RFID BUSINESS CASE FOR BAGGAGE TAGGING

DOCUMENT STATUS

REVISION

Version	Date	IATA StB - Authors	Notes
1.0	20.11.2006	↗ Andrew Price, RFID Manager ↗ Nicolas Bondarenco, RFID Deputy Manager	Initial Version
1.1	01.12.2006	↗ Nicolas Bondarenco, RFID Deputy Manager	Add of a new chapter (chapter 6)
2.0	12.12.2006	↗ Nicolas Bondarenco, RFID Deputy Manager	Updated version with Review Group member inputs. The Review Group is based on the involvement of baggage experts from the airlines and the airports.
2.1	30.6.2007	↗ Andrew Price, RFID Project Manager	Update for public release

REFERENCE DOCUMENTS

ID	Title	IATA StB - Authors	Notes
1	Extranet Discussion Forum – Summary, Version 1.0	↗ Nicolas Bondarenco, RFID Deputy Manager	This document contains all the Review Group member inputs asked by IATA.
2	Traceability Matrix - Comments on the Business Case	↗ Nicolas Bondarenco, RFID Deputy Manager	This document contains all the Review Group comments on the Business Case document and IATA updates traceability.

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Section 1 Executive Summary

The IATA Board asked the StB team to investigate RFID, as the Board realised that this technology has potential for many airline applications.

StB was asked to investigate the performance of the technology and examine the business case for the use of RFID in baggage handling. StB has done this and are able to report a positive business case based on the implementation of RFID across the industry - defined here as the top 400 airports.

The objective of this business case is to validate the main cost saving drivers and the industrial saving opportunities per stakeholder on the assumption of a big bang rollout. This roll out pattern has been chosen for purpose of simplicity, and the next stage of this project is to examine a realistic implementation pattern. The realistic implementation pattern will form the basis of recommended short and medium term implementation targets.

The adoption of the RFID technology for the sorting and handling of baggage along the global supply chain provides a Win-Win-Win for the three main stakeholders, the airlines, the airports and the passengers.

	WIN – WIN – WIN	Supported by
Airlines	$733 million per year savings: • $343 million by read rate improvement • $390 million by BSM inclusion	• IATA Campaign & World Tracer statistics • RFID trial results
Airports	• Optimize operating costs • Better manage the infrastructure • Enhance safety & quality control	• Industry Survey • IATA Airport Analysis
Passengers	• 5.7 million fewer passenger claims • Faster resolution of problems • Accurate & timely information	

Figure 1: The Win Win Win for stakeholders

IATA analysed the Win-Win-Win through activities completed in 2005 and 2006:

- IATA undertook an airline campaign that highlighted where airlines thought the baggage handling process failed. The main causes of failure were due to punctuality, which is not solvable with RFID. IATA found that out of the 20 baggage mishandled per 1,000 passengers 9.7% are due to poor barcode read rates and 11% are due to poor BSM handling.

- IATA undertook trials to prove that RFID could actually deliver a significantly higher read rate than the currently used barcode. Results showed that RFID could achieve 99% efficiency in the baggage environment.

- IATA conducted business investigations that showed that RFID Tag suppliers are currently trying to gain market share by offering low cost tags. The memory limitations of these tags prevent the inclusion of BSM (Baggage Service Message) information, denying 11% of the benefit from RFID. Lower cost tags, i.e. lower memory tags can only solve the read rate problem and so have a smaller impact on mishandling.

- One of the most revealing studies undertaken was at airports. Here IATA examined not only the bags that could be saved, making a real bottom line improvement for airlines, but also the additional effort of processing baggage for which the read rate was poor or for which there were BSM message failures. IATA found that baggage re-work items were reduced significantly, allowing an increase in efficiency for airports. This study needs further confirmation and there is an activity underway to determine the benefits for airports.

IATA has found that interpreting the RP 1740c can be a challenge to the market suppliers. IATA can take steps and simplifying the Recommended Practice, allowing more companies to produce and hence increased competition for airline business.

The business case presented in this document shows that the use of RFID in baggage handling would have a positive return for the industry. However, as this is a business case at an industry level it by definition does not cover the industry transition to RFID technology. IATA has therefore produced an RFID Transition Plan that considers a realistic move to RFID at 80 airports, covering 80% of the baggage claim files raised between February and April 2007. This transition plan would take 5-6 years to deliver, and as shown in this business case the reduction in baggage mishandling would be in the order of 20%.

However, leveraging on the fact that the business case describes all causes of baggage mishandling, the IATA Board tasked IATA to expand the scope of the RFID for baggage project to address also the cause of mishandling, which would not be addressed purely through RFID implementation. IATA will formalise a comprehensive baggage management assessment methodology and test a range of solutions, comprising of process and technology changes, at airports. This will lead to a refined solution set and targets for mishandling reduction that will be presented to the IATA Board for adoption. This approach forms the IATA Baggage Improvement Programme.

Section 2 Introduction

2.1 Positioning Statement

This report provides insight into the use, costs, benefits and limitations of RFID for baggage handling.

RFID in the StB Programme

RFID is one of the five projects comprising the StB programme, which aims to reduce costs and complexity whilst improving passenger convenience. Accordingly, the IATA Board of Directors, believing in the potential of RFID, tasked IATA to explore and prove the use of RFID in the baggage environment. In addition, StB was asked to evaluate the performance of the technology through trials and to produce a business case.

2.2 Issue Statement

Airlines have to carry baggage, and the infrastructure needed to take a bag from a passenger and return it to them at the end of their journey is both complex and costly. This results in a double impact for airlines, which face increasing mishandling rates due to the complexity and increasing charges due to the compensation costs when baggage is mishandled.

Last year the industry paid $1.21 Billion in direct compensation, and IATA estimate that the total industry costs, including labour, were $3.6 billion.[1]

The Montreal Convention (applicable to EU carriers since 2004) has three clauses that affect an airline's baggage operations. These relevant articles are:

- Article 3: Airlines must provide a unique baggage tag for each piece of baggage checked and the airline must notify the passenger in writing that the Montreal convention applies to their journey.
- Article 17: The carrier is responsible for damage caused to the baggage whilst in their care. A bag is lost if it takes more than 21 days to be returned to the passenger.
- Article 22: The airline must pay 1000 SDRs for destruction, loss, delay or damage to baggage, per passenger, unless the passenger declared a higher value at check in.

Passengers have not yet taken advantage of the increased liability of airlines to make claims. Each claim relates to the actual damage that occurs due to the baggage mishandling, but these damages are increasing due to the changing nature of checked luggage[2].

[1] Direct cost figures from SITA based upon 2005 passenger volume of 2.1 billion. Indirect costs estimated by IATA.
[2] When the UK government enforced new check-in rules in August for passengers' checked in items such as mobile phones and laptops. Such transitory regulation changes cause massive disruption.

2.3 A Global environment

The airline industry must adapt itself and become more flexible to face new challenges, low cost competition, to identify and set up new services and to cut costs:

- The increase of passengers and baggage volumes and the development of alliances as well as the increase of dual transfer flights require both solid baggage handling system and global high-level service.
- All the major airlines based their strategy on the Hub concept. In such a case, it is critical for those airlines to have an airport that is able to deliver all the services with a high level of performances, especially on transfer flights.
- The international or national regulations, such as baggage security control or the Montreal Convention, affect directly the bottom line of the airlines. The use of new screening machines, as well as the time to deliver baggage, has sometimes increased the opportunity for pilferage.
- The airline industry must develop an ability to respond to a rapidly changing regulatory environment. Recent changes enforced in the UK have lead to 25% month on month increase in the number of checked bags at UK airports. The impact of this increase will be noticed by the airlines in the next quarter.

The airports are also competing and are developing their own strategy to become more efficient and provide passengers and airlines with new services with high level of benefit:

- Airports have to adapt themselves to the demands of the airlines, whilst also managing their own infrastructure performance. Many airports are also preparing for the introduction of the Airbus A380, which will stress the processes for both passengers and baggage. While becoming more and more sophisticated, the poor barcode read rate tracking in the transfer process acts as an impediment to the adoption of a robust solution to process management and the addition of further barcode readers to improve the visibility of the baggage process is not actually realized due to the high investment needed to purchase automatic readers.
- This results in a low level of control and business process management. To increase safety, airports are required to develop fast, cheap, inspection processes whilst at the same time airports must reduce time and cost. The introduction of a real control mechanism would allow better delivery of the process through improved efficiency in resource usage and perhaps also improve working conditions as mundane and repetitive tasks could be reduced.
- In some airports, airlines require and pay for additional security services to limit baggage pilferage.
- Some airports have lost airlines to other airports to get better baggage handling process performances for their transfer flights and thus reduce passenger claims.
- The passengers are now more aware of the airport baggage performances, and frequently include airport choice in their purchase decision.

Passengers have a greater access to information and greater freedom of choice:

- A low service level, by a delayed, damaged or lost baggage, affects the customer satisfaction with potential direct loss of business and compensation costs.
- In Europe, the Association of European Airlines (AEA) communicates monthly baggage performance information from its airlines members and in USA the Department of Transportation produces a detailed monthly report covering baggage performance results from US airlines:

o This allows customers the opportunity to compare quality of service between airlines
o Improving positively or not customer perception and airline brand position.

Given this context, the need for a technology that can help overcome the issues described as well as rise to new challenges is great. The remaining question is: Is there a more robust solution to handle baggage that could be directly used and at what cost?

2.4 Scope/Purpose of Business Case

The business case presented in this report answers the question "would a move to the use of RFID for baggage tags from the current barcode system be sensible for the aviation industry as a whole?"
The business case is developed through an examination of the causes of baggage mishandling, the application of trial results of RFID technology to the baggage space and an analysis of the costs involved in migration to RFID technology.

Baggage operations are complex and vary greatly between airports. In addition, handlers at each airport operate in different ways. It is not possible to apply this business case equally to each airline at each airport of operation. However, the underlying method behind the business case is applicable universally in order to estimate individual benefits.

The following approach has been used to evaluate the business case and is described in Section 4 and Section 5:

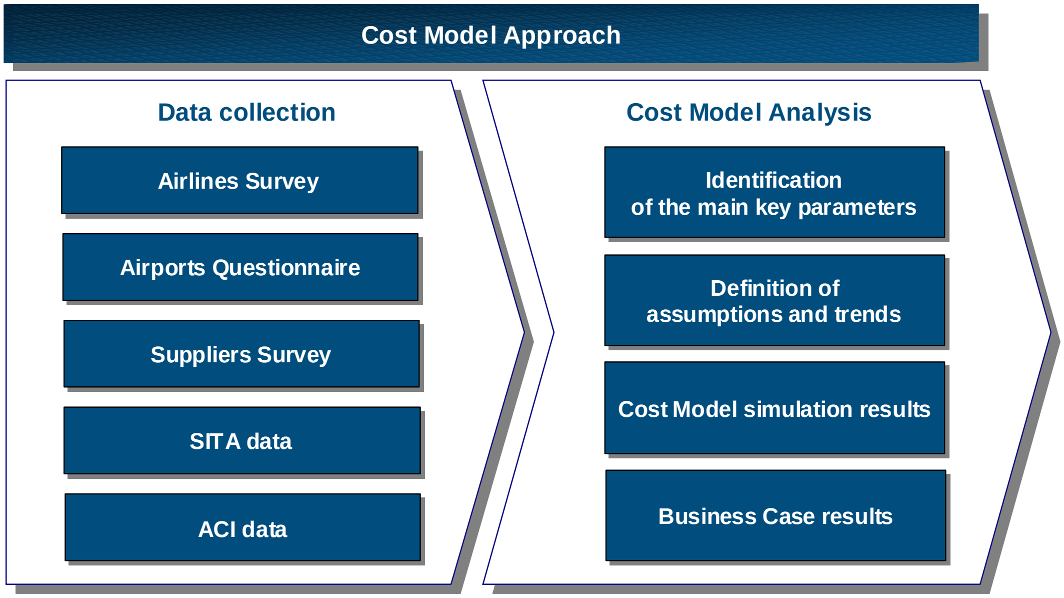


Figure 2: The business case approach

Section 3 Project Analysis

The RFID project team has considered all aspects of implementing RFID for airline baggage handling. These are:

- Why did IATA choose the UHF band and what are the implications of selecting UHF band?
- Are all systems components mature enough for use?
- What are the likely cost lifecycles of the components?
- Will technical advancements affect implementation payback periods?
- What product innovations are expected?
- Will environmental concerns impact RFID deployment?
- What regulations apply to RFID use?
- What barriers need overcoming for implementation?

Until 2005 the major barrier was the lack of standards. To date, the lack of guarantee that RFID tags could be read globally had detracted many from adopting the technology. The adoption of RP1740C at the passenger services conference in 2005 overcame this barrier. At the time of writing this report the scale of adoption to gain benefit was not known, however this is answered in the IATA Baggage RFID Transition Plan which considers implementation at airports involved in 80% of baggage mishandlings. The other main adoption drivers are detailed herewith:

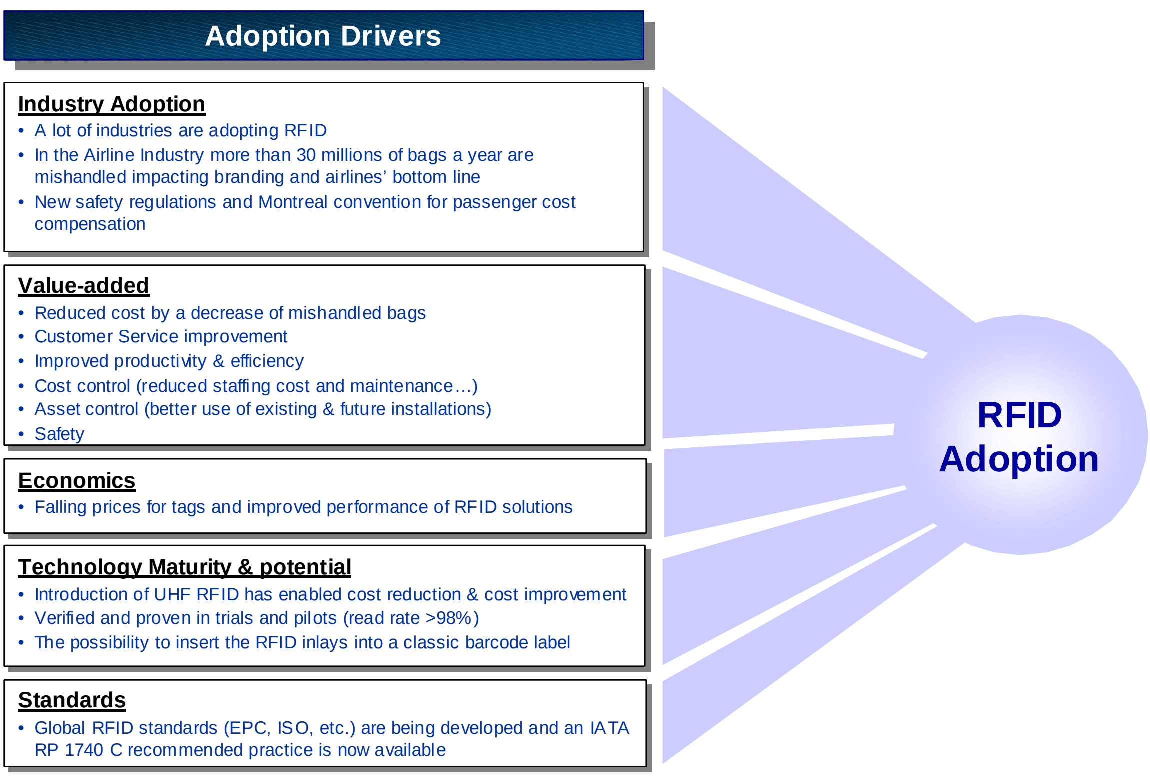


Figure 3: Adoption drivers for RFID

3.1 Why did IATA choose the UHF band for RFID?

Summary: *Radio regulations control the use of RFID, leading to the only global band allowing sufficient read distance and performance for baggage being UHF. The Transport Security Administration proved showed global interoperability using UHF tags. This result drove the Baggage Working Group to adopt UHF for RP 1740C.*

RFID is not a new technology. The physics and engineering behind RFID as a technology stem from the world of radar. It is therefore not surprising that the technology links closely to aviation.

