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Improving on Passenger and Baggage Processes at Airports with RFID

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1. Introduction

Today's airports are overcrowded. The queues are long, passengers don't have time to spend it on the airport queuing, but security restrictions must be kept. Everyone would like to lower the high cost wherever it is possible. Such an area is the amount of costs generated by the baggage loss within the air travel. Another factor is the delay of flights, which can be generated by passengers late at the boarding or even not appearing. The aircraft can only take off if all the checked-in baggage has its owner on board. If not, the baggage has to be offloaded.

The costs generated by baggage loss are very high for both the airlines and the airports. The application of RFID technology would reduce these costs extremely. Today's implementation and chip prices are very high but with time it will decrease. The average industry cost per mishandled baggage is US$100. Approximately 1% of the 1.7 billion bags that passes through the system every per year is mishandled and RFID is an ideal candidate to reduce these losses. Upon full implementation, RFID would save the industry US$760 million annually.

2. Airport passenger and baggage reconciliation systems in use

After arriving at the airport, the traveller enters the terminal building at the departure hall. There the passenger checks-in himself and his baggage, which will be part of the Departure Control System (DCS). The DCS after entering all the necessary data will print a Boarding Pass and the long Baggage Tag (BagTag) with a barcode. The Boarding Pass is printed to inform the passenger of the flight number, boarding time, boarding gate number and seat number, and it is used to identify the passenger at the security and immigration check and boarding gate too. The barcode of the checked-in baggage serves the identification until the final destination. The longer part of this BagTag is put on the checked-in baggage. The passenger receives the smaller slip that contains the same barcode as the checked-in baggage. In case of baggage loss the airline is able to identify and find out where the baggage has been lost. Without the passenger having this receipt the airline is not obliged to find the lost luggage and compensate the passenger.

In recent years industrial deployments have changed the previous infrastructure of the departure hall. The operation of the check-in system has not changed much, but for

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lowering the cost, the used tools (check-in desks, boarding card) have changed. The operation became more automatic and the passengers are more independent.
Currently on many airports there are different facilities available:

1. Traditional check-in desks with an agent: serving mostly the business, frequent flyer and the through check-in passengers.
2. Self check-in kiosks: where the passenger has to check-in himself, following the indications of the touch-screen kiosks. The passenger has to provide the requested data and can print his own boarding pass and baggage tag and then continue to the Baggage Drop to weight and drop off the checked-in baggage. When self check-in kiosks are introduced, an agent can help the passengers.

Fig. 1. Self Check - in kiosk

3. Portable Agent Workstations, Mobile Check-in device: agents circulate around the check-in area looking for customers for checking them in with a hand-held personal computer. These agents can also print the boarding pass and baggage tag, and then the passenger can to continue to drop off its luggage. This method is rarely used (e.g. Kingfisher is using it at Madras Airport). (Pilling, 2001)
4. A mixture of the above mentioned possibilities.
5. A new trend is for passengers without checked-in baggage:
   - web check-in: the boarding pass is issued through the web and the passenger has to print it at home
   - mobile check-in: the passenger can check in via his mobile and the boarding pass will be sent by SMS/MMS to the passenger's mobile phone
     Solutions are being prepared for this kind of check-in for passengers with checked-in luggage too.
6. Remote Check-in: in some cities (e.g. Las Vegas) it is possible to check-in in the hotel or in other cities (e.g. Hong Kong) at major interchanges and the airline will deliver the checked-in baggage to the airport.

The above mentioned check-in possibilities can use several tools too:

1. Boarding Passes:
   - Traditional Magnetic Strip
   - BarCoded Boarding Pass: using 2D barcode printed on a paper from the airport's check-in facility or outside the airport from the web or sent to mobile phones or

PDAs in SMS/MMS format. It should be used by all IATA member airlines by the end of 2010, and it should completely replace the magnetic strip

2. Baggage Tag:
   - Barcode: this is the commonly used solution
   - RFID tags embedded in the back of barcode paper: some airports and airlines have adopted it after some trials (e.g. Las Vegas, Hong Kong)

After the check-in the ways of the passenger and the baggage will separate, and unite again at the Baggage Claim of the final destination. The following graph (*Fig. 2)* shows the way and the steps a passenger and a luggage takes while travelling by an airplane:

