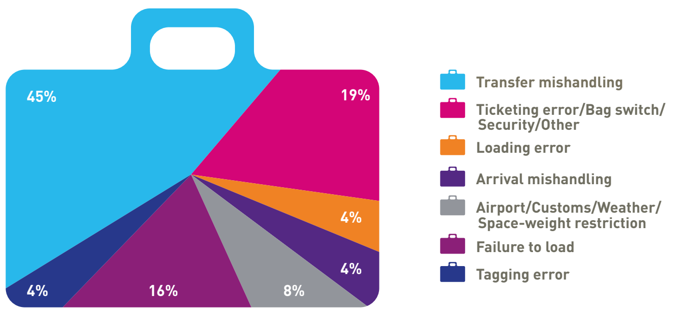
RFID is expected to further reduce baggage mishandling by improving read rates and tracking accuracy.

Bags mishandled - Trends 2014-2015 (fig.10)



Source: SITA

2015 reasons for mishandled bags (fig.11)



10.4 million transfer bags mishandled in 2015

Source: SITA

5.1.2.2 Cost of bagagge mishandling

According to SITA's Baggage Report 2016 the cost of baggage mishandling to the industry is more than US$2 billion per year (see fig.12).

This cost has decreased by more than 3% per year from 2006 to 2015 while passenger volume has increased by almost 5% per year over the same period.

As a result, the cost of mishandled bags per passenger has decreased from US$1.40 in 2006 to US$0.65 in 2015 (see fig.13).

5.1.3 Cost of the RFID components

5.1.3.1 Bag tags

The cost of an RFID bag tag (single use bag tag) is variable depending on the characteristics of the RFID inlay and the quantity ordered. The incremental cost for an RFID bag tag, compared with a standard paper bag tag, is estimated being between US$0.05 and US$0.09 depending on volumes and characteristics of the inlay.

5.1.3.2 Printers

The cost of an RFID printer is estimated being between US$1,000 and US$2,500, and the cost of adding an RFID module to an existing printer is estimated being between US$500 and US$1,500.

5.1.3.3 Readers

The cost of the readers varies depending on the type of reader and the manufacturer.

The costs given below are indicative, as the market is expected to evolve rapidly in the coming years.

READING POINT	INDICATIVE PRICE FOR ONE READING POINT
Automatic bag drop	Between US$5,000 and US$10,000
Sortation	Between US$15,000 and US$40,000
Conveyor	Between US$1,500 and US$3,000
Belt (aircraft loading/unloading)	Between US$3,000 and US$8,000

5.2. ASSUMPTIONS

The assumptions used for the business case for RFID are split between:

- **Passengers and bags:** Reference data for passengers and bags
- **Airports:** Reference data for airports
- **RFID elements:** Reference data and costs associated with RFID
- **RFID benefits:** Reference data and expected savings linked with the deployment of RFID

Cost of baggage mishandling (fig.12)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total bag mishandling cost to the industry (US$ billions)	3.19	4.22	3.32	2.82	3.23	2.53	2.60	2.09	2.40	2.31

Cost of mishandled bags per passenger (fig.13)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost of mishandled bags per passenger (US$)	1.40	1.89	1.32	1.14	1.21	0.90	0.88	0.67	0.72	0.65

APPENDIX 1 – INPUTS AND ASSUMPTIONS (continued)

5.2.1. Assumptions on passengers and bags

PASSENGERS	VALUE	DESCRIPTION
Passenger volume (2015)	3,545 million	Latest estimate from IATA for 2015
Passenger volume trend	+5% per year	Estimated passenger volume growth for the coming years based on the evolution over the past years
Transfer passengers	25%	Estimated percentage of passengers having to be transferred to another flight

BAGS	VALUE	DESCRIPTION
Bags per passenger	1.0	Number of bags registered in average per passenger
Bags mishandled (2015)	23.1 million	Latest estimate of number of bags mishandled for 2015 based on SITA's Baggage Report 2016
Bags mishandled trend	-3% per year	Estimated mishandling volume decrease for the coming years based on the evolution over the past years
Bags delayed	80%	Estimated percentage of bags delayed across all mishandled bags. (based on % in SITA's Baggage Report 2016
Cost of mishandling per passenger (2015)	US$0.65	Latest estimate of cost for bags mishandling for 2015 based on SITA's Baggage Report 2016
Cost of mishandling trend	-5% per year	Estimated cost of mishandling per passenger decrease for the coming years based on the evolution over the past years

5.2.2 Assumptions on airports

The assumption taken in the business case is that only the airports with more than 1 million passengers per annum will deploy RFID in the next 5 years.