1940's	1950's	1960's	1970's	1980's	1990's	2000+
↗ The IFF transponder, was invented by the British in 1939 and was routinely used by the allies in World War II to identify airplanes as friend or foe ↗ Another early work exploring RFID is the landmark 1948 paper by Harry Stockman, titled "Communication by Means of Reflected Power"	↗ The wheels of RFID development were turning ↗ Long-range transponder systems of "identification, friend or foe" for aircraft	↗ Commercial activities were beginning in the 1960s ↗ Sensormatic & Checkpoint were founded in the late 1960s ↗ These companies, with others, developed electronic article surveillance equipment to counter theft	↗ Developers, inventors, companies (Raytheon, Philips, GE…), academic institutions, and government laboratories were actively working on RFID and notable advances were being realized ↗ Interest in animal tagging was high in Europe	↗ The 1980's became the decade for full implementation of RFID. ↗ The greatest interests in were for transportation, personnel access and animals, toll roads	↗ RFID widely deployed in toll collection, animal tagging and personal identification and rail applications ↗ Development of the ultra-high frequency (UHF) RFID system ↗ UHF RFID got a boost in 1999, when the Uniform Code Council, EAN International, Procter & Gamble and Gillette put up funding to establish the Auto-ID Center at the MIT	↗ The Auto-ID Center gained the support of more than 100 large end-user companies, plus the U.S. Department of Defense and many key RFID vendors. It opened research labs in Australia, the United Kingdom, Switzerland, Japan and China. It developed two air interface protocols (Class 1 and Class 0), the Electronic Product Code (EPC) numbering scheme, and a network architecture for looking up data associated on an RFID tag on the Internet. ↗ Gillette buys 500 million tags from Alien Technology ↗ Wal-Mart & Department of Defense announce supplier mandates ↗ **More than 40 tests, trials or pilots have been conducted in the air transport domain (baggage, vehicles, cards, parts, conveyances and other assets)**

Table 1: The History of RFID

The airlines examined RFID for baggage in 1991. The costs of the technology were very high and products examined were proprietary. These factors placed RFID on a list of interesting, but not useful, innovations. The introduction of small, cheap HF (High Frequency) devices promised to overcome barriers to adoption such as price, performance and supply. A second technology working at the microwave frequency band was also looking promising. British Airways executed an IATA trial of the competing technologies. The trial aimed to prove that RFID improved the read rate for bar codes, which was then very poor at 55% for transfer baggage. The trial was a success, with read rates of over 97% in a live environment and proof that RFID could work for baggage identification. The issue was that costs were still high, at $0.33 per tag, and regulations prevented the use of HF technology globally.

The radio regulations in place lead to the need for 2 types of RFID. The recommended practice from IATA, RP1740C, was impossible to implement globally as no dual frequency readers existed.

The final issue that prevented the adoption of RFID for baggage was uncertainty that a poor read rate lead directly to mishandled baggage. This uncertainty went much deeper than solving a simple problem and attacked the entire reason for investigating the use of RFID.

Shortly after the end of the first IATA trial a new RFID technology was developed. This used the Ultra High Frequency (UHF) band and claimed many improvements over HF and microwave. Two critical success factors for this development were the promotion of RFID by a group called the Auto-ID centre and an investigation into the technology from Wal*mart. Initially problems plagued the technology, and claims made about performance and cost exacerbated the situation. The Auto-ID centre later formed EPCglobal, part of the GS1 organization responsible for the allocation of numbering systems. EPCglobal put forward a standard – EPC Class 0 – for the tags, allowing a fixed serial number to be stored on the tag. This was a number that they would own and allocate, with appropriate charging mechanisms. This did not affect the world of baggage, as the numbering system for baggage was already well established and owned by the airlines. However there was one exception. Delta Airlines were looking to improve the baggage performance at their Atlanta hub, and they did not use the baggage numbering system for sorting bags. Delta was free to choose a new approach, and believed that the use of an EPC allocated number would work. The problem was interoperability – a bag tag issued by Delta could not have been used by another RFID baggage system elsewhere. There were no other RFID baggage systems though.

EPCglobal introduced a new RFID tag, the class 1 tag. Data can be written to class 1 tags, although EPCglobal still allocates the numbers that could be used. The subscription model was well suited to retailers such as Wal*Mart and Gillette. The subscription model does not fit baggage though, as the numbers are allocated by the airline DCS. Paying EPCglobal for a number allocated by a DCS did not make sense. EPCglobal drove retail use and retail standards dramatically reducing the price of UHF tags. Finally, EPCglobal agreed a new standard, Class 1 Gen 2. The International Standards Organization (ISO) would ratify the Class 1 Gen 2 standard, allowing use of the technology without subscription to the numbering schemes owned by EPCglobal. ISO had already allocated an application identifier for baggage handling. The application identifier allowed airlines to use ISO standard tags for baggage handling with their own DCS allocated numbering system.

Nobody had proved the capability of the UHF technology as a mechanism for baggage identification. Nobody knew if UHF provided high read rates, how to encode a UHF tag or how UHF worked in the airport environment.

The Transport Security Administration of the United States of America (TSA) had been looking at RFID for baggage security. The TSA had sponsored projects using the microwave form of RFID at San Francisco.

When the TSA learnt of the new UHF technology they wanted to test it at an airport. Las Vegas was looking for a new inline security system at the time and it volunteered to be a test site. The use of RFID at Las Vegas showed that UHF worked with baggage, but global interoperability was not tested. Therefore, The TSA sponsored a trial to test encoding at the

US optimum frequency and reading at the EU and Asian frequencies. This trial was a success, proving that UHF is usable for global baggage handling.
Following the TSA trials IATA updated Recommended Practice 1740C for the use of RFID tags for baggage handling. The RP now contains a single frequency band for the use of RF tags on baggage. However the question of whether using RFID on baggage tags makes sense was unanswered.

3.2 Are all systems components mature enough for use?

Summary: *RFID components can deliver benefit today. RFID labels are mature; readers will become standard network devices. Baggage Tag printers need development to handle data streams for RFID in a flexible manner.*

RFID technology changes rapidly. Until recently, business focus has been on the development of the technology. With standards developed, there is an opportunity to pause and consider the business challenge.
There has never been a doubt that it is possible to read an RFID tag with high reliability and high accuracy. The first baggage trials achieved a read rate of 97.3% in 1998. These trials used readers made from copper pipes and wood, installed over a regular baggage sorter. Thirteen baggage-related trials have taken place for RFID, excluding the most recent trials planned by IATA.

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

Table 2 RFID Trials and Implementations

None of the trials listed above had a problem with read rates or systems reliability. Most of the trials closed successfully, and did not become implementations due to a lack of standards. Product maturity allowed radio regulations to be developed, which in turn allowed standardization.

Successful HF trials used well-developed and mature products from Philips and Texas Instruments. These products are not useable in the United States due to the limiting radio regulations in force. The read range required for baggage handling application is a minimum of 2 meters, which is not achievable at the permitted power. There were no such restrictions in Europe and the Far East. A further problem was the proprietary nature of the products.

The introduction of UHF RFID products offered a greater read range at permissible powers across the globe. The TSA and other trials have proved this possible.

The technology brings a number of advantages compared to the barcode solution:

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

Table 3: Bar code vs. RFID Costs and Capability

3.2.1 Other System Components

The RFID tags will form the major cost component for any system based on disposable tags. The other system components needed to make a useable system are the RFID readers to collect information from the tags and encode information to the tags and the integration of the readers into some meaningful data representation medium.

3.2.1.1 RFID Readers

Many varieties of RFID readers exist. There are stand-alone readers that will record anything passing through them. There are hand-held readers. There are shelf readers designed for small spaces.

Reader design now includes far more than basic reading. It is possible to have intelligence embedded into the reader. The intelligence is used to allow the reader to make informed decisions about the items it is reading – for instance, if an item is where it should be, when it should be, then is there a need for the reader to report anything at all? Reader intelligence also applies to the configuration and maintenance of the readers. This is a trivial task during a trial where there are a small number of readers, but a great complexity when there are several hundred readers in a major installation.

Whilst reader technology is maturing, there is still no plug and play reader available.
Antenna configuration is also an area where reader technology needs to mature. The configuration and alignment of antennas is a time consuming task for the initial phases of an RFID project. Configuration of the antennas must ensure that they do not cross interfere with other antennas on other readers, whilst also ensuring a gap free reading field. Different antenna designs have various performance characteristics and careful choices determine the correct design for an application. This area is likely to continue to develop.

Innovation will continue in development of readers and antennas. This will simplify the installation of RFID systems. Initially the cost of innovative designs will be high. The marketing of readers will develop along the lines of other network devices.

3.2.1.2 Baggage Tag Printers

Baggage tag printers are key components in the RFID system. The printer encodes the baggage license plate and other data into the tag and is the source for all the following processes. A poor encoder will cause problems across a network of airports. Standards for encoding are therefore critically important. The IATA Recommended Practice 1740C defines exactly how data is encoded onto the tag. It does not define how the data should arrive at the printer. There are currently two mechanisms for getting the data to the printer. Firstly, the printer may interpret the data stream and PecTab sent to it. The interpretation works well for the encoding of the license plate, as this is an easily identifiable data element. When this method is used, it is necessary to encode the date using a real time clock local to the printer, as the date of issue is not easy to decode from the PecTab. The second method of getting data to the printer involves modifying the PecTab so that an identifier precedes each data element. The printer can then encode the data elements as needed.

This is a very immature area, as there are no standards for the identification of data elements in the PecTab. The use of a real time clock is a proprietary solution that enables the encoding of the mandatory information from the Recommended Practice. If additional data needed to be encoded using the real time clock solution then it would be necessary to change the printer firmware to achieve this.

IATA and the AEA (Association of European Airlines) are addressing the lack of a good encoding mechanism for printers. The AEA owns the PecTab standard.

3.2.1.3 RFID Data Handling

The introduction of RFID to a process increases the amount of information that is available to describe the process. The introduction of RFID causes the volume of information needing interpretation to increase dramatically. There is a storage burden and system cost for making a sensible picture of the process. The maturity of this area depends upon investments already made in management reporting systems.

3.2.2 What are the likely cost lifecycles of components?

Summary: *RFID tags for a major airline should be in the region of $0.18 in volumes of 10 Million per year, RFID printers can be as low as $1,600 a piece and RFID Readers cost $1,500 for a simple reader and antennas, but up to $20,000 for a reader integrated into a baggage handling system.*

The RFID market place is very active. There are a number of new entrants eager to gain market share by undercutting traditional airline equipment suppliers, whilst traditional players are more experienced with successful implementations.

3.2.2.1 RFID Inlays and Tags

Several companies have made public announcements about the cost of RFID inlays and RFID labels. There is an important distinction between these two items. An inlay comprises of the RFID chip and antenna mounted on a substrate, normally plastic. A label consists of a paper base that contains the inlay.

RFID inlays have been publicly stated to cost $0.079 US per inlay in volumes of more than 1 million. UPM Rafletac made this statement. Avery Dennison has quoted RFID Labels at $0.159 US per label.

Many other manufacturers were quick to say that they could provide labels at the same cost, although this has not been borne out in practice.

3.2.2.2 Industry Opinion

The current prices quoted for labels are not realistic. At the prices quoted there are large losses being absorbed by the label manufacturers in order to gain market share. The process of making an RFID label for use in baggage that conforms to IATA RES 740 for disposable tags does not take advantage of actual manufacturing capacity, as the normal label run is about 7 labels wide and the RFID process limits this to only 4 labels wide. There is thus a loss of efficiency.

A further consideration is the volume of the RFID labels that are being produced and the volume of RFID labels being purchased. The global production capability for RFID inlays is around 2 billion per year. The aviation market uses less than 100 million of these inlays, so there is further wasted capacity. The retail market absorbs some of this capacity.

Finally, the production of the RFID inlay itself is a relatively slow process. Once the actual silicon has been assembled the chip needs to be mounted onto an antenna. The pick and place systems used for this must run slowly due to the physical size of the antenna (you can fit fewer large antennas into the machine).

Product innovation and investment in new machinery will overcome these limitations, but only when the aviation market makes a solid commitment to the industry that justifies the necessary investment.

3.2.2.3 RFID Readers

An off the shelf RFID reader with 4 Antennas is a relatively low cost item. The IATA RFID team have purchased such a reader from Quatrotec in San Francisco for $1,500. The problem is that the reader really does not do very much as a stand-alone item. At the very least a PC is needed to control the device and a suitable framework is needed to mount the antennas.

3.2.2.4 Reader Integration

The reader needs to be integrated with the baggage handling system. It takes into account costs that cover the housing (tunnel / portal structure in place), the commission (tests) and the PLC integration. Current estimates are that this will require an investment $5,000 per reader for housing (tunnel / portal structure in place), $5,000 per reader for commission (tests) and around $100,000 for PLC integration - based upon the installation of a around 30 readers, for a big airport. For a medium size airport, the PLC integration is estimated at $50,000. This represents a significant saving over the use of barcode 360 readers that cost between $75,000 and $200,000.

3.2.2.5 Readers working together

Making RFID readers work together in a confined space also adds to the cost of the system. Whilst RFID readers require very little maintenance, the initial set up to ensure that the readers are not interfering with each other is at least as time consuming and complex as setting up a barcode scanning array.

3.2.2.6 RFID Printers

RFID printers are often normal baggage label printers that have been modified to use RFID. There are modification kits available from IER and Intermec, whilst complete RFID printers are available from Vidtronics. Toshiba are also new entrants to this market.
The way in which the printers work is also important. Some printers are directly compatible with the airline DCS without having to make modifications to the PecTab. Other printers are need modification to the PecTab to provide the data elements in a certain order. The cost of modifying the PecTab should be borne in mind.

3.2.3 Will technology advancements affect implementation payback periods?

Will a new generation of RFID tags supplant UHF, as UHF supplanted HF and Microwave in the baggage handling recommended practice? Other frequency bands are not under consideration. Regulations have ruled out the HF and Microwave bands as a global proposition for the baggage application. The low frequency band, around 125 KHz, is costly to manufacture and therefore not possible to implement. Frequencies beyond microwave, around 5GHz, are still undeveloped and perhaps more likely to be used for next generation mobile communications.

UHF is uniquely suited to global logistics issues. This has been born out by the adoption of UHF by companies like Wal*Mart for their global RFID implementation.

There will be other class-1 generation-n implementations of the technology. The entire class-1 range of products will remain compatible – readers for the class-1 generation-2 tags are capable of reading class-0 and class-1 generation-1 tags. There are performance and power refinements in the generation-2 products that make them more useable in the logistics space. Wal*Mart has mandated an early move from generation-1 to generation-2. This has effectively closed the market for generation-1 tags, and users of these tags may have procurement issues in the next 2 years. If airlines adopt RFID for baggage handling then the volume of tags needed to supply the market would be sufficient to ensure supply upon the introduction of generation-3 products. A public road map for generation-3 products is not available.

There will also be class-Y generation-n developments. There are definitions for the Class-1, Class-2, and Class-3 products from EPCglobal.

EPCglobal Class Number	Tag Type
Class-0	Passive Anti-theft read only
Class-1	Passive or Active – Identification – read / write
Class-2	Passive or Active – Data Logging – read / write
Class-3	Semi-Passive / Active – Onboard Sensing – read / write

Table 4: Tag types

There is no clear definition of how much memory a tag classifies a tag as a class-2 as opposed to a class-1 tag. Class-1 and class-2 tags should be interpretable. An example of a class-2 tag could be the Boeing active tag for parts identification.

It is unlikely that the introduction of class-2 or class-3 tags will make an investment in current technology redundant.

3.2.4 What product innovations are expected?

Component	Expected Innovation	Time frame
RFID Tag	Increased memory size. Current 96 bit tags will be complemented by 512 bits and greater	Small-scale 512-bit production is underway with aggressive licensing
RFID Label	Increase in production width for production	With multi-million tag orders – 2007
	Standard RFID tag to reduce cost of production	2008
RFID Readers	Inclusion of network edge functionality	2007
	Dense reader modes proved	2007
	Increased singulation and directional feedback	2008
	Useability wizards (auto set-up, Application selection, location templates)	2008
	RFID Intelligent services in reader	2008
RFID Printers	Data elements identified within pectab	2007
	Airline pectab changes	2008-2012
RFID Information Systems	RFID extensions to available systems	Some ERP systems currently available with RFID

Table 5: Innovation time frame

3.2.5 Will environmental concerns impact RFID deployment?

Summary: *The WEEE directive probably does not to apply to RFID baggage tags.*

The Waste Electrical and Electronic Equipment directive from the EU specifies that devices relying upon electronic current or electro-magnetic fields as a source of power must be sorted and recycled.