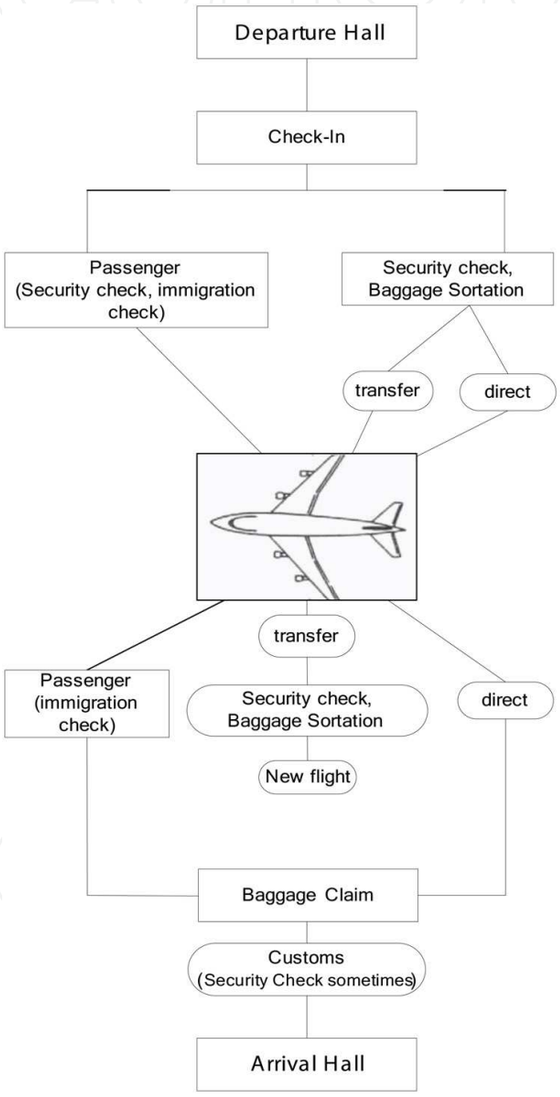

Fig. 2. Passenger and baggage flow during the flight procedure

The passenger is attending the security and immigration checks, the order depends on the airport and then at the time of boarding it will proceed to the plane. In the meantime, after the baggage check-in, the baggage passes through security check and baggage sorting. In the sorting room, with today's reconciliation technology, the stevedore scans the BagTag's

barcode with a scanner that translates the encoded barcode and shows the stevedore to which baggage cart or container and airplane the luggage should be directed to. After arrival of the flight, in case of a direct passenger, the passenger continues to the immigration check and then to the baggage claim to collect his baggage and leaves the airport through the arrival hall. At the exit of the baggage claim nobody checks if the baggage was taken by its owner or another person. In case of a transfer passenger and baggage, the passenger stays in the transit of the terminal building after leaving the aircraft, and he passes through immigration check (depending on the destination) and a security check before re-boarding. The baggage passes through security check, re-sorting and then goes to the new aircraft. If the transfer time is one hour or less, the baggage is tagged with the ShoCon (Short Connection) sign. However, when the airplane is delayed, and the baggage would be needed to be transferred quickly to the next airplane, there is no special sign tagged on the luggage (originally it was supposed to arrive on time and supposed to have enough transfer time), the possibility of the non-arrival of the baggage is very high.

2.1 Problems with in-use barcode-scanner system for the checked-in baggage

Most of the world's airports use a scanner and a paper printed barcode for baggage identification.

The key problems with the barcode and scanner are as follows:

- The barcode needs optical sight, without the line of sight, it can not be read
- Concurrently the scanner is able to read only a single barcode, which is time consuming
- Barcode baggage tag read rates average 85%
- Barcode is printed on a paper that easily crumples, thus the scanner is not able to decode the information properly
- After printing the barcode it is not possible to overwrite the information (only by printing a new one)
- The paper of the barcode is long, full of information that comes off easily, thus making it impossible for the stevedore to identify where the luggage is supposed to be sent and the airline is unable to find it in the computer database. It will be regarded as the airline's mistake, and the airline has to compensate the passenger.
- *Fig.3* shows that the barcode is printed on a long-hanging paper, which is only attached at the middle or at a suitable part to the luggage. The most important part of the paper is just hanging down – without being fixed to the luggage- so it can easily come off or someone can tear it away.