The following roll-out plan is considered for these airports:

TIER	PASSENGERS PER AIRPORT (ACI 2014)	NUMBER OF AIRPORTS	RFID ROLL-OUT					
			2016	2017	2018	2019	2020	2021
1	> 25 million	67	2	7	10	14	16	18
2	> 10 million	97	4	10	15	21	24	23
3	> 5 million	119	6	12	18	26	29	28
4	> 1 million	439	9	44	66	97	110	113
% total passengers (ACI 2014)			3%	13%	28%	50%	75%	100%

5.2.3. Assumptions on RFID elements

The incremental cost used as reference in the business case, per single use bag tag based volume is:

	INCREMENTAL COST	VOLUME
RFID SINGLE USE BAG TAG	US$0.06	> 10 million bag tags
	US$0.05	> 100 million bag tags
	US$0.045	> 1,000 million bag tags

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APPENDIX 1 – INPUTS AND ASSUMPTIONS (continued)

The business case takes into account the following percentage of single use and multiple use bag tags:

SINGLE USE BAG TAG	100%
MULTIPLE USE BAG TAG	0%

The assumptions considered for the RFID printers are:

RFID PRINTER	INCREMENTAL COST	US$1,500
	INSTALLATION	US$1,000
	VOLUME	12 printers per million bag tags

The average costs considered for the RFID readers are:

RFID READER	HARDWARE AND SOFTWARE	US$2,500
	INSTALLATION	US$5,000

These average costs are based on the following distribution per airport type:

TIER	PASSENGERS PER AIRPORT (ACI 2014)	NUMBER OF AIRPORTS	ESTIMATED NUMBER OF READERS PER AREA			
			ACQUISITION	LOAD/UNLOAD	ARRIVALS	TRANSFER
1	> 25 million	67	22	53	35	13
2	> 10 million	97	8	19	13	5
3	> 5 million	119	4	8	6	2
4	> 1 million	439	1	3	2	1
Total number of readers for all airports			**3,165**	**7,663**	**5,198**	**2,033**
			18,059			

APPENDIX 1 – INPUTS AND ASSUMPTIONS (continued)

The estimated cost for integrating the RFID infrastructure with the bag tracking tools and processes in each airport is:

TIER	PASSENGERS PER AIRPORT (ACI 2014)	INTEGRATION FOR BAG TRACKING
1	> 25 million	US$150,000
2	> 10 million	US$100,000
3	> 5 million	US$60,000
4	> 1 million	US$30,000

The estimated costs for deploying the RFID infrastructure are:

TIER	PASSENGERS PER AIRPORT (ACI 2014)	IMPLEMENTATION AND PROJECT MANAGEMENT
1	> 25 million	US$450,000
2	> 10 million	US$210,000
3	> 5 million	US$140,000
4	> 1 million	US$60,000

5.2.4. Assumptions used for RFID benefits calculation

The following benefits are considered for the business case to estimate the savings associated with RFID.

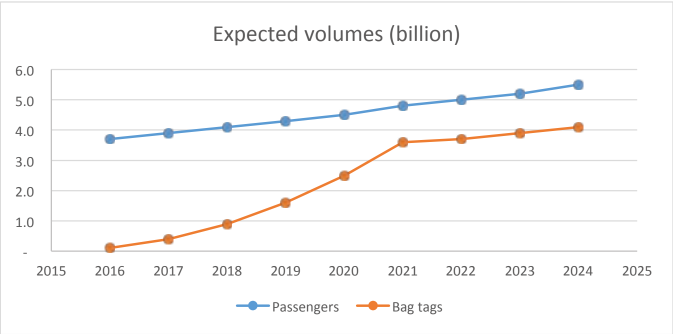
AREA		VALUE	DESCRIPTION
Improve end to end tracking	Decrease in the number of mishandled bags	A 25% decrease in mishandled bags per year	Bags tracked more efficiently. Fewer bags mishandled due to proactive care
	Operational efficiency	US$15,000 saved per million bags	Operational efficiency by application of Key Performance Indicators
Improve aircraft loading/ offloading	Operational efficiency - Load	US$9,000 saved per million bags	Loads aircraft faster
	Operational efficiency - Offload	US$5,000 saved per million bags	Bags offloaded more efficiently when passengers are not showing up
	Reduction in flight delays	US$0.02 saved per passenger	Less delays linked with loading/offloading
Ease adoption of IATA's Resolution 753	Ease deployment of new tracking capabilities	US$15,000 saved per reading point	Deployment cost significantly reduced with RFID compared with traditional barcode scanner
		Assumptions: - 48 additional readers for airport tier 1 - 18 additional readers for airport tier 2 - 8 additional readers for airport tier 3 - 3 additional readers for airport tier 4 with more than 1 million passengers	
	Decrease in the number of delayed bags	-2.5% per year	Bags read more efficiently. Less delayed bags due to manual processing
	Operational efficiency	US$25,000 saved per million bags	Reduce need to manually process the bags when tag misread