EU directives are seldom specific and clear in their advice, and the vague nature of the directive does not make it clear if RFID tags are included. The DTI Guidance states that for products that do not require the electrical and electronic components to fulfil their primary function, the directive does not apply.

Evidently, whilst attached to a bag the primary function can fulfilled without the use of the electrical components. In this case, the primary function of the bag and tag as a whole is to carry the owner's belongings. Removing the label from the bag changes the primary function of the tag to identification. It is possible to perform this function without the electrical components, but the reason for the components is that it improves the function.

It would seem from the guidance that the spirit of the directive is not to force the recycling of RFID tags used as labels (certainly tags in toys do not come under the directive).

3.2.6 What regulations apply to RFID use?

Summary: *Each country sets regulations that provide an unlicensed use of RFID.*

The International Telecommunications Union (ITU) is responsible for regulating the global use of the electromagnetic spectrum. The ITU has three administrative regions that group policy for each area of the globe. In practice, these span the Americas, Europe and Asia. Ultimately individual countries allocate spectrum according to the guidelines set by the ITU.
RFID broadly falls into an unlicensed spectrum known as Industrial, Scientific and Medical. This unlicensed area exists to allow equipment such as home wireless networks to exist without obtaining licenses for individual equipment. This is essential for large RFID installations.

Most countries have allocated additional spectrum for RFID. Those that have not will do so in the near future. In addition to allocating spectrum, the countries also define the power and the duty cycle at which equipment may operate. For instance, the UK has recently provided spectrum between 865 and 868 MHz, with a 10% duty cycle at 2 watts ERP.

The result of these regulations is that an RFID Reader must comply with the regulations set by the country in which it operates. A passive RFID tag that responds across the entire 850MHz to 960MHz band, only reflecting energy to an interrogating reader, may be used anywhere in the world.

3.2.7 What barriers need overcoming for implementation?

The main barrier that prevented the adoption of RFID was the lack of standards. This is no longer the case, as the standards issue is now resolved. The main barrier to adoption is now the lack of a business case that is appealing to the industry. This report presents such a business case and the conditions for implementation.

The remaining major barriers that need overcoming are:

- A lack of skilled integrators: A small number of people completed most of the world's RFID installations. This means that the real skill base for RFID is still quite small, despite many people claiming skills. In order to address this IATA has prepared training materials to enable an in-house IT department identify appropriate partners.
- Belief in the Big Bang; Many people claim that RFID needs to be implemented everywhere to achieve full benefits. Whilst this report is based upon a 100% implementation, the actual transition will not be possible as a big bang due to the limited resources available to the industry. An IATA analysis of baggage mishandling presented in the IATA Baggage RFID Transition Plan shows that 80 airports need to be equipped with RFID to get global benefit, as this would cover 80% of all baggage mishandling.
- Privacy concerns and lack of proper public consultation can create a public backlash. Fear of this backlash can result in a hesitation to implement. Clear rules on the data elements encoded and the use of data must be created.

Section 4 IATA Surveys & data collection

This Section covers the data gathering required to build the Business Case.

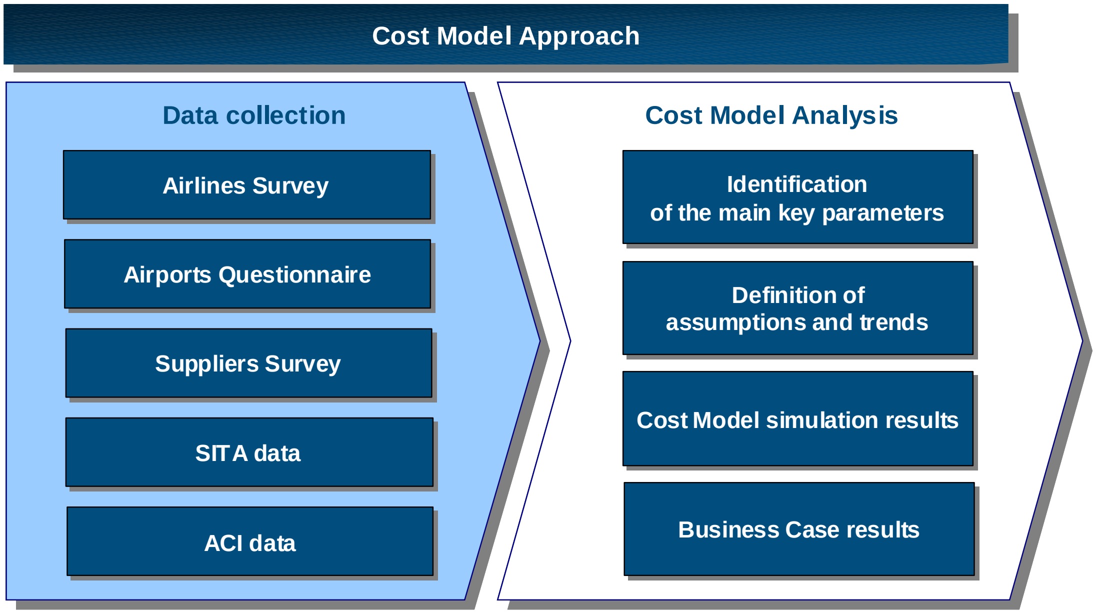


Figure 4: Business Case Data Collection

4.1 Main objectives

The main objectives of each research are described below:

Airlines Survey	• Airlines position regarding RFID • Baggage mishandling reasons - distribution
Airports Questionnaire	• Airport position regarding RFID potential benefits • Baggage mishandling reasons - distribution • Existing infrastructure data for calculation of material replacement
Suppliers Survey	• Refine real cost of RFID tags based on large volume purchase, benchmark suppliers • Examine and optimise various proposals for rollout which are technically feasible to install
SITA data	• Amount of mishandling baggage distributed per type (delayed, damaged, lost…) per 1000 passengers • Cost distribution per mishandling baggage type
ACI data	• Passenger volume for each airport for RFID cost calculation

Figure 5: Business case research objectives

4.2 Airline Survey

In May 2006, IATA launched a campaign, involving 361 airlines. The main objectives were to:

- ↗ Determine the airline position about the RFID
- ↗ Identify the airline needs and interests
- ↗ Help to validate and define RFID priorities

4.2.1 Scope of the survey

- ↗ Airline scope
  - o 361 airlines:
    - ▪ 198 airlines being IATA and MITA members
    - ▪ 15 airlines being IATA member only
    - ▪ 79 airlines being MITA member only
  - o Airline types – distribution:
    - ▪ 263 Passengers & Cargo
    - ▪ 64 Passengers only
    - ▪ 34 Cargo only
- ↗ Functional scope
  - o Baggage Handling
  - o In-Flight
  - o ULD Asset Management / Pallet Management
  - o Parts Management
  - o Freight

4.2.2 Airlines position regarding the use of RFID in the air industry

Half of the airlines think that RFID will offer real benefits while the non-convinced airlines argue that:

45%	No ROI	↗ Cost is too high (28%) ↗ No Business Case available (8.5%) ↗ Additional cost while low amount of lost/mishandled bag (4%) ↗ The IT applications can solve the problems (1.5%), etc.
11%	Not at the moment	↗ Not yet ready, no project plan ↗ Not yet evaluated, no visibility...
6%	Technology not mature	↗ Technology not tested / must be improved ↗ When technology available in local market ↗ Not aware of this technology, limited understanding
15%	Other	↗ Not applicable (5%) ↗ Have no idea (4%) ↗ Lack of internal resource / expertise (2%) ↗ Manual system in place ↗ Etc.
23%	No comment	

Table 6: Airline positioning regarding RFID

Whilst across the entire survey there was an even balance between those believing in the benefits of RFID and those doubting them, 60% of the top 50 airlines (by passenger volume) believe RFID offers the industry real benefits.

4.2.3 The main reasons for baggage mishandling

IATA surveyed airlines on their understanding of the reasons and proportions for bags being mishandled. Among the main reasons, the airlines identified two areas where the RFID can fix the issues:

- Barcode reading problems as causing 9.7% of all mishandled baggage and
- Failure to receive a BSM message as contributing to a further 11% of mishandled baggage.

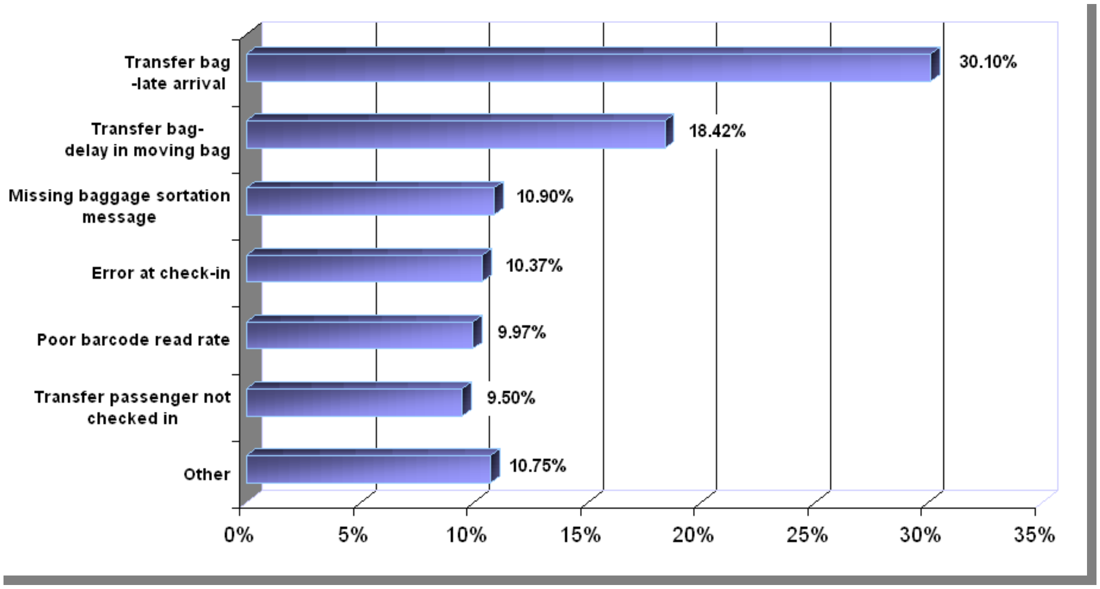


Figure 6: Reasons for baggage mishandling

As shown later, the first issue related to poor barcode reading can be fixed by the use of a cheap RFID tag while the second issue mentioned would require the use of a more expensive tag in which large amount of data could be recorded.

Further reasons (other) were given for baggage mishandling:

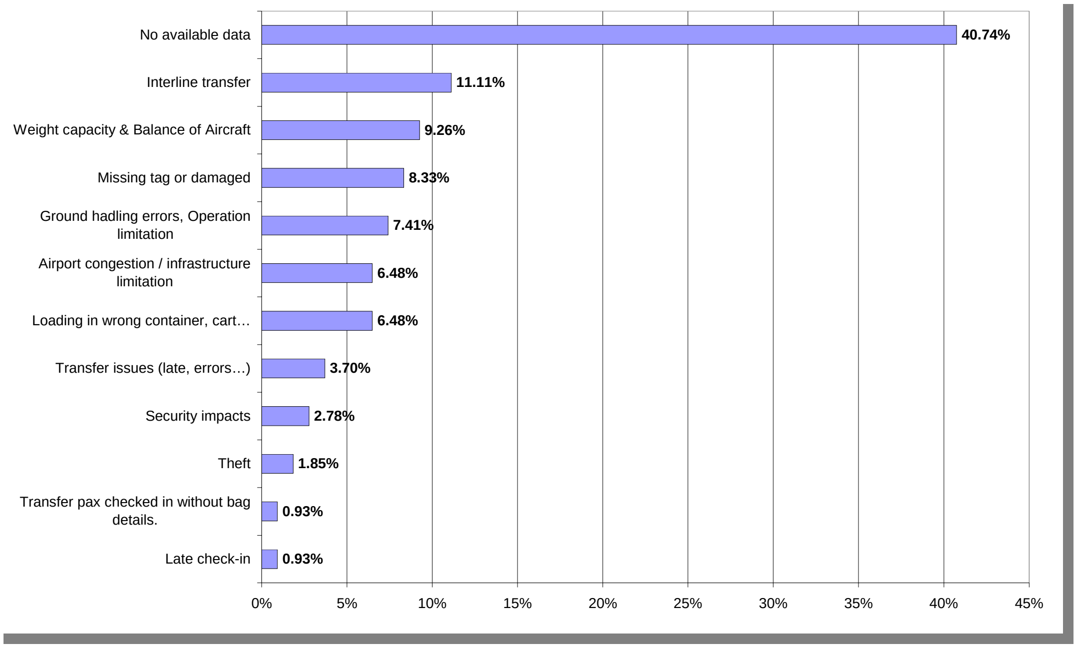


Figure 7: Categories of mishandling in "other" group

Some of the reasons highlight a lack of information availability, errors in the operational processes and infrastructure limitations for instance.

As the number of passengers is predicted to increase by around 5% per year, the infrastructure limitation as well as potential new security regulations will affect global baggage performance adversely. The growth in baggage may greatly outstrip the growth in passengers if restrictions on liquids allowed in hand baggage and the number of hand baggage items are maintained.

Around half of the airlines surveyed were not able to provide detailed data about mishandling reasons showing a gap of knowledge and limiting the possibilities to improve the baggage supply chain. Without a track and trace solution, finding solutions to minimize and control risks will be more difficult.

4.3 Airport Questionnaire

In September 2006, IATA conducted a worldwide survey on a limited and representative number of airports in order to:

- Consolidate information regarding the main drivers to consider for evaluating investment cost for replacing barcode solution by RFID
- Collect key elements to build its cost model analysis
- Communicate about IATA involvement on RFID
- Understand the airport position regarding the use of RFID

The collected answers came from airports in North America, Europe, Commonwealth of Independent States and Asia regions.

4.3.1 Infrastructure key elements

In order to evaluate the cost of replacement of the actual barcode materials, IATA asked the surveyed airports to provide them with their following actual equipment volumes:

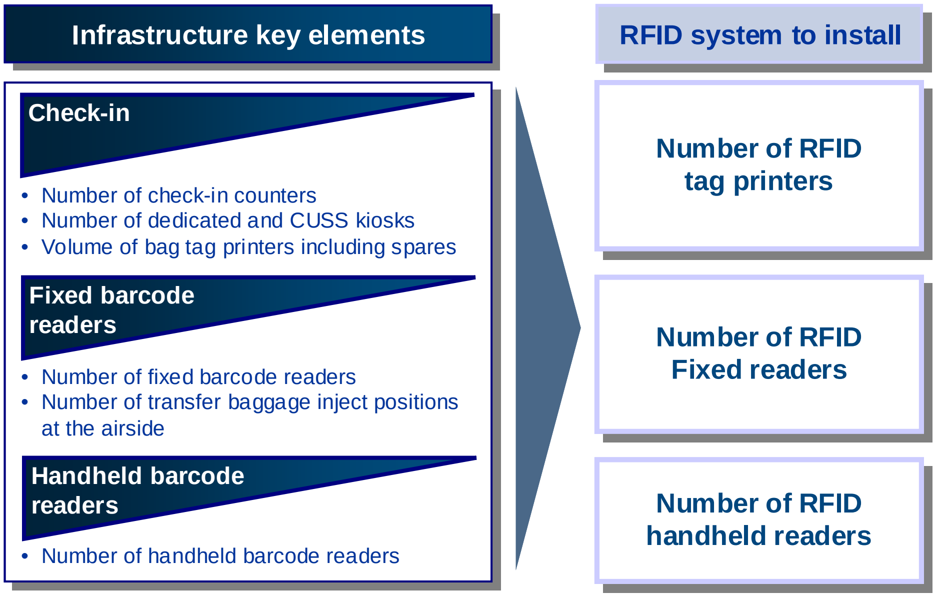


Figure 8: Key infrastructure elements

4.3.2 Barcode performance

Some airports provided very good read rates for both direct and transfer flights. This is usually due to staff scanning baggage tags with a hand held scanner at strategic points in the baggage system. Other airports use automatic systems, but perform some baggage label straightening and bag alignment when the bags are introduced to the baggage system. Both of these methods increase manual handling, therefore reducing security and increasing cost.