Fig. 3. Today's Baggage barcode solution

2.2 Issues with the lost baggage

The causes of losing a luggage can be diverse: airline baggage system integration, the baggage process of an airport is overly complicated, new and tighter security regulations and more congestions at the airport, tagging error or mistake in the identification, sorting, loading or offloading of the baggage (it could simply fall of the trolley) at the departure or/and arrival /transfer airport, the transfer baggage could be directed to a false destination due to wrong identification or due to too short transfer times, due to human error at the check-in (e.g. wrong typing, passenger is checking in too late), weather or space-weight restriction, communication error between the agents (e.g. in case of rerouting) or the BagTag can fall off the baggage. In the last case the baggage is lost forever, the system for finding lost luggage can not find it as it is not possible to identify it, and according to data of IATA this is the case with 800,000 bags in the world every year.

The baggage can also get lost at the baggage claim without the error of the airline, airport or the operator: it can be taken by another passenger by accident (due to similarities) or it can be intentionally stolen. Irrespective of the reasons, it costs the airline and the airport a lot of money. The airline has to compensate the passenger in some form, depending on whether they find it and forward it to the owner within 24 hours, days or weeks or never and depending on whether the passenger was arriving at home or not. The compensation rules are standardised by IATA and the airlines.

The retrieval costs of a lost bag costs the airlines between US$100-150, excluding the eventual cost of an airplane being held up because of a mishandled bag (Ornellas, 2006).

Carriers	Passenger Checked-in baggage (million)	Mishandled
Airlines of the USA, 2005	440	2.93 million
US domestic airlines	Ca. 600	4.08
Southwest Airline	98	525.000
US Airways	49	420.000
Delta Air Lines	66	456.000

Table 1. Mishandled baggage in the USA in 2006 (Ornellas, 2007)

Year and Continent	Total passenger Checked-in baggage (million)	Lost luggage rate (bag/1000 passenger)
2006 Globally	N/A	6.73
2005 Europe	346	14.1
2006 Europe, airlines belonging to AEA	357	15.9

Table 2. Lost baggage rate (Ornellas, 2007)

Association of European Airlines (AEA) pointed out that this statistics do not differentiate between irrevocably lost baggage and bags later found and returned to their owners (Ornellas, 2007). It doesn't matter, if it is returned or not it costs the airline time and money and the passenger has hassle and is unsatisfied. Approximately 1% of the 1.7 billion bags that pass through the system every year are mishandled. Mishandled baggage is an annual US$3.8 billion problem for the aviation industry. It also affects about 42 million passengers

annually and is the second most important factor in having a pleasant trip, according to the 2009 IATA CATS survey. Between 2005 and 2007, the passenger growth has increased by 9% in Europe, while the number of mishandled baggage has increased by 28% (IATA data source) In the USA the passenger numbers grew by 10.5% while the number of mishandled luggage has increased by 27% (IATA data source). According to IATA the key regions are: Europe, the USA and Latin America. In 2008 the rate of mishandling decreased around 20%, according to data of the Société Internationale de Télécommunications Aéronautiques (SITA) (Bondarenco & Price, 2009). The reason for this is the tremendous effort by airlines and airports and the fewer number of bags per passenger. In 2008 and 2009 the low cost airlines progressively introduced to pay extra for hold baggage and the global economy problems led to fewer passengers too.

2.3 Problems with passengers

The plane can only take off if the owner of the checked-in baggage is on board, if not, the agent has to find and remove the checked-in baggage. This takes a lot of time and can cause flight delay which can lead to further problems and delays costing the airline a significant amount of money and efforts.

There are several possibilities why a passenger is late at the boarding gate: the passenger can get lost, cannot find the way to the correct gate, it is stocked at the long queue of border control or security check, arrived simply too late at the airport, it was lost within the shops or any of the airport facilities, forgot the time and the flight, cannot understand or hear the loud speaker in case of gate change, or is simply to absent-minded, the signs of the airport are not clear enough, or even some medical problem or emergency occurred etc. Whatever the real reason, it costs money for the airline.

At Copenhagen Airport 4% of the flight delay for SAS (Scandinavian Airlines) are due to late passenger at the boarding gate (Ornellas, 2008).

3. Radio Frequency Identification as the improvement

Radio Frequency Identification (RFID) is a technology incorporated into a silicon chip that emits a radio signal which matches a user-defined serial number with an item. In this case the item is a piece of check-in baggage. This number can be read at a distance by an antenna. The following characteristics enable baggage to be sorted automatically and loaded faster than with barcode systems, while reducing the number of mishandled baggage and its associated costs at the same time.