6. APPENDIX 2 - FINANCIAL STATEMENT

6.1. COST MODEL

The assumptions taken in number of passengers and bag tags for the period 2016-2024 are as per graph below.

2016-2024: Projection in number of passengers and bag tags



The number of bag tags will follow RFID adoption from 2016 to 2021 (ref. table below) and will be proportional to the volume of passengers after 2021.

RFID adoption globally (as per assumptions in section 5.2.2)

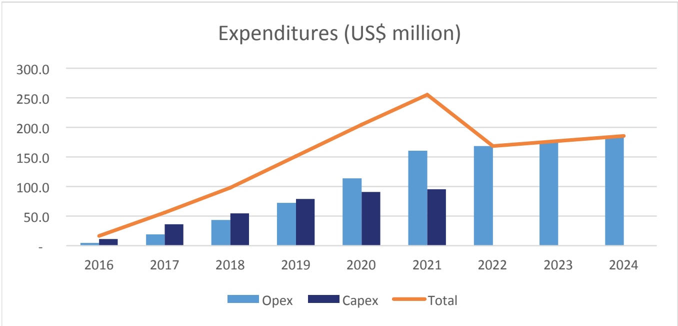
RFID ROLL-OUT	2016	2017	2018	2019	2020	2021
Passengers covered by RFID	3%	13%	28%	50%	75%	100%

Based on these volumes, the expected forthcoming expenditures linked with the introduction of RFID are split between:

- Operational expenditure (Opex): Recurring cost of the bag tags
- Capital expenditure (Capex): Roll-out of the RFID infrastructure (printers, readers, implementation and integration) from 2016 to 2021

The Opex is based on a deployment using single use bag tags only. Having a portion of the bag tags being multiple use will improve the financial figures as it will reduce the expenditures linked with the tags.

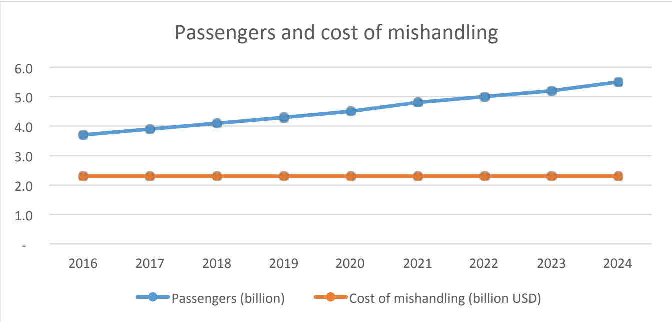
2016-2024: Cost of RFID - Capex and Opex



6.2. COST SAVINGS

The assumptions taken for the cost of mishandling for the period 2016-2024 are as per graph below.

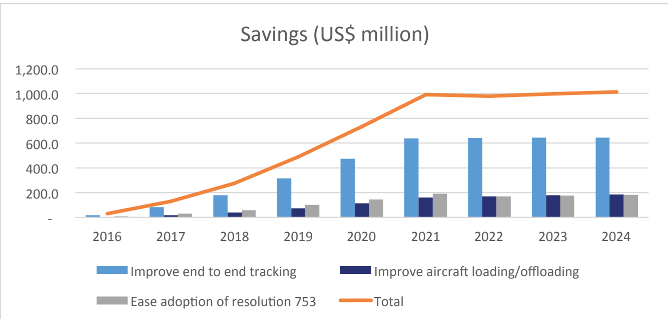
2016-2024: Projection in number of passengers and cost of mishandling



The savings are expected to be generated by:

- The improvement of the end-to-end-tracking, counting for around 65% of the global savings,
- The improvement in aircraft loading/off-loading, counting for around 15% of the global savings,
- The ease of adoption of IATA Resolution 753, counting for around 20% of the global savings.