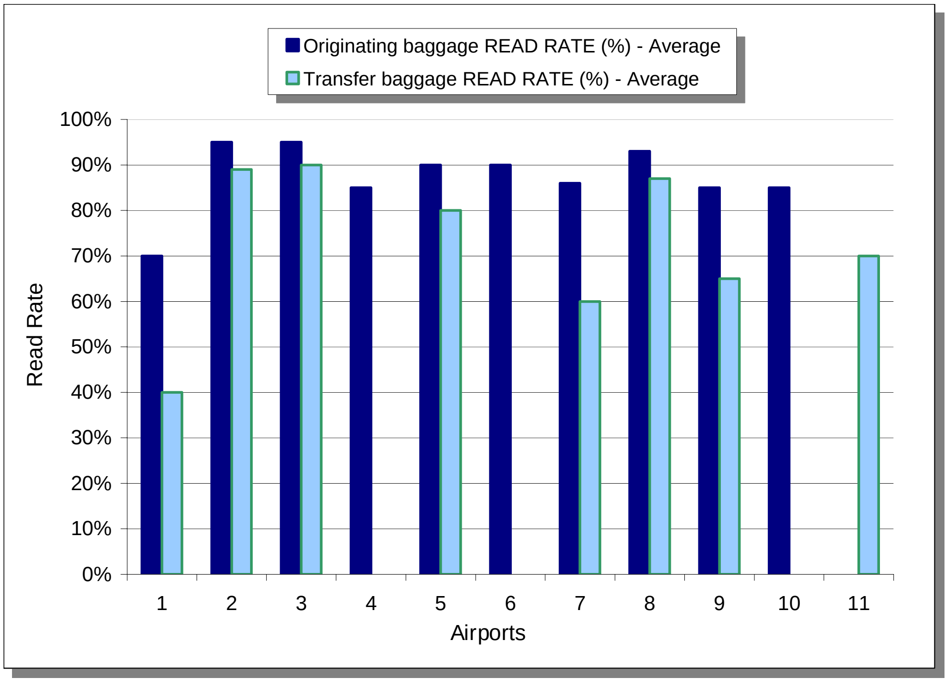


Figure 9: Barcode performance measurements

Airports remain interested in RFID and additional airports are planning RFID baggage trials. Examples of these are San Francisco, where RFID is being introduced for security and Sydney, where RFID is being evaluated to overcome poor read rates. Airports are generally unable to implement RFID without the consent of their operating carriers.

4.3.3 Potential performance improvement by the use of a global RFID solution

Considering different categories of airports based on their existing infrastructure and process support (fully, partially, not automated) the use of RFID could benefit to those different categories as follows:

	Infrastructure	Added Value	Level
Control bag	Security screening in-line	• Enhance a safety 100% reliability control • Security tracking improved (fewer high level re-screens due to bag movement) • Security status information encoded into the tag	++
Control bag	Bags carried manually	• Baggage track & trace for a proving process step control (use of a portal tracking)	+
Sort bag	Belt Conveyor	• Reduce mishandled baggage via very good read-rate (PLC confirmation) • Good visibility • Faster rework when necessary (for long belt) • Better Theft control	+++
Sort bag	DCV or Tilt Tray sorter	• Multiple bag detection • Confirmation of eject	(+)
Sort bag	Manual	• Baggage track & trace for a proving process step control (use of a portal tracking)	++
Store bag	Automated Store	• Baggage in & out unique identification tracking (above PLC level) • Matching of bag to store tote	+++
Store bag	Manual Store	• Time speed increase for loose bag control (scan of many baggage at once) • Better baggage inventory tracking and where (introducing a low cost IT solution)	++
Reconcile & load bag	Reconciliation system	• Time speed increase / efficiency • Manual loading – hands free reconciliation • Reduce operating cost (one ground handler required to reconcile & load bag)	++
Reconcile & load bag	Manual Reconciliation	• Time speed increase / efficiency • Manual loading – hands free reconciliation • Reduce operating cost (one ground handler required to reconcile & load bag) , with a low cost IT solution • Improve security of reconciliation process	+++

Table 7: Potential operational areas for improvemen

4.4 Supplier Survey

In August 2006, IATA conducted a survey with the main RFID suppliers in order to:

- Refine real cost of RFID tags based on large volume purchase
- Examine and optimise various proposals for rollout, which are technically feasible to install.

4.4.1 Label cost

IATA recently asked a number of suppliers of RFID labels for their costing strategy. The prices reflected the following trend.

From the right you can see how the volume of sales affects the price. All of these prices are higher than the current prices quoted in the press.

Baggage labels are available from Print-o-Tape, Toshiba, Security Label GmbH, IER, Symbol and Bartsch.

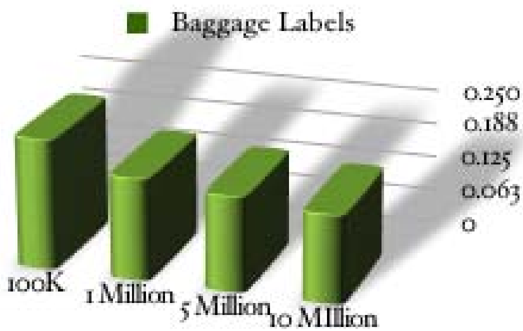


Figure 10: Baggage label costs by volume

4.4.2 Reader cost

There have been no responses to the requests for information on volume pricing of RFID readers. The actual cost will vary considerably according to the complexity of the environment into which the readers are being installed.

4.4.3 RFID Printer cost

RFID printers are often normal baggage label printers that have been modified to use RFID. There are modification kits available from IER and Intermec, whilst complete RFID printers are available from Vidtronics. Toshiba are also new entrants to this market.

The way in which the printers work is also important. Some printers are directly compatible with the airline DCS without having to make modifications to the PecTab. Other printers are need modification to the PecTab to provide the data elements in a certain order. The cost of modifying the PecTab should be borne in mind.

The IATA Survey responses contained information for the supply of complete baggage tag printers, rather than the supply of conversion modules. Some traditional suppliers did not respond, and the prices quoted ranged from $1,600 to $1,800 depending upon the number ordered.

Recent discussions with the major supplier of RFID readers and modules have brought up an interesting debate on the cost of converting a printer to include RFID. This supplier believes that they can beat the price quoted by a considerable margin.

4.4.4 RFID Cost Summary

Bag tag Printers	↗ RFID printers are often normal baggage label printers that have been modified to use RFID.	↗ **$1,600 - $1,800**
Labels	↗ There is an important distinction between inlays and labels. An inlay comprises of the RFID chip and antenna mounted on a substrate, normally plastic. A label consists of a paper base that contains the inlay.	↗ **$0.10** (label) incremental (for 10 million per year)
Readers	↗ An off the shelf RFID reader with 4 Antennas is a relatively low cost item ↗ The reader needs to be integrated with the baggage handling system. This will require an investment of: ↗ $5,000 per reader for housing (tunnel / portal structure in place), ↗ $5,000 per reader for commission (tests) and ↗ around $100,000 for PLC integration - based upon the installation of 28 readers, for a big airport and $50,000 for a medium size airport	↗ **$1,500 - $2,500** ↗ **$380,000** (big airports)
Airport implemen-tation	↗ This investment covers the set up of a track & trace solution that will provide the foundation of an efficient solution reinforced by the RFID system (S/W & H/W solution)	↗ **$1,000,000** (big airports) ↗ **$350,000** (others)

Table 8: Summary of RFID costs

Label precision:

- A 'cheap' RFID tag, with incremental cost of $0.10, can eliminate reading errors of barcode tags causing 9.7% of all 'mishandled' bags
- An 'expensive' RFID tag, with incremental cost of $0.30, can eliminate dependence on BSM messages whose current failure causes 11% of all 'mishandled' bags

4.4.5 RFID Rollout

Today, only a few suppliers are able to install a complete RFID baggage handling solution at an airport. For a large rollout plan, it is necessary to take into account a realistic number of airports that could be equipped each year.

- An RFID supplier can handle 10 airports a year
- The set up of a full operational RFID system depends of the airport size:
  - For a big airport: 3 months[3]. This is a study state rollout based on companies having gained experience from previous implementations. It will take considerably more than 3 months for the first airports to equip. In the cost / benefit analysis, benefits have not been included at all for the first year.
  - For a small airport: 6 weeks[4]
- As 3 main suppliers are able to provide this service, we can reasonably assume that 30 airports can be equipped during the first year.

If the airport transition business proves to be a successful one then we can expect this figure can be increased by a factor of 1.5 the second year and a factor of 2 the third year. This leads to a number of 135 airports potentially equipped after 3 years.

[3] Estimate based on supplier interviews
[4] Estimate based on supplier interviews

4.5 SITA Mishandling Baggage data

4.5.1 Mishandling distribution

Mishandling occurs for a number of reasons, and not all of these reasons may be addressed with the introduction of RFID. SITA collect data on global baggage performance and document the causes of mishandling.

In 2005, the single largest cause of baggage delay was in transfer baggage mishandling, with 61%.

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

Table 9: World Tracer mishandling reasons

Transfer Baggage Mishandling

Nearly two-thirds of all baggage delays (61 percent) are attributed to transfer baggage mishandling. This may not mean that all those bags are delayed in the transfer section of their journey. However, it takes longer for bags to reach a connecting flight than for passengers to reach that same flight. In recognition of this, ATA and IATA established minimum connecting times for each individual airport, largely based on the time needed to transfer baggage. However, flight delays -- caused by severe weather, air carrier maintenance or crew problems, air traffic control problems, or security delays -- can reduce the actual time available to make a connection, resulting in delayed baggage.

Failure to Load at Originating Airport

The second most common cause of baggage delays (15 percent) is a failure to load the bag at the originating airport. This can occur when a passenger checks in late, or there is a last-minute gate change. It can also occur if the barcode on the baggage tag is not read properly when the bag is being sorted. When this happens the bag is automatically sent to a default area where the baggage tag has to be read manually.

Ticketing Error/ Bag Switch/ Security/ Other

This category represents nine percent of delays. "Ticketing error" occurs when the wrong flight number is recorded on a ticket, and therefore the baggage tag. This is less of a problem now than it used to be due to the increased use of automated systems. "Bag switch" occurs when a ticketing agent places one passenger's baggage tag on another passenger's bag. Baggage delays caused by security are also included in this category. For example, a back-up in security screening at the originating airport can result in a bag missing its flight. According to SITA, a failure to load due to security delays would be reported in this category, rather than the more general "failure to load" category.

Loading/ Offloading Error

This category represents just four percent of delays. Examples of loading errors include a bag that is put on the wrong airplane, or a bag that is put in the wrong area of an airplane, resulting in it not being off-loaded correctly at the transfer airport. Examples of offloading errors include a bag that is not transported to the baggage claim area in a timely manner once it arrives at the destination airport, or a bag that is inadvertently mixed in with connecting bags at its destination airport.

Other Causes of Baggage Delay

Space-weight restriction delays (representing five percent of all delays) occur when there is not enough room on-board a particular aircraft for all baggage. Arrival station mishandling (causing three percent of delays) is similar to "offloading errors," discussed above. Tagging errors (also causing three percent of delays) occur when a tag with a damaged barcode is placed on a bag, or the wrong information is placed on a baggage tag. Again, this is less of an issue today, with the use of automated systems.

Average Time a Bag is Delayed

According to SITA, the WorldTracer inventory shows that the average delayed baggage file is open for 1.3 days, or 31.2 hours, from the time the bag is entered in WorldTracer to when it is found and restored to its owner. It should be noted that the time the customer files a lost baggage claim and the time the claim is entered in WorldTracer are not necessarily the same. In its February 2001 Final Report on Airline Customer Service Commitment, the DOT Office of Inspector General (OIG) stated that it found instances where customers' claims were not entered into WorldTracer until several hours after the customers' claims had been filed at the baggage claim office.

In Europe last year, 21% of flights were delayed and irregularities in baggage delivery performance were experienced for up to 14.1 bags per thousand passengers compared to 13.9 in 2004 (Source: Association of European Airlines Consumer Report).

It is difficult to obtain exact information on the total number of checked bags, and how many of those bags are mishandled. SITA1, a cooperative venture owned by the airline industry, estimates that 3 billion bags were checked worldwide in 2005, and approximately one percent (30 million) of those bags was mishandled. According to data reported to the U.S. Department of Transportation, approximately 3.6 million bags were mishandled in the United States in 2005. If the ICAO figures of 2.1 billion passengers are used with the SITA figures then the number of mishandled files is 28 million, with 1.47 bags per file. Obtaining an accurate number of bags carried globally is an essential element of the business case as this determines the primary cost of using RFID with baggage – labelling the bags.

4.5.2 Cost distribution

The following cost information is from the Baggage Information Repository Worldwide Statistics – 2005

No. of mishandlings per thousands	Value
Delayed Bag Files per 1000 Passengers Enplaned	11.4
Damaged / Pilfered Files per 1000 Passengers Enplaned	1.8
Lost / Stolen / Not Located Files per 1000 Passengers Enplaned	0.46
Average cost per mishandling	**Value**
Actual OPE (Out of Pocket) Costs or Reimbursement Paid	
Delayed	USD$ 21.90
Damage / Pilferage	USD$ 92.27
Lost/Stolen/Unable to be located	USD$ 348.70
Average delay	**Value**
Average Delayed Baggage File is open (time from creation to closure)	1.3 days
Average number of bags per delayed baggage file	**Value**
Average number of Bags per Delayed Baggage File	1.47 bag

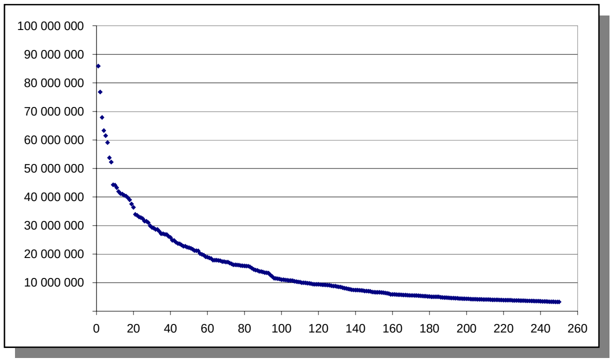
Table 10: World Tracer baggage mishandling figures - courtesy of SITA

4.6 ACI & ICAO data

4.6.1 ACI data

The Airports Council International (ACI) have provided IATA with airport passenger figures and ranking for the first 800 airports (based on Airports participating in the ACI monthly traffic stats collection).

Passenger volume by airport



Airport - Passengers Analysis

Number of airports	Number of passengers	Total pax (%)
Top 40	1,603,012,577	39.98%
Top 50	1,837,379,485	45.82%
Top 60	2,042,357,491	50.94%
Top 70	2,220,493,613	55.38%
Top 100	2,652,421,799	66.15%
Top 150	3,095,497,324	77.20%
Top 200	3,363,071,015	83.88%
Top 250	3,551,314,610	88.57%
Top 400	3,846,034,346	95.92%

Figure 11: Airport passenger volumes and weightings

Total Passengers definition: Terminal Passengers are arriving and departing passengers. It includes transfer passengers who are counted twice (on arrival and on departure from the airport). It excludes direct transit passengers.

The first 400 airports represent a total number of 3,846,034,346 passengers with a marginal number of airports not included in ACI figures regarding the global volume. If we consider all the airports, this number is around 4 billion. This figure is different from the real number of passengers carried by the airlines (around 2 billion).

4.6.2 ICAO data

Following the International Civil Aviation Organization (ICAO), in 2005 the number of passengers carried was: 2,022,768,000.

Passengers carried definition: The number of revenue passengers carried (i.e. passenger for whom the carriers receive commercial remuneration) should be obtained by counting each passenger on a particular flight (one that has the same flight number throughout the journey of the passenger) only once and not each individual stage of that flight, with the single exception that a passenger flying on both the international and domestic stages of the same flight should be counted as both a domestic and an international passenger.

4.7 AEA Missing Baggage data

The Association of European Airlines provides airline figures showing the rate of baggage reported missing upon the passenger's arrival at their final destination per 1000 passengers transported by each carrier. On average 85% of the missing bags are traced and delivered to the passenger within 48 hours.