The main differences between the RFID and the barcode-scanner technology are listed below:

- The tag is read by an antenna, it doesn't need optical sight
- Greater amount of baggage can be read simultaneously
- It is able to talk-write to a single tag allowing updating the status of the baggage as it is processed
- Barcode baggage tag read rates average 85% while RFID baggage read rates range between 95-99%

4. International approach to RFID Applications for airports

Current trends of the aviation industry, following the Simplifying the Business (StB) program of the International Air Transport Association (IATA), are: simple and seamless

Attributes	Bar-code	RFID
Optic view	Necessary	Antenna is reading from the distance
Reading possibility	Scanner points	Active tag: always, Passive tag: access points
Read rates accuracy	80-90 %	95-99%
Read – Write	Read only	Read-Write
Up-dating	1 time	Anytime
Real time bag matching	No	With the people
Data	Definite	Indefinite
Location	Top of bags	Everywhere
Removable, Vulnerability	Easily	Impossible
Reading after Vuln.	Mishandling	It can be identified correctly
Configuration	Long Paper	Can be embedded in everything
Technical equipment	Paper, Printer Scanner	Tag Read-Writer Antenna for the reading International Database possibility
Environments	Disposable	Re-usable
Speed	Slow	Fast
Automated (Manpowered)	Manually	Automated
Price	6-8 cent	20-42 cent
Cost	Cheap	The tags are expensive, + implementation costs
Maintenance	Has to be wiped daily	Little

Table 3. Comparing the technologies

travel experience with minimised hassle and more control by the passenger (e. g. less queuing, less time needed at the airport, more independency), meet the consumer friendly expectations, establish financially sustainable business environment, lower the costs of the airlines, environment friendly (paperless e-ticketing), faster and more efficient baggage handling, to create industry-wide standards (IATA b.)

IATA's StB Program had a part concerning RFID, but the related project was closed. On the website (www.iata.org) of the organisation it is written:"Because the value of RFID is subject to the individual merits of each business case, there is no mandate for the universal adoption of RFID from IATA." The project standardized the used RFID tag and frequency for the aviation industry, implementing it into the paper BagTag on the back of the barcode.

Within the StB Program, there was a goal to introduce the BarCoded Boarding Passes (BCBP) using 2D barcode. They can be accessed from anywhere, from mobile phones, PDAs, web, they don't need to be printed on expensive paper stock, and they facilitate off-airport check-in, they are cost saving and environmental friendly. Nowadays they are already in circulation or trials are undertaken.

Another program run by IATA related to passengers was Simplifying Passenger Travel (SPT). The goal was to facilitate the flight procedure for passengers, while emphasizing the simplified and secure passenger processing.
The aviation industry is already trialling and in some areas already applying the RFID technology. Tracking Ground Support Equipment (GSE), catering, cargo is becoming common.
Another useful application of the RFID technology is for the access control of vehicles to airport operational areas (Pilling, 2001). At London Heathrow airport American Airlines' access control system prevents unauthorized drivers from using American Airline equipment as the driver can only start the vehicle's engine by using Airport Security pass which is recognized by the use of RFID technology supplied by Vehicle Telematics Information System (VTIS) (Ornellas, 2007).
Airbus and Boeing cooperated in using RFID for the parts of the aircrafts. Airbus applied it to track tools and for inventory control on inbound shipping pallets (Mecham, 2005).

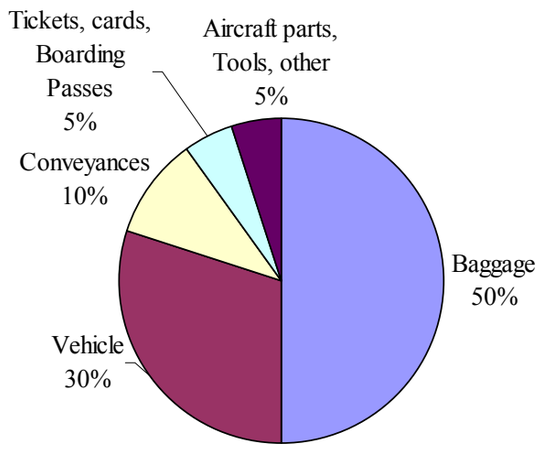

Fig. 4. Spent on RFID systems in the civil air industry in 2006, (Ornellas, 2006)