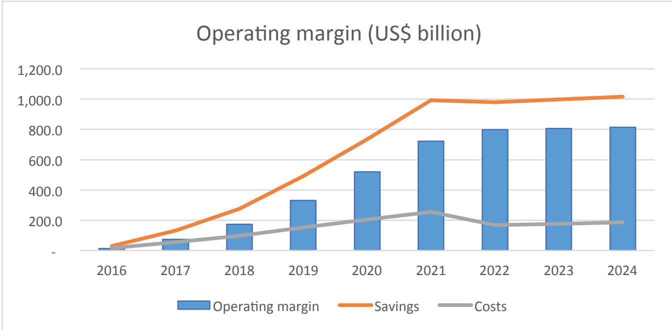
2016-2024: Expected savings linked with the adoption of RFID



6.3. RESULTS

The expected costs and savings shown in the previous sections, allow to estimate the operating margin associated with the adoption of RFID for baggage

2016-2024: Expected operating margin linked with the adoption of RFID



The operating margin is positive from the start.

The savings that could be linked with the adoption of RFID for baggage are far above the investment required to generate them.

The Net Present Value (NPV) has been calculated over 7 years (period 2016-2022) and is used to estimate the value of the future cash flows.

This NPV is calculated based on a discount rate representing the time value of money (earnings that could potentially be made using the money and inflation during the period), and also the risk or uncertainty of the future cash flows.

DISCOUNT RATE (%)	12%
NPV OVER 7 YEARS (US$)	**3.4 billion**

IATA FACT SHEET

MISSION

- To represent, lead and serve the airline industry.
- To be the force for value creation and innovation driving a safe, secure and profitable air transport industry that sustainably connects and enriches our world.

VISION

- To be the force for value creation and innovation driving a safe, secure and profitable air transport industry that sustainably connects and enriches our world.

LEADERSHIP

- Chair of IATA Board of Governors (2016-2017), Willie Walsh, CEO of International Airlines Group (IAG).
- IATA Director General and CEO: Alexandre de Juniac.

MEMBERSHIP

- IATA membership: 268 airlines in 117 countries.
- IATA members represent 83% of total scheduled traffic (Revenue Tonne-Kilometres, 2014).
- IATA members' total freight (scheduled) – 46 million tonnes in 2014, of which 31 million tonnes were international.
- IATA members' total freight tonne-kilometers (scheduled) – 189 billion tonne-kilometers in 2014, of which 165 billion tonne-kilometers were international.
- IATA members' total passengers 2014 (scheduled) – 2.2 billion, of which 1.0 billion were international .
- IATA members' total revenue passenger-kilometers 2014 (scheduled) – 4.9 trillion passenger-kilometers, of which 3.3 trillion passenger-kilometers were international.

HISTORY

- IATA was founded in Havana, Cuba, in April 1945.

IATA OFFICES

- IATA has 54 offices in 53 countries.
- Head Office: Montreal, Canada.
- Executive Office: Geneva, Switzerland.
- Regional Offices in Amman, Beijing, Madrid, Miami, Singapore.
- Also significant presence in Brussels, Moscow, Johannesburg and Washington, D.C.

IATA ANNUAL GENERAL MEETING & WORLD AIR TRANSPORT SUMMIT

- Formalizes industry positions on industry and public policy issues and provides a focus for emerging industry issues.
- Attended by representatives from IATA member airlines, industry partners, international and regional associations, manufacturers and suppliers and government.
- The first AGM was held in Montreal, Canada in October 1945.
- The 73rd AGM will be held in Cancun, Mexico on 5-6 June 2017.

IATA FINANCIAL SERVICES (2015)

- IATA financial systems processed some US$347.1 billion.
- IATA Clearing House (ICH) — US$54.3 billion.
- IATA Currency Clearance Service (ICCS) — US$33.7 billion.
- Billing and Settlement Plan (BSP) — US$230.3 billion.
- Cargo Account Settlement Systems (CASS) — US$28.8 billion.

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- Our vision is to be the chosen technology partner of the industry, a position we will attain through flawless customer service and a unique portfolio of IT and communications solutions that covers the industry's every need 24/7.
- We are the innovators of the industry. Our experts and developers keep it fuelled with a constant stream of ground-breaking products and solutions. We are the ones who see the potential in the latest technology and put it to work.
- Our customers include airlines, airports, GDSs and governments. We work with about 400 air transport industry members and 2,800 customers in over 200 countries and territories.
- We are open, energetic and committed. We work in collaboration with our partners and customers to ensure we are always delivering the most effective, most efficient solutions.
- We own and operate the world's most extensive communications network. It's the vital asset that keeps the global air transport industry connected.
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