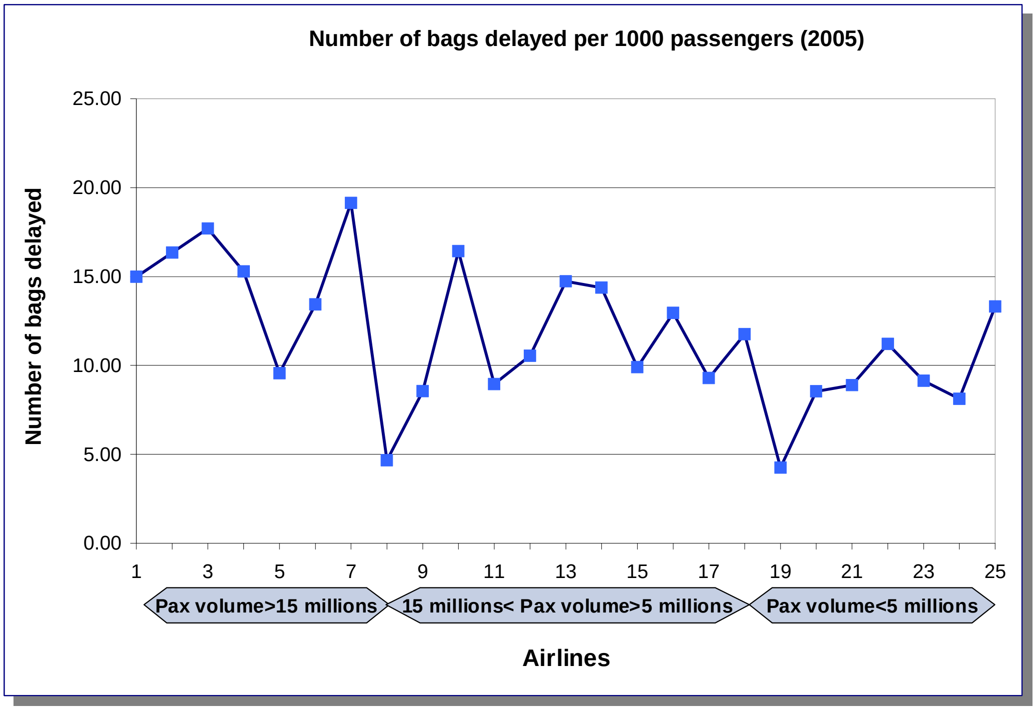


Figure 12: AEA Missing Bag Data

A number has replaced the name of the airlines, and airlines are ranked by their volume of passengers transported (from the biggest on the left to the smallest on the right).

Remark: this data is limited to less than 40 airlines and the average number of bags delayed per 1000 passengers is 14.09. The minimum annual average was equal to 4.66 while the maximum annual average reached 19.4 delayed bags per 1000 passengers.

4.8 Network effect

The overall business case for the industry can be explained by looking at key drivers such as the number of bags, number of airports and average costs / benefits per bag and airport.

Examples of the network effect:

- Savings in the number of RFID tags issued, as the transfer baggage between two networked airports does not require re-tagging with RFID before introduction to the baggage handling system. This is a common practice in Hong Kong.
- Reduction in the amount of manual labour needed to re-tag baggage with an RFID label.
- Decreased waste of tags. Most direct departing bags do not have a problem, as the barcode label has not had an opportunity to be handled and damaged. A tag that is used for a point-to-point journey could be considered to be waste from an airline point of view, as barcodes appear to perform satisfactorily in this area. The airports will still extract benefit from the track and trace activity however.
- Elimination of the need to associate the barcode on the label with the RFID tag – as the RFID tags are encoded at check-in there is no need to read the barcode, overcoming read rate issues.

The network effect is an important aspect of the transition to RFID and will be examined in detail in the development of a transition plan, subject to airlines agreeing the positive industry level business case for RFID.

4.9 Stakeholder potential benefits

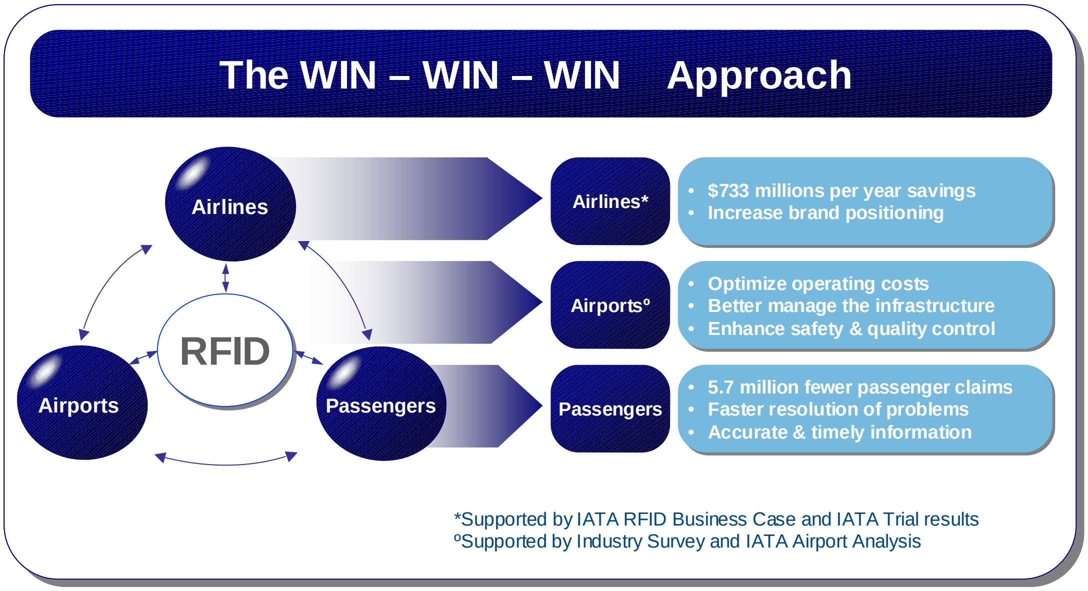


Figure 13: Stakeholder Benefits

4.9.1 <u>Airlines potential benefits</u>

Increase revenue & Brand positioning

- Decrease number of claims limiting compensation cost
- Improve passenger service
  - More responsive delivery for mishandled baggage research
  - Better information & transparency to passenger reducing stress
- Develop customer loyalty

Reduce Operating Costs

- Optimize customer relationship resources
- Improve planning and operational global visibility and traceability
- Improve operational decision making
- Improve global performance measurement productivity via automated tools (dashboards…)
- Better fault identification belonging to other carrier connections

Optimize Contracts in place

- Improve measurement visibility of Service Level Agreement
- Optimize resource allocation & employed and renegotiate contract with Ground Handlers

Enhance Safety & Quality Control

- Increase security management & record security levels for all bags
- Enhance responsiveness to baggage process & baggage visibility
- Better monitor of baggage process and optimize the audits
- Reduce Theft

Figure 14: Potential Airline Benefits

4.9.2 Airports potential benefits

Increase Brand positioning

- Attract airlines
- Develop the well-run airport picture

Optimize Operating Costs

- Reduce maintenance cost
- Reduce manual activities
- Improve operational global visibility and traceability for all airlines
- Define new optimized ways of working and working conditions

Better manage the infrastructure

- Accommodate to the future passenger growth and better foresee the future installations and flows in a global approach when adding capacity
- Accommodate to any regulations impacting the infrastructure and baggage flows

Enhance Safety & Quality Control

- Guarantee security management & record security levels for all bags
- Reduce extra time by reducing the number of lost bags dispatched to high security level
- Identification of zones causing issues with a high detailed level
- Improve process control & performances
- Reduce Theft

Figure 15: Potential Passenger Benefits

4.9.3 Passenger potential benefits

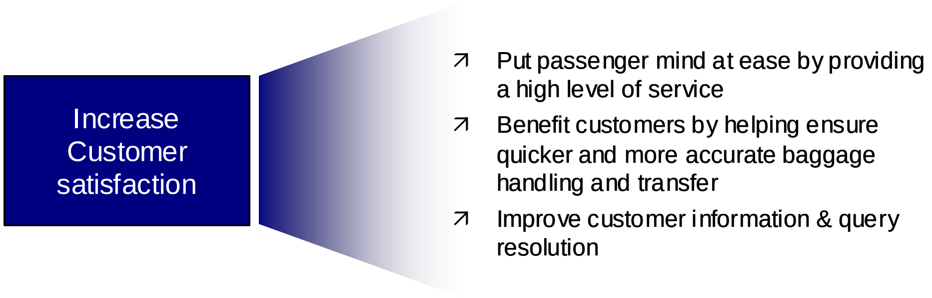


Figure 16: Potential Customer Benefits

Section 5 Business Case

5.1 Introduction

The cost of mishandled baggage to the industry is more than US $3 billion per year. It can be split into:

- US $ 1,168 million for direct cost of compensation paid to the passengers (based on SITA figures) and
- US $ 2,392 million for indirect cost for labour associated with handling the baggage and processing the claims.

There are many reasons for the mishandling of baggage and not all of these may be addressed with RFID. This means that implementing RFID will not solve all the mishandling issue and save the industry the all costs caused by mishandling.

Before being able to measure accurately the reasons and consequences some considerations have to be taken into account:

- The use of a track & trace solution as a foundation would allow better visibility of the baggage in real time and post processing analysis along the global baggage chain.
- In addition, using an efficient technology such as the RFID would improve the level of automation and reliability along that chain.
- It is likely that over time the barcode solutions require replacement due to wear and tear and new developments in reader technology. The cost of including RFID in a replacement reader will not drastically impact the cost of replacement.
- Handheld dual barcode and RFID readers are already available for the cost of a single (barcode) technology reader, and RFID heads for barcode arrays are available.

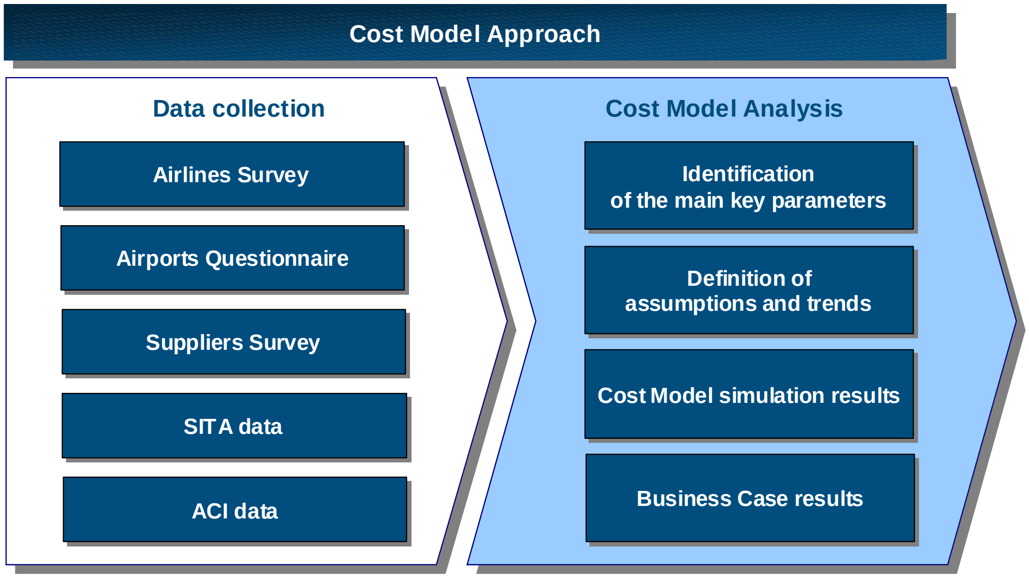


Figure 17: Business Case Approach - Cost Model

5.2 Identification of the main Key drivers

5.2.1 Introduction

The cost benefit model is based on the use of the following parameters. With RFID, the improvement of the barcode read rate should reduce the number of mishandled bags by 9.7% (Case 1) and the use of an RFID tag with a large memory (Case 2) by additional 11%.

mishandled bags	• More than 30 million of bags are mishandled each year for an annual US $3.5 billions cost
Barcode read rate	• Airlines identified barcode reading problems as causing 9.7% of all mishandled baggage • A change in the assumption value impacts strongly the results
No of bags per pax	• Different assumptions regarding this parameter impact directly the investment cost: ➢ the more the bags we have to tag the more it will cost ➢ an assumption between 0.8 to 1.2 bag per passenger has been taken
Airport size	• The model is based on airport passenger volume as: ➢ the amount of RFID materials (thus cost) is directly linked to the airport size
Transfer pax volume	• The number of transfer pax between airports has not yet been identified precisely • To reach a critical mass level and fast payback the rollout map shall be based on network effect and thus airport selection
Rollout	• Identify the project timescale & cost for an RFID installation regarding airport size • A rollout map with airports to equipped (not necessarily all but those where there is a business case) and based on network affect must be analysed at a second step.

Table 11: Key Business Case Drivers

There are two key cost drivers to consider:

- The cost of tags is proportional to the worldwide number of baggage per passenger
- The cost of returning the bag to the passenger (direct +indirect)

5.2.2 Level of confidence for key drivers

Parameter	Aim	Details	Level of confidence
Passenger volume	↗ Cost of material ↗ Cost of tags ↗ Cost of IT solution ↗ Savings	↗ This information is provided by ICAO and ACI	95%
Number of bags per passenger	↗ Volume of tags	↗ This information has been provided by the airlines and the airports during the Business Case Review Process.	90%
Transfer pax volume	↗ Volume of tags ↗ Savings	↗ This information has been retrieved via the Airport questionnaire and is not representative of an Industry level. The airlines have not delivered enough information.	65%
RFID Printer tags	↗ Cost of material	↗ This information has been retrieved via the Airport questionnaire (check-in desk printers including spares, CUSS and kiosks volume) and Supplier Survey (cost). A realistic assumption has been made based on Airport pax volume.	85%
RFID Fixed Readers	↗ Cost of material	↗ This information has been retrieved via the Airport questionnaire (volume) and Supplier Survey (cost). An assumption has been calculated based on Airport pax volume. Lack of visibility for airport size below 30 million of pax a year.	80%
Installation	↗ Cost for a full RFID reader installation	↗ This information is provided by the suppliers. ↗ The cost varies from $10,000 to $20,000 with a margin that needs to be taken into account.	75%
Project Mgt	↗ Cost for an airport Project Management	↗ Assumption.	60%
Track & Trace tool	↗ Cost of IT implementation asset	↗ This takes into account the global implementation project cost (software lifecycle, middleware and change management). A trend has not been used but could be considered.	80%
Read Rate	↗ Mishandling bag reduction	↗ This parameter is a key business driver for the Business Case. This assumption has been obtained from the Airlines survey.	60%
Mishandled cost	↗ Cost of bag to return to passenger	↗ Based on SITA direct cost figures, an airline has to consider the add of the resource and communications costs required to action the mishandled bag file.	80%

Table 12: Data Confidence Levels

5.2.3 Key Assumptions

5.2.3.1 Introduction

The objective of this business case is to validate the main cost saving drivers and the industrial saving opportunities per stakeholder on the assumption of a big bang rollout for purpose of simplicity. Having established the industry benefit in this business case IATA has developed a transition plan to RFID.

This business case assumes that the RFID solution is implemented and operational at the industry level in year 1 and that:

- There is not a great variation in baggage handling performance between airlines and airports.
- The airport cost investment is as follows:
  - The first biggest 200 airports are equipped with printer tags at check-in desks, with RFID readers and an IT track & trace application solution
  - The next 200 airports, regarding the volume of processed bags are equipped with printer tags only and do not require a fully automated solution.
- Airports do not use RFID for reconciliation, and need only 28 readers to improve tracking for the big airports and 5 readers for the medium size airports (below 11 passenger volume).
- The cost of RFID tags will fall but this study is based on a conservative approach with a fixed tag cost for the next years. The use of tags with a large onboard memory will increase tag cost.
- A 5% of passenger increase per year.

The actual transition to RFID for baggage handling is documented in the IATA Baggage RFID Transition Plan. It should be noted that this transition does not form the basis for a drive to RFID for the industry, as RFID can only address a small percentage of the causes of mishandling.