4.1 RFID for baggage handling

At the Passenger Services Conference in Geneva November 2005 the International Air Transport Association (IATA) has introduced a global standard for RFID baggage tags that paves the way for the use of RFID. In 2005, however, only two or three European countries have permitted site licenses for testing at the higher power level.
Various tests are conducted at major airports with RFID baggage tags. At Las Vegas McCarran International Airport, Hong Kong International Airport it is already operational. Paris, Amsterdam, Milan and San Francisco airport the trials are still going. Trials were completed in Vancouver, Philadelphia, New York, Honolulu, Nairobi, Frankfurt, London, Amsterdam, Rome, Kuala Lumpur, Beijing, Narita in Japan and some Korean airports (IATA a.).
Hong Kong Airport is using the technology for the checked-in baggage and is providing for the transfer baggage arriving to the airport without an RFID tag an extra tag. Currently, more than 70 airlines are involved in this project (Ornellas, 2009).
Heathrow started a six month trial of RFID technology for Emirates passengers (Ornellas, 2008).

For 2004 Delta Airlines has tagged its 40 thousandth passenger's baggage within a pilot program. While in 2004, the amount of RFID enabled baggage tags delivered was only a couple of thousands (and all in a trial setting), by 2005, however, this amount has increased to about 15 million, with an average price of 22 cents per tag.
The airports testing the RFID put the RFID tag into a paper and then attach the paper to the baggage. Even though the paper can come off, the identification is much easier. The other main problem is that if only some airport are applying RFID and the rest is using only barcode application it is not as efficient and still can get lost during the air travel. IATA calculates that airlines would save $768 million annually from reducing their mishandled baggage by only 1%. Even more can be saved by airports, about three times as much. The use of RFID in transfer processes was carefully analysed by IATA as part of the RFID transition plan. This analysis showed that only 80 airports needed to adopt RFID to deliver an annual benefit of over US $200 million to the industry (IATA c.).
Currently the trials and already applied systems are embedding the RFID tag into a BagTag. The baggage tag is a long paper and with embedded RFID tag it can still fall off the baggage.

4.2 RFID for passengers, and other improvements for passenger handling

In 2008, on the Amsterdam Passenger Terminal Expo and Conference international companies showed their latest developments, which provide the technologies necessary for printing and reading 2D Boarding Cards in any format. Different 2D boarding pass printers and technologies were on display, that could be built into Self Check-in kiosks or mobile printers. One of the latest possibilities was the boarding pass sent to mobile phones or PDA-s via SMS or MMS. The greatest advantage of this technology was that the passenger can be informed of the changes related to his trip, but this requires the user to have a modern mobile phone or PDA capable of receiving MMS, which is always on, and can communicate on all frequencies. These solutions are targeted for frequent flyers and business passengers, but they cannot be used for all passengers, because it cannot be expected that everyone has a mobile phone or PDA with such technology. Another problem with this innovation is that a mobile phone or PDA can run out of battery without possibility to recharge it. In the show, boarding pass readers and identification machines were also on display.
The automated boarding gate can read 2D barcode Boarding Passes from mobile phones, PDAs and paper. It is not only a boarding gate it has the facility of the basic process of automated passenger authentication. That means to have the biometric data of the passenger scanned while he is standing at the gate, to instantly compare this data to an existing biometric template of the same passenger and to check if both match. The second step is to check whether this passenger ID is included in the list of passengers who checked-in for the flight. The biometric data is sufficient to perform both steps and reading the

Fig. 5. Boarding Pass with bar code, and with RFID in a paper, 2D bar code in a mobile phone

Fig. 6. Automated Boarding Gate

boarding pass is not necessary (PTEC.) In such an automated boarding gate an RFID reader can be integrated easily.

Scandinavian Airlines tested at Copenhagen airport a more efficient passenger processing and reduced the flight delays due to passengers. The point was that each passenger having an RFID tag card were informed by SMS in case they were not appearing on time at the gate (Ornellas, 2008). The only problem with this is that the passenger has to have a boarding card and an RFID tag card as well.