5.2.3.2 Assumption values

Parameter	Assumption value	Level of confidence
Passenger volume	↗ Industry level: 2,022,768,000 (2005) ↗ At each airport: ACI figures (2005)	99%
Number of bags / pax	↗ Average, based on 1 year of data: 1.0 bag per passenger ↗ This is based on figures from several airlines and airports	90%
Transfer pax volume	↗ 30% at industry level	65%
RFID Tags	↗ Small memory tag: $0.10 (incremental) ↗ Large memory tag: $0.30 (incremental)	90%
RFID Printer tags	↗ Trend calculation: 12 printers per million of pax ↗ Incremental cost: $2,000 per unit	85%
RFID Fixed Readers	↗ Airport pax volume: ↗ > 11 million: 28 readers / airport ↗ < 11 million: 5 readers / airport ↗ < 4 million: none ↗ Cost: $2,500 per unit	80%
RFID Installation	↗ Housing / Tunnel (Portal structure) – cost per reader: $5,000 ↗ Commission – cost per reader: $5,000 ↗ PLC integration: $100,000 for a big airport; $50,000 for a medium size	75%
RFID Project Mgt	Cost for an airport Project Management: ↗ Airport pax volume > 4 million: $100,000 ↗ Airport pax volume < 4 million: $10,000 for printers installation only	60%
Track & Trace tool	↗ Per airport with Airport pax volume: ↗ > 20 million: $1,000,000 ↗ between 20 and 11 million: $350,000 ↗ between 11 and 4 million: $250,000 ↗ < 4 million: none	80%
Read Rate	↗ Mishandling bag reduction: 9.7% of savings on the number of mishandled bags at industry level. ↗ The potential benefits brought by the use of a Track & Trace application solution is not added on the top of the 9.7% figure.	60%
Mishandled cost	↗ Global average cost: $90	80%

Table 13: Assumption values

5.3 Cost Model Results – Business Case Results

5.3.1 Cost Reduction Opportunity

The opportunity to reduce costs is threefold:

- Firstly, airlines can reduce mishandling due to failures to read barcode labels. Our airline survey estimated this to offer a 9.7% opportunity.
- Secondly, airlines can reduce mishandling due to failures in receiving a baggage service message. Our airline survey estimated this to be an 11% opportunity.
- Thirdly, airports can improve efficiency by not handling the bags above. Whilst no-reads attribute 9.7% of the total baggage mishandlings, airports deal with a much higher no-read rate. This baggage volume requires manual interaction to ensure that the baggage makes the intended flight. Tackling this large volume allows the airport to increase the efficiency of the baggage handling operation. The same reasoning applies to bags without a BSM or with missing flight information. This has been estimated as a 12.5% opportunity based upon an analysis of airport baggage statistics.

5.3.2 Capital requirements

The main capital investment is enabling an airport with RFID. The business case assumes that an airport serving more than 11 million passengers will require 28 RFID readers to enable track and trace at the airport. An airport serving less than 11 million passengers would need only 5 readers. RFID readers have not been included for the purpose of baggage reconciliation, and hand held readers have not been included either. Further investigation into the use of automatic RFID readers for reconciliation is needed.

The main cost in addition to the readers is the cost of providing a baggage management system at airports to report on the track and trace of baggage. The size of the market for this tool is such that several products exist; however many are charged at a premium rate. The industry may find it appropriate to develop a tool. The vision is to get a baggage application integrated with the other airline corporate applications to become more structured and to get access to the consolidated information, centralized and with a unique passenger/baggage view. This will be done step by step.
A step further - or in parallel depending on the strategies – is to share information between airlines & airports as well as between airlines members from a same alliance towards a more collaborative business.

Capital Expenditures	Cost in $
RFID equipment	
RFID Tag Printers	92,304,824
RFID Readers / Antennas & Installation	58,050,000
Project Management	23,170,000
	173,524,824
IT - Track & Trace Application Integration	
Project Development	
User Requirements	
Architecture & coding	
Integration	101,300,000
Test & Validation	
Change Management	
Middleware (interfaces, servers, licenses...)	
	101,300,000
TOTAL	**274,824,824**

Table 14: Capital Expenditures (first top 200 RFID airports & next 200 with printer tags only)

5.3.3 Operational requirements

The following cost figures are based on 2005 passenger/bag volumes. One should consider passenger growth of 5% a year.

Operational Expenditures	Cost in $		
	Number of bags per passenger		
Consumables	0.8 bag	1.0 bag	1.2 bag
Purchase of RFID tags - small memory	137,548,224	171,935,280	206,322,336
Purchase of RFID tags - large memory	412,644,672	515,805,840	618,967,008
RFID Maintenance			
Not calculated (less than Barcode Maintenance)	-	-	-
TOTAL Case 1: RFID tags with small memory	**137,548,224**	**171,935,280**	**206,322,336**
TOTAL Case 2 : RFID tags with large memory	**412,644,672**	**515,805,840**	**618,967,008**

Table 15: Operational Expenditures - 400 airports

5.3.4 Savings

5.3.4.1 Savings per year

It is important to keep in mind that this model is based on a fully worldwide operational RFID solution in year 1.

Mishandling Cost Savings per year	Savings in $
Case 1: RFID tags with small memory	343 million
Case 2: RFID tags with large memory	733 million

Table 16: Mishandling Cost - Savings

5.3.4.2 Cumulated savings

- In year 1, there is no savings; the savings start in year 2.
- In year 6, the RFID solution is replaced by a new RFID generation.

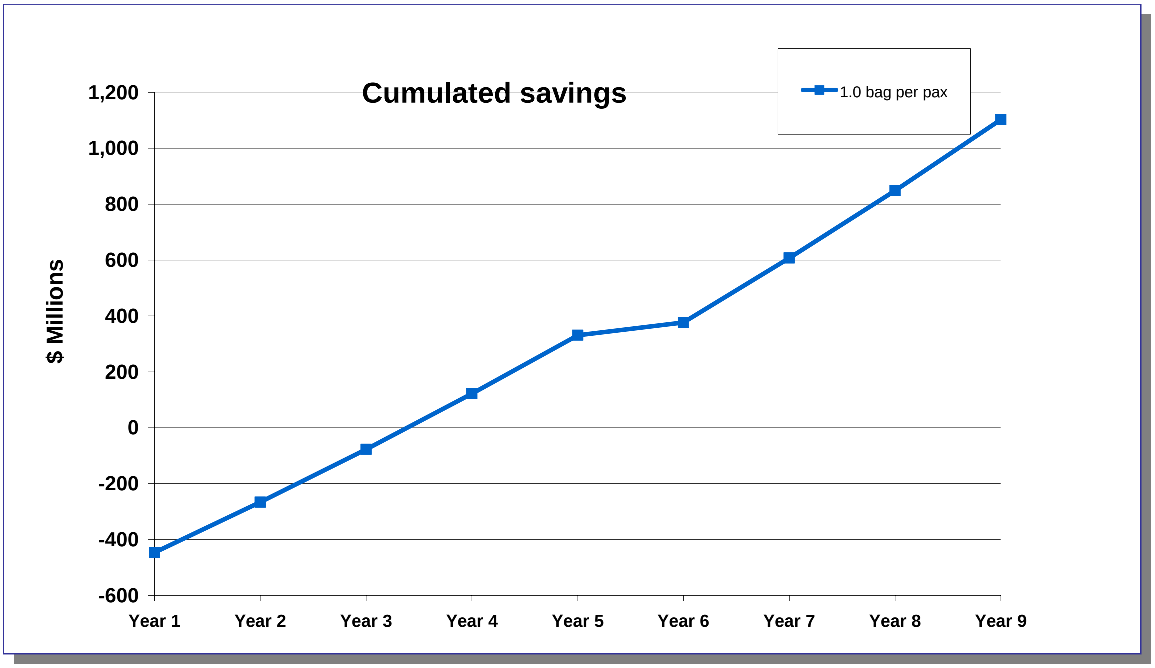


Figure 18: Case 1 - RFID tags, small memory

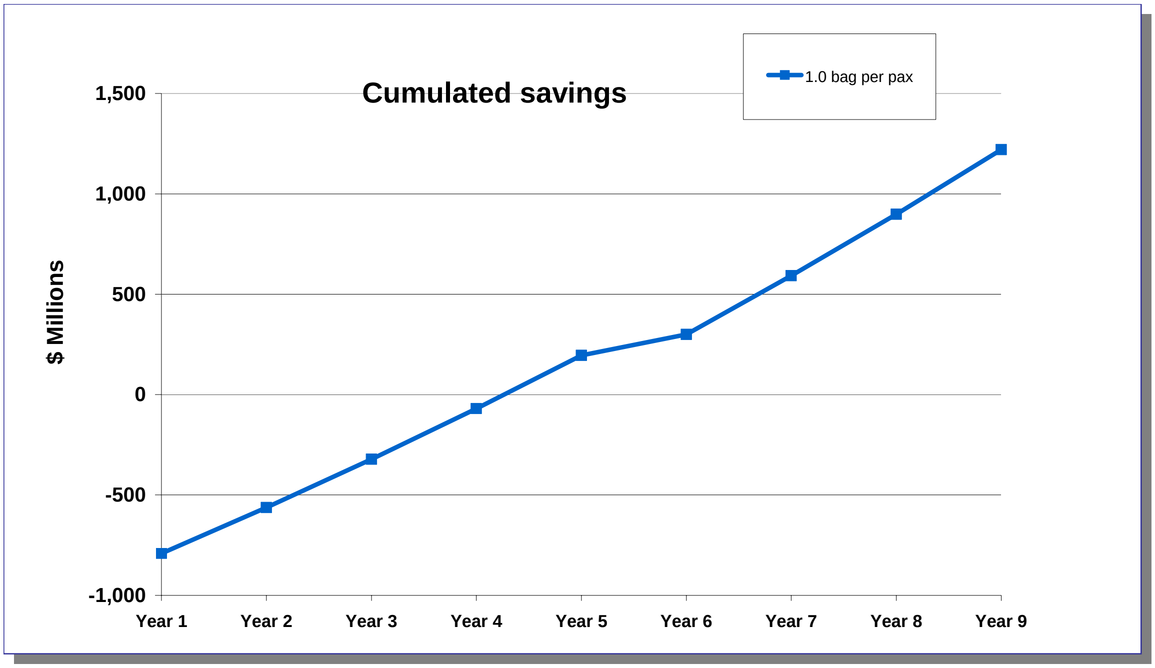


Figure 19: Case 2 - RFID tags, large memory

5.3.5 Pro-Forma Financials

Net Present Value (NPV) over 9 years	
Case 1: RFID tags with small memory	**in $**
1.0 bag per passenger	1,311,178,487
Case 2 : RFID tags with large memory	**in $**
1.0 bag per passenger	261,880,954

Table 17: Net Present Value Results

5.3.6 Cost of Investment with respect to airport size

This chapter describes the cost of RFID investment based on different passenger volume assumptions. The RFID implementation for each airport will vary according to the complexity of operations and the existing baggage system. For the purposes of this business case we developed a model as follows:

- Large airports are to be fully RFID equipped with a track & trace application solution and 28 readers per airport.
- Medium airports, below 11 million passengers, would be equipped with printers and a smaller number of readers, as the baggage system is less complex;
- Small airports, below 4 million passengers, would only have RFID printers installed.

5.3.6.1 Large Hub ~ 50 million of passengers per year

Capital Expenditures	Cost in $
RFID equipment	
RFID Tag Printers	1,290,149
RFID Readers / Antennas & Installation	366,000
Project Management	100,000
	1,756,149
IT - Track & Trace Application Integration	
Project Development	
User Requirements	
Architecture & coding	
Integration	1,000,000
Test & Validation	
Change Management	
Middleware (interfaces, servers, licenses...)	
	1,000,000
TOTAL	**2,756,149**

Operational Expenditures	Cost in $		
	Number of bags per passenger		
Consumables	0.8 bag	1.0 bag	1.2 bag
Purchase of RFID tags - small memory	1,301,207	1,626,509	1,951,811
TOTAL Case 1: RFID tags with small memory	**1,301,207**	**1,626,509**	**1,951,811**

Table 18: Capital Expenditures for a large Hub

5.3.6.2 Medium size airport ~ 11 million of passengers per year

Capital Expenditures	Cost in $
RFID equipment	
RFID Tag Printers	262,311
RFID Readers / Antennas & Installation	77,500
Project Management	100,000
	439,811
IT - Track & Trace Application Integration	
Project Development	
User Requirements	
Architecture & coding	
Integration	350,000
Test & Validation	
Change Management	
Middleware (interfaces, servers, licenses...)	
	350,000
TOTAL	**789,811**

Operational Expenditures	Cost in $		
	Number of bags per passenger		
Consumables	0.8 bag	1.0 bag	1.2 bag
Purchase of RFID tags - small memory	393,774	492,218	590,661
TOTAL Case 1: RFID tags with small memory	**393,774**	**492,218**	**590,661**

Table 19: Capital Expenditures for a medium size airport

5.3.6.3 Small size airport – below 4 million of passengers per year

Capital Expenditures	Cost in $
RFID equipment	
RFID Tag Printers	95,864
RFID Readers / Antennas & Installation	0
Project Management	0
	95,864
IT - Track & Trace Application Integration	
Project Development	
User Requirements	
Architecture & coding	
Integration	0
Test & Validation	
Change Management	
Middleware (interfaces, servers, licenses...)	
	0
TOTAL	**95,864**

Operational Expenditures	Cost in $		
	Number of bags per passenger		
Consumables	0.8 bag	1.0 bag	1.2 bag
Purchase of RFID tags - small memory	156,058	195,072	234,087
TOTAL Case 1: RFID tags with small memory	**156,058**	**195,072**	**234,087**

Table 20: Capital Expenditures for a small airport

5.4 Soft Benefits

There are many opportunities to associate soft benefits with the introduction of RFID for baggage handling. Some of these are described in Section 4 of this document. Whilst it is tempting to include financial figures for these benefits it is unrealistic to do so, as the savings from soft benefits need to be proved.

There is a parallel from the introduction of barcodes to the retail industry. When this transition was undertaken a good estimate of the hard benefits for barcode adoption was made.

After 25 years of use the business case for barcodes was re-examined and it was found that soft benefits had contributed 3 times the financial return of hard benefits. Some additional soft benefits include:

- Improved Sales due to better management information
- General Efficiency
- Improved Employee Morale by automating boring tasks such as data entry, creating more enriching job opportunities for workers
- More Satisfied Customers due to higher quality, faster response and improved accuracy.

Section 6 Towards a shared track & trace solution and future steps

The baggage supply chain is complex due to the Hub concept, the actual solutions in place and the number of actors involved. The lack of visibility and tracing leads to dead time in processes and loss of delivery control.
The processes are adapted on a regular basis to respond to new rules, service quality and efficiency objectives. Lack of real time visibility in individual baggage position & status, in baggage volume, for all of the actors undermine improvement opportunities and cost savings.

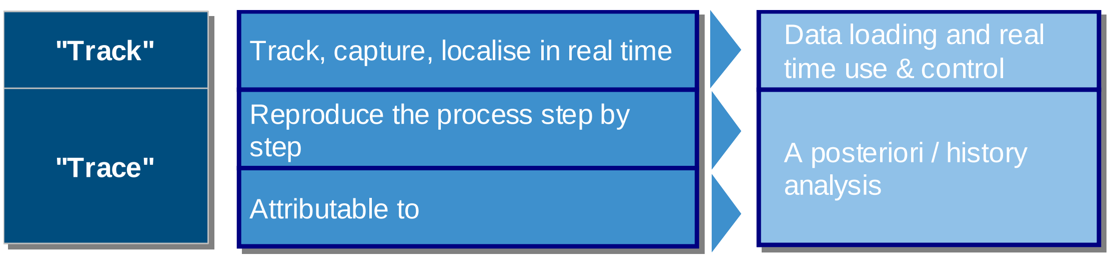
The airlines need to integrate their existing applications to get passenger/baggage consolidated and updated information on real time basis.

The next step is to increase collaboration become more collaborative by sharing information. This will provide a continuous information flow access and at a lower cost.

6.1 The track & trace application approach

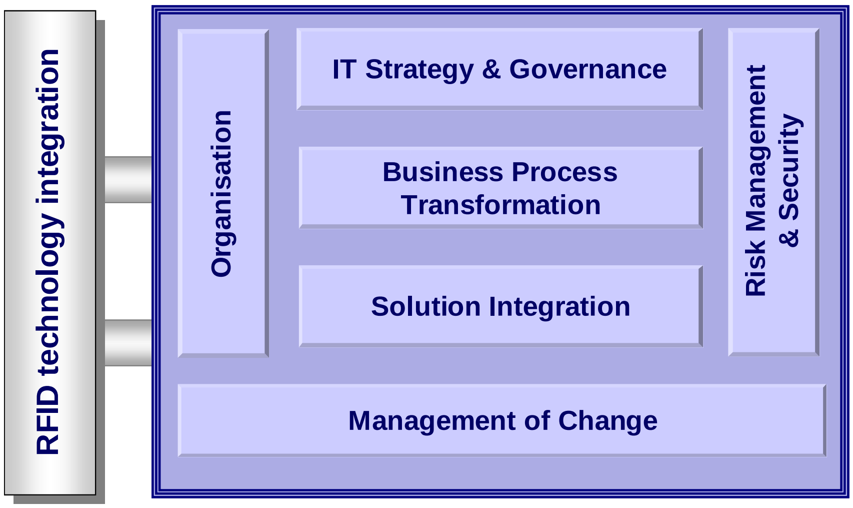
The principle is to have a baggage traceability solution aligned with processes that captures and stores data, accessible to anybody at anytime.

This will allow putting in place a better planning, organisation, co-ordination and control to better manage effectively and efficiently the baggage handling activities.



6.2 The RFID integrated onto track & trace application and within IT Corporate system

Obviously, such a global IT solution is expensive to put in place, especially for a Hub airport. As a fundamental corporate asset, information systems have to be integrated to each other mainly to support airline processes, on a real time basis. To some extent, all the dimensions presented in the figure below will be required by such a project. And this should be planned, and organised step-by-step.



The set up of a track and trace solution is seen as inevitable to get real effectiveness. The RFID system will improve read rate, provide a stronger automated solution and will to be integrated to an operational application solution to gain real benefits.

6.3 New rules approach

The implementation of a track & trace tool with access to all staff involved will bring added value. Then, once integrated with the other corporate applications such as back-office and front-office systems, the track and trace tool will provide the airlines an additional improved service performance. Staff dedicated to baggage logistics at the airport side will gain advantage of an application tool; other staff dedicated to theft control, after sales, ground handler audits, process audits, passenger services and accounting & finance will also benefit.

Aircraft operational activities could be better managed by integration of passengers and baggage operational activities via, for instance, an operational control room. Obviously this vision requires several steps towards a global collaborative management strategy with mainly two phases, described below. This will impact the existing rules and business model.

Process, organisation and business model transformations using new technologies and integrated IT systems:

	Old rules	Information System & Technologies	New Rules
Phase 1	The information is available at only one place	Shared Database with track & trace functionalities	The information is available simultaneously wherever it is needed
Phase 1	Operational staff expend effort gathering data	Data Radio transmission, mobile tools...	Operational staff have informed view on data and then information
Phase 1	Managers make all the decisions	Decision Making tool (planning, simulation, flow management, choice analysis...)	Each person can really make decisions at his own level of responsibilities
Phase 1	The information is not well shared between actors of a same company	Corporate integrated Systems	The information is shared between all the actors for a high service level delivery (fast & accurate)
Phase 1	Without a clear identification of responsibilities in issues, claims are shared between airlines	Tracing functionalities	Put in place new compensation rules between all stakeholders
Phase 2	The information is not well shared between stakeholders / partners	Collaborative Systems	The information is shared between all the stakeholders for a high service level

Section 7 Conclusion & Recommendation

7.1 Conclusion

The Business Case results have been based on the implementation of RFID across the industry with the top first 400 airports equipped. A reduction in the mishandling of baggage by at least 10% is achievable. The only benefit claimed for this saving is a reduction in the mishandling of baggage due to the increased ability to read the baggage tag.

The presented scenario for a small tag memory is conservative and has not associated benefit to any factor that cannot currently be measured:

- No benefits have been included during the first year of implementation.
- The cost of tags has been deliberately fixed at the same cost for the following 9 years, as it is difficult to get a clear vision on the cost variation even if it should decrease. A cost difference of $1 cent would save around $200 million on the same period or would increase the NPV from $1.311 billion to $1.902 billion.
- While the suppliers have given incremental cost from $1,600 to $1,800 for an RFID printer, a conservative value of 2,000 has been used. Following recent discussions with suppliers this cost could fall to less than $400 for a fully integrated module that converts a printer to RFID. This reduction is based on discussions with the largest producer of RFID readers in the world, and allows for a reasonable software development cost to integrate the module to the printer. A block to this could be that the printer manufacturers would choose to produce proprietary modules leading to an inflated market price for their modules.
- A 12% decrease of mishandled baggage instead of 10% would nearly save the industry an additional $1 billion on the same period.
- The average cost for mishandled baggage has been fixed at $90. It takes account of regional effects, based on figures provided by airlines in several regions.
- The approach has been also based in adding an operational track & trace application solution, first not necessarily completely integrated to the existing applications. The cost of this system has been set at $1 million for a big airport. Some airlines and airports already have such a system and their costs would be greatly reduced, allowing RFID to be incorporated to provide greater visibility.

IATA has prepared the Baggage RFID Transition Plan that shows that RFID deployment need only actually take place at 80 airports to be effective in 80% of all the mishandling files raised. This transition plan is not being used to drive the industry to RFID as RFID baggage tags cannot address all the causes of mishandling. Instead of driving RFID adoption IATA has developed a Baggage Improvement Programme aimed at addressing all practical causes of baggage mishandling and introducing RFID where appropriate.

The other cost savings such as time saving by accessing information history, optimization of contracts, reduction of manual activities (manual encode positions) have not been taken into account.

A further excellent opportunity currently being progressed is the adoption of new data sharing techniques to allow the benefits of the RFID tag with larger memory to be realised using the RFID tag with a smaller memory. The techniques under consideration involve using the RFID identifier as an index into a discovery service. The discovery service acts as a reference to the originator or consolidator of baggage information. Thus when a tag is seen in a place where it is not expected, either off route or one-route with a missing BSM, the discovery service can point to the holder of the information needed to process the baggage. The holder of the information can then decide if it is acceptable to release the information to the requesting party.

This immediately opens an argument against RFID in that these techniques can be realised using barcodes, however it is simply not cost effective to provide automatic barcode scanners at the number of locations needed for a global baggage handling system when considering the use of automatic identification in the off-route scenario. It is relatively easy and very cost effective to provide RFID readers at arrivals points, in high-loaders and at airport pinch points though.

7.2 Recommendation

The IATA Board have recommended that IATA proceed with the development of an RFID implementation plan and for use in baggage handling.

The implementation plan will give more detailed information about the cost of implementation and airport selection. The plan will be presented to the StB Steering Group in April 2007.

7.2.1 Other Key Deliverables

In addition to implementing at airports, IATA can work in a number of areas to speed adoption. The deliverables in these areas are:

- RFID antenna design criteria: tightening the specification of the tag design allows more companies to produce useable inlets.
- Baggage tag supply models: IATA can examine the supply of baggage tags in order to reduce costs.
- Training and consultancy: IATA will continue to support the industry through the provision of training materials, the RFID implementation guide and workshops to airports and airlines investigating RFID.

Section 8 Appendices

8.1 RFID Trial Results

Summary: *During the last years, a number of trials have been conducted between airports, airlines and manufacturers and additional ones should start in a near future with other airports. The main results are summarized in the following table.*

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

Table 21: Overview of RFID trail read rates

From this we can see that RIF has consistently managed to outperform transfer barcode read rates. RFID is therefore well suited to addressing read rate issues in baggage handling.

The map provides an overview of the trials and their actual status:

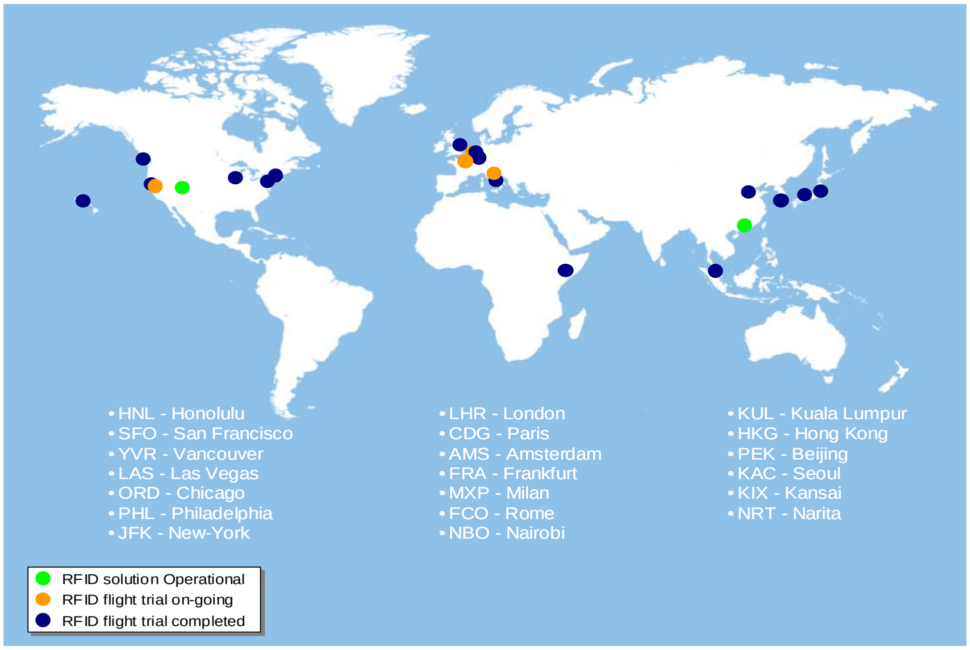


Figure 20 : Worldwide trial distribution

8.1.1 Kuala Lumpur International Airport Trial

8.1.1.1 Introduction

This trial of UHF band involved the FEC Group, the Malaysia Airports Group, the Malaysia Airlines System BHD, and the Toppan Forms Co., Ltd. and the CBS Technology BHD.
This trial had two main objectives:

- To study the characteristics of UHF tags placed on the test baggage in various situations to identify when reading would become difficult
- To study the recognition rate by placing the UHF tags on passenger's baggage in the actual airport environment and:
    - To verify the effectiveness of the baggage tags during operations between airports
    - Effects on UHF band by the airport facility materials

In this trial, a large amount of RFID materials has been tested and performances analyzed in details. The process starts with the tag preparation (pre-encoding), the tag issuing and tag reading along the baggage chain.

8.1.1.2 Description of the trial equipment

Type	Equipment	Manufacturer
Reader	Sensormatic Agile 2	Tyco
	AR400	Symbol
Antenna	Sensomatic Omniwave	Tyco
	High Performance Area RFID Antenna	Symbol
Baggage Printer	BT 201e	Genicom / IER
	PF2i	Intermec
RFID Handy Terminal	IP4 Portable (UHF)	Intermec
	MC 9060 (UHF)	Symbol
Inlet	Meander line	Toppan Forms
	EPC Class 0+, Dual Dipole Antenna	Symbol
	EPC C1 Gen2, Dual Dipole Antenna	Symbol

Table 22: RFID Trial equipment

8.1.1.3 Trials Results

In this flight trial, recognition rate in using EPC Class 0+ Gen 1 inlet was 98.38%. In the latest protocol of the next generation, EPC Class 1 Gen 2, inlets with chip were tested with different readers and antennas yielded a 100% recognition rate.

8.1.2 Kansai International Airport – Hong Kong International Airport Trial

8.1.2.1 Introduction

This Trial of UHF Band Wireless IC Tag (e-Tag) for airline checked baggage was conducted by ASTREC and executed between Kansai International Airport (KIX) and Hong Kong International Airport (HKG) with the cooperation of Japan Airlines.
The trial was conducted on both directions. E-tag was affixed to the airline bag of the Kansai International Airport and read at the arrival process at Hong Kong International Airport. The same was conducted at the reverse direction.

The trial consisted of:

- Reading of IC tags which were affixed to checked baggage on a JAL701, KIX to HKG and conducted between November 28 through December 16, 2005
- Reading of IC tags affixed to checked baggage, already a standard operating procedure at HKG, on JAL 702, HKG to KIX and conducted during the same period
- Individual experiments conducted over 3 days during the end of February 2006

The main purpose of this trial was to accomplish a basic performance validation in an operational environment and different from Narita Airport and:

- to verify the international interoperability of Japan's UHF-band airline baggage tag
- to confirm the data recognition of the airport baggage tag affixed at Hong Kong and read it at Kansai International Airport
- to verify characteristics of UHF band radio frequency
- to verify electric intensity measurement inside the airport
    - E-tag recognition area measurement in the positioning of the antenna

ASTREC undertook trials using both 13.56 MHz and UHF band RFID devices. The primary reason for this is that the only globally interoperable frequency that can be used at sufficient power for baggage handling is the UHF band. The adoption of UHF band RFID in Japan has only begun following changes to the radio laws in April 2005.

8.1.2.2 Description of the trial equipment

Two different types of inlay were used (different antenna shape). The inlays were embedded in the back of the trial tags.

Five fixed antennas were used:

- Antenna 1 at the F Counter Belt in KSI
- Antenna 2 at the Baggage Make-up area at KSI
- Antenna 3 & 4 at HKG arrival
- Antenna 5 at the arrival baggage process of KSI

Inlays	Antennas
↗ Manufactured by Symbol Technologies	↗ Symbol Technology Model AR-400J
↗ Range: 902 Mhz – 928 Mhz	↗ KIX: compliant with new Japan Radio Code
↗ RF Air Protocol: EPC global class 0, Version 1 (Class 0+)	↗ HKG: compliant with Hong Kong Radio Code
↗ Memory: 96 bits + 16 bit CRC	↗ Output 1W
↗ Electronic Product Code (EPC) compliant	↗ Frequency KIX: 952 MHz – 954 MHz
↗ Read/write	↗ HKG: 920 MHz –925 MHz
	↗ RF Air Protocol: EPCglobal Class 0, Version 1 (Class 0+)

Table 23: Inlay and antenna manufacturers for trials

8.1.2.3 Trials Results

From Kansai International Airport to Hong Kong International Airport

1388 items of baggage were tagged. The following tables compare read rate results between antennas. Antenna 1 was used to read the tags located at the F counter, just after check-in. The bags were then conveyed to the make up area where antenna 2 was installed.

Read rate Antenna 2 vs Antenna 1	Total
Number of trial tag Antenna 1 read at KIX Departure	336
Number of trial tag Antenna 2 read at KIX Departure	321
Number of No Read	15
Read Rate	95.54%

Table 24: Read rate improvements between antennas at KIX

Evaluation of Read Rate Antenna 2:
The averaged daily fluctuation of Read Rate was between 94.25% to nearly 100%.
The main causes of No-Read were due to:

- Tag wrapping around the handle of the baggage
- The tag was placed under metal baggage.
- Affixed tag to online transfer baggage beyond HKG (miss handling), taking a non-antenna installed route
- The baggage travels on a particular side of the side guard at the junction point of sorter in the BHS (where the tag contacts the side antenna).

From Hong Kong International Airport to Kansai International Airport:

The baggage loaded into the JAL flight from KSI to HKG were then unloaded to the conveyor belt at KHG and read by Antenna 3.

Read rate Antenna 3 vs Antenna 2	Total
Number of trial tag Antenna 2 read at KIX Departure	1067
Number of trial tag Antenna 3 read at HKG Arrival	1054
Number of No Read	13
Read Rate	98.78%

Table 25: Read rate improvements between antennas at KIX

Evaluation of Read Rate Antenna 3:
The averaged daily fluctuation of Read Rate was also between 94.25% to nearly 100%.
The main causes of No-Read were due to:

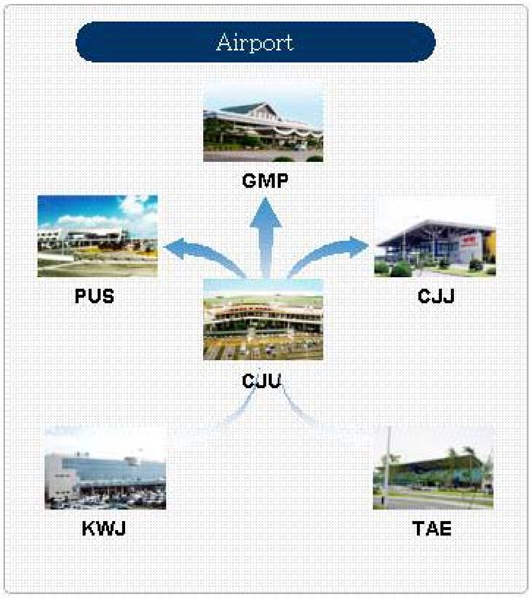
- Tag wrapping around the handle of the baggage
- The tag was placed under metal baggage.
- Affixed tag to online transfer baggage beyond HKG (miss handling), taking a non-antenna installed route.

Additional tests were conducted during 3 days from February 27, 28 and March 1, to investigate the tags not previously read.
Twenty one pieces of test baggage covering various e-tag affixing configuration and characteristics of the conveyor line were prepared to verify the recognition based on e-tag affixing method and material differences.

- The test of bag material revealed that the tag affixed to the metal baggage need a distance of 10 mm or more between the tag and the baggage itself to be recognized by the antenna. It was also not possible to read tags on baggage that contained items wrapped in evaporated metal packaging, such as instant noodles.
- The recognition based on various e-tag affixing configuration were tested. As a result insufficient recognition was verified when the e-tag was folded or coiled around the handled of the bag.

8.1.3 Asiana - RFID Airline Baggage Tracking and Control System

This trial was performed in Korea between the Korean Airport Corporation, NCA and Asiana IDT. The trial ran from October 2004 to April 2005, with a pilot phase running from June 2005 to December 2005.
The trial used many Korean airports, as shown below:



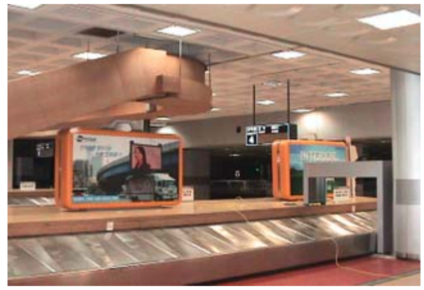
Baggage tags for the trial were issued at check-in and then read at a number of points throughout the baggage process. RFID was used to track baggage through security, reconciliation and finally to verify arrival. When the bag had been placed on the reclaim belt it was possible to contact the passenger by SMS to tell them where their bag was. This information could also be displayed on FIDS.

The trial had some issues with the encoding of tags, and work had to be undertaken to develop the encoding software by Asiana IDT.

The trial also enabled a number of new processes. There was a link between the security screening station and the airline security database allowing baggage belonging to passengers listed in the database to be notified to the security staff. This baggage could then be manually searched after x-ray.

RFID was also used for sortation, and the trial was the first use of RFID to enhance a manual sortation process. Baggage loaders were informed that the bag on the carousel was for their flight by the RFID reader. The functionality was also extended to reconciliation through the use of lights for loading, and recording the licence plate of the loaded bag.

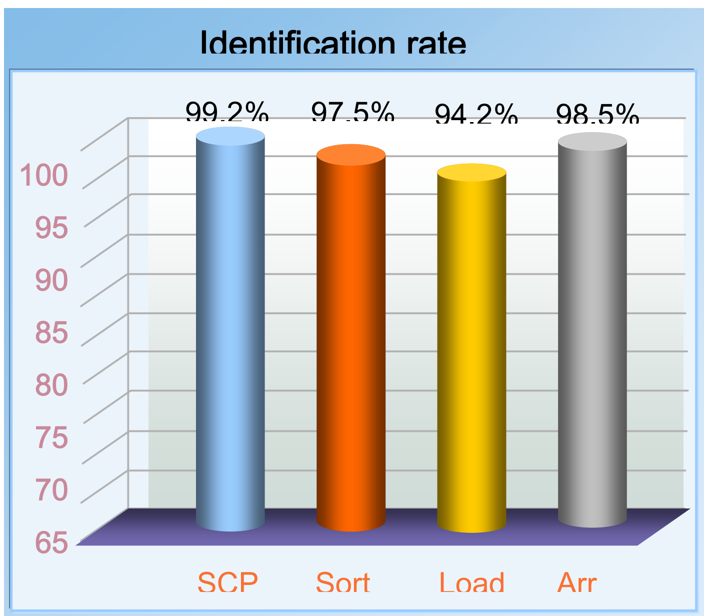
The display of information to the passenger was a particular challenge, although the issue was one of law. It was not possible to display the passenger names on the arrival FID, so instead the passengers' seat number was shown.



The trial was a success, achieving a 97% read rate. The trial also provided insight into that way in which RFID can be used to enhance processes and improve customer service.

The trial also showed that RFID had improved the baggage handling operation by 40 seconds per bag. This was estimated to return a benefit of $1 million per annum. The accuracy of sortation was also improved, although the manual process had very few errors in the first place. The expectation was that RIFD would lead to a reduction in baggage mishandling saving the airline $570,000 per annum.

The read rates at each process step are shown below:



The reasons for read rate failure were examined and found to be:

- Tag attaching error 30%
- Network problem 25%
- Baggage type 15%
- Environment 40%

These errors accounted for the 3% read rate loss.

Asiana IDT remains involved in the use of RFID for baggage and other airline operations, having founded an RFID development centre in Seoul. Despite a very successful trial and a great amount of knowledge acquisition, there are no plans to implement RFID at this stage.

8.1.4 UHF RFID BAGGAGE TAG World-wide TRIALS by TSA

8.1.4.1 Introduction

This aim of this world-wide trial was to demonstrate interoperability of UHF RFID Baggage Tag systems between worldwide geographic regions having different UHF transmission regulations (low, middle, high of band):

- U.S. and Japan that have different UHF transmission regulations (2004)
- U.S. and Europe that have different UHF transmission regulations (2004)
- Worldwide 2005 UHF Interoperability Trial

8.1.4.2 UHF RFID Worldwide Interoperability – Background

- By design, a UHF RFID tag's performance will be "optimal" within a subset of the entire UHF band.
- The tag, however, generally is designed to operate over the entire band with minimal degradation in performance.
- This leads to frequency interoperability of the UHF RFID system since each country can operate its RFID reader equipment at the designated frequency for that country while the tag, which moves from one country to another, can operate at multiple frequencies within the UHF band.

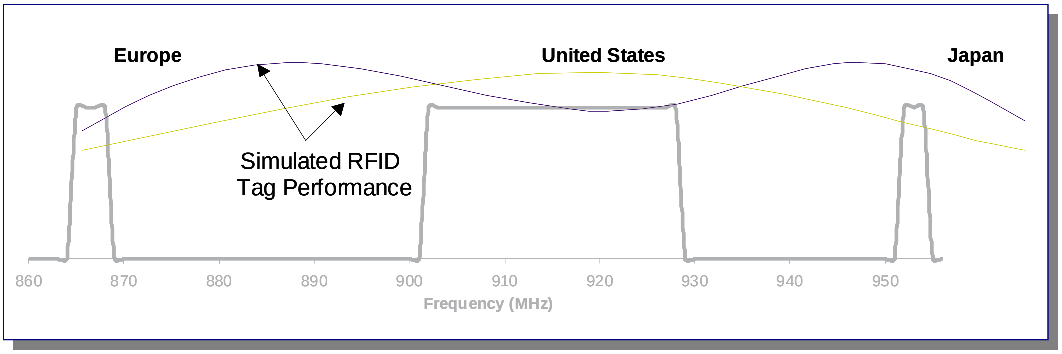


Figure 21: Ideal antenna characteristics

8.1.4.3 Description of the trial equipment

- The trial tested UHF RFID systems provided by Symbol Technologies (formerly Matrics, Inc.) and included writable tags containing RFID inlays.
- The frequency/power of operation of the reader equipment used at each location is as follows:

Location	Frequency	Power
Chicago, Beijing and Nairobi	902 - 928 Mhz	4 watts ERP (1 Watt (30 dBm) at connector, 6 dBi antenna gain maximum)
Narita	952 - 954 Mhz	4 watts ERP (1 Watt (30 dBm) at connector, 6 dBi antenna gain maximum)
Amsterdam	865 - 868 Mhz	2 Watts ERP

Table 26 : TSA Interoperability trial frequencies

The trial included:

a) pre-encoding of RFID baggage tags using RFID equipment operating in the frequency range specified for the location where the tags are issued,
b) reading of RFID baggage tags via belt readers as the baggage was transported through the baggage handling system, and
c) reading of the RFID baggage tags via belt readers as the baggage was placed on the arrival belts.

All RFID tags were pre-encoded with data. All pre-encoding was done using RFID equipment operating in the frequency range specified for the location where the tags were issued.

Example: Tags issued in Narita, Japan (NRT) were pre-encoded using RFID equipment operating in the 952-954 MHz range.

Encoding at one frequency and reading at another verifies the frequency interoperability of the RFID tags across the UHF band of 860 to 956 MHz.

RFID UHF Tag Inlays	Readers
↗ Provided by Symbol Technologies	↗ ORD Arrival: Read at 902-928 MHz, 4 Watts EIRP
↗ RF Air Protocol: EPCglobal Class 0, Version 1 (Class 0+)	↗ NRT Departure: Encode/Read at 952-954 MHz, 4 Watts EIRP
↗ Memory: 96 bits + 16 bit CRC	↗ AMS Departure: Encode/Read at 865-868 MHz, 2 Watts ERP
↗ Size: 1 in. x 4 in. (2.5 cm x 10.2 cm)	↗ PEK Departure: Encode/Read at 902-928 MHz, 4 Watts EIRP
↗ Electronic Product Code (EPC)™ compliant	↗ NRT Arrival: Read at 952-954 MHz, 4 Watts EIRP
↗ Read/Write Single Dipole	↗ NBO Departure: Encode/Read at 902-928 MHz, 4 Watts EIRP

Table 27: TSA Interoperability trial inlays and readers

8.1.4.4 U.S. and Japan Interoperability results

Key result indicating success of the Interoperability trial is the read rate of the arrival readers

- Average read rate for HNL arrival reader à 98.46%
- Average read rate for NRT arrival reader à 98.01%

It proves that a UHF RFID tag can successfully operate at both the U.S. band of 902-928 MHz and the Japanese band of 950-956 MHz.

The Read rates averaged in excess of 98%. Although to some observers they may be considered slightly less than desired, these rates can be attributed both to less-than-optimized installations and to first-generation RFID tags.

8.1.4.5 U.S. and Europe Interoperability results

Key result indicating success of the Interoperability trial is the read rate of the arrival readers

- Average read rate for PHL arrival reader à 98.82%
- Average read rate for FCO arrival reader à 96.26%

The lower observed read rate on the arrival reader in Rome was almost exclusively due to the less than optimum single antenna configuration of the arrival reader.

It also proves that a UHF RFID tag can successfully operate at both the U.S. band of 902-928 MHz and the European band of 865-868 MHz.

8.1.4.6 Worldwide 2005 UHF RFID Baggage Tag Interoperability Trial results

The aim of this trial was:

- To demonstrate the interoperability of UHF RFID systems between worldwide geographic regions having different UHF transmission regulations (low, middle, high of band) and
- To prove the theory that UHF RFID tags can operate outside of the designed frequency range with little degradation in performance. This in turn would support the global adoption of UHF RFID technology for baggage

The main Routes were:

- Amsterdam (AMS) to/from Chicago (ORD),
- Narita (NRT) to/from Chicago (ORD), and
- Beijing (PEK) to Chicago (ORD) with United Airlines.

The Feeder Routes were:

- Beijing (PEK) to Narita (NRT) with Air China, and
- Nairobi (NBO) to Amsterdam (AMS) with Kenya Airways.

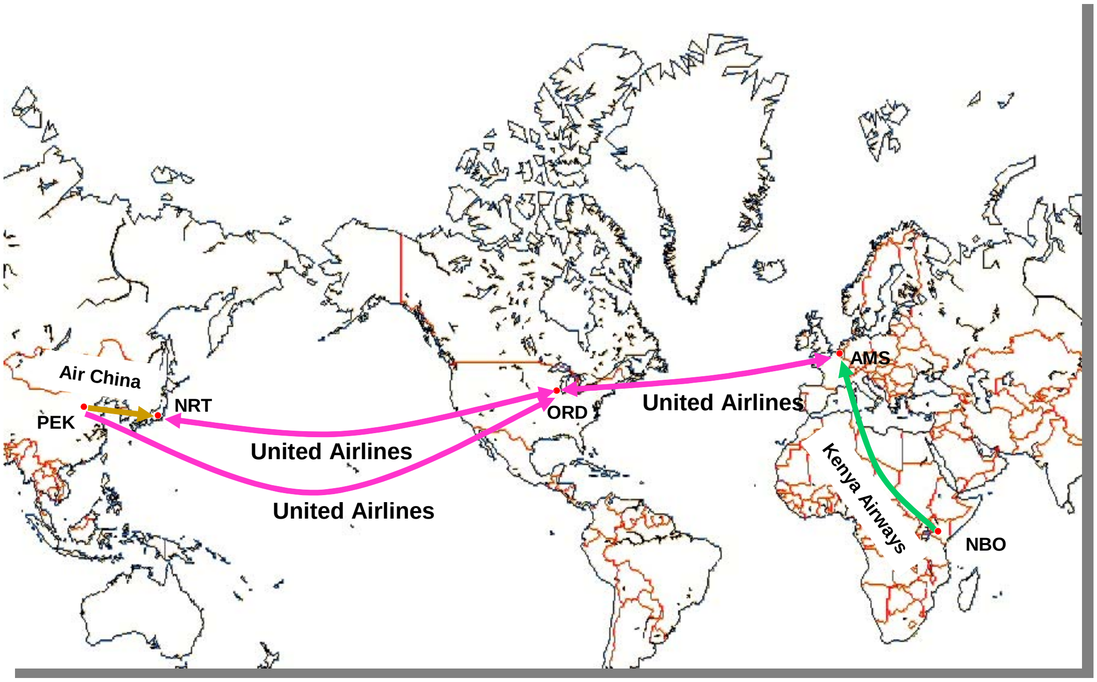


Figure 22 : TSA interoperability Trial locations

- A limited number of empty test bags were used that traveled from NRT to ORD to AMS and back during the trial.
- The provided data allow to evaluate the interoperability across the entire UHF spectrum (European, U.S., and Japanese)
- The results (99.2% to 100%) clearly indicate that, as predicted, the UHF RFID tag is interoperable across the entire UHF spectrum.

Amsterdam (AMS) through Chicago (ORD) to Narita (NRT)		
865-868 MHZ AMS Departure	902-928 MHz ORD Transfer	952-954 MHZ NRT Arrival
99.4%	100.0%	99.2%
Narita (NRT) through Chicago (ORD) to Amsterdam (AMS)		
952-954 MHZ NRT Departure	902-928 MHZ ORD Transfer	865-868 MHZ AMS Arrival
100.0%	100.0%	99.2%

Narita (NRT) to Chicago (ORD)	
ORD Arrival Read Rate	ORD Arrival – Total Tags Read
98.8%	4586
Amsterdam (AMS) to Chicago (ORD)	
ORD Arrival Read Rate	ORD Arrival – Total Tags Read
99.6%	1199
Beijing (PEK) to Chicago (ORD)	
ORD Arrival Read Rate	ORD Arrival – Total Tags Read
99.2%	4628
Beijing (PEK) to Narita (NRT)	
NRT Arrival Read Rate	NRT Arrival – Total Tags Read
99.3%	7540
Nairobi (NBO) to Amsterdam (AMS)	
AMS Arrival Read Rate	AMS Arrival – Total Tags Read
98.2%	2593

Table 28: TSA Trial Interoperability Read Rates

8.1.4.7 Conclusions

- The Worldwide UHF RFID Trial was the culmination of a decade of work by the FAA/TSA as related to RFID baggage tracking and security.
- UHF EPCglobal compliant RFID systems also have been viewed as the future for supporting baggage/cargo and many other assets identification requirements for security and operational tracking applications.
- This trial was intended to demonstrate operation of UHF RFID baggage tags at multiple UHF frequency assignments (860 MHz to 956 MHz) to ensure around-the-world baggage tag read interoperability, and to determine/prove the basic interoperability between UHF RFID baggage tags programmed at one frequency and read at a different frequency.
- The demonstrated read rates averaged in excess of 98.2% for the operational portion of the trial, and in excess of 99.2% for the test bag portion of the trial therefore successfully achieving the desired goal of demonstrating interoperability.

8.1.5 Narita International Airport Trial - 2004

8.1.5.1 Introduction

The Advanced Airport Systems Technology research Consortium (ASTREC) was founded in August 2003 to promote the use of RFID technology in an airport environment and establish the basis for technology for advanced airport systems such as baggage handling, in a more diverse and advanced information-based society. More than 60 corporations are members of the consortia (NAA, JAL, ANA, Delivery companies, Vendors, etc.)

The trial consisted of evaluating the RFID performances on the 13.56 MHz frequency band at Narita Airport with the participating:

- Airlines: Japan Airlines and All Nippon Airways
- Airports: JFK, Vancouver, Amsterdam Schipol, Frankfurt

At the time of the trial, Japan's Radio Law did not allow the UHF band. Read rates of 92 to 95% were achieved. The main issue with reading the baggage was that the tags were in contact with the metallic sides of the reader. There are materials useable in the region of the reader to provide the strength of the metal framework with RFID transparency. Metallic bags and wet bags read successfully, although issues were found if bags were loaded exclusively with pots of instant noodles as the evaporated metal packaging cause reflective RFID read errors.

8.1.6 Air France / KLM Trials 2005-2006

These trials are currently underway and a report will be provided in 2006 to IATA for inclusion in this document.