Swissair conducted a trial at Zurich airport for checking passengers with RFID tags. Each TravelClub member was issued an e-pass, which is based on the membership number. Upon booking the flight this is entered into the reservation system of the airline. The trial involved only for members of the TravelClub without a checked-in baggage. They are automatically checked-in when they pass through the passport control and show their passport (the reservation system passes their data to the DCS), after the border control they had to proceed to the information desks and pick up the boarding pass (Pilling, 2000). The problem with this is that they still needed to print a boarding pass for the passenger and it was not the immigration who gave them the boarding pass, so they had to find the information desk and queue again, which was time consuming.

5. Using RFID tag implemented into a bracelet for passengers and baggage

The now common boarding pass with the magnetic strip or the new 2D barcode boarding pass has a very short lifetime, and is not used after the boarding, only for redeeming frequent flyer points. The recently introduced 2D barcode Boarding Pass, which should be adopted by all IATA members until the end of 2010, avoids printing a new boarding pass for each connecting flight, it can store the boarding pass data of all the connecting flights. But still, after the last boarding it will be thrown away and it is not possible to re-use it.

The airports testing RFID are only using the RFID tag as a baggage tag to minimize the costs for lost baggage. More can be profited from this new technology when it is applied for the baggage as for the passengers too. By giving the passenger an RFID chip implemented into a watch/bracelet, the passenger tracking at the flight procedure can be solved and it facilitates the orientation at the airports for the passengers. In case of a problem it is much quicker and easier to locate the passenger and its luggage. The passenger's way after the check-in could be tracked until the end of the flight procedure. This would make the followings possible:

- The RFID tag implemented into a watch/bracelet, etc would be machine fixed to the baggage at the check in. (It would be almost impossible to remove it.) No more barcode would be attached to the baggage. (It would be almost impossible to remove the bracelet from the baggage.) The possibility that the Bag RFID Tag comes off or someone tears it away is zero. The machine that fixes the bracelet to the baggage could be built into the check-in counter. At all the baggage checking points an RFID reader can be implemented instead of the now used scanner. An example is shown in the *Fig.7:*

Fig. 7. RFID implemented into a bracelet

- The passenger's bracelet could have a small display to show the information of today's boarding pass, the flight information, and, at the arrival to the final destination, the details about the baggage claim. In case of transfer flight the actual details would be shown. This makes the passenger's orientation much easier.
- With the bracelet of the passenger having a speaker and vibration it would be possible to warn the passenger in advance so he would not be late at the gate. In case the passenger is late, it would be much simpler to find him. The flight coordinator could contact the passenger or simply find him in a second within the terminal and the time and costs of unloading its luggage would be minimized or totally avoided.
- In the transit hall right at the entry point or at several points, an information appliance could be installed to facilitate the passenger's orientation. The passenger has to hold his RFID tag against the machine and the machine shows automatically how much time the passenger needs to get to his gate and how far he is by illustrating the way with a printable map. It's also possible to offer the shop list and additional services on the way. In case of an arrival passenger it could show the number of the baggage belt and the way to it and whether his baggage is already circulating on the belt or not. This could be a good service provided to the passengers feeling lost at big, complicated airports.

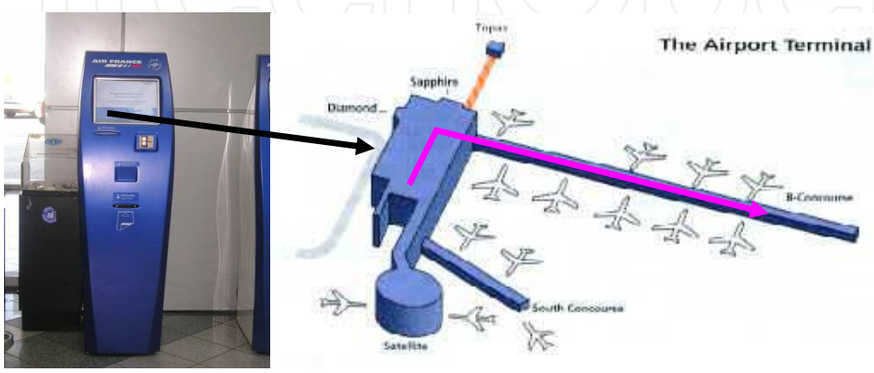

Fig. 8. Passenger Information kiosk

- At the boarding, where today the boarding passes are checked manually, the whole process could be automated with much less human intervention. The passenger would only have to hold his chip against the identifier and if he is at the wrong gate it would automatically alert with a sound or just simply say: 'Sorry you are at the wrong gate'. In case of automated boarding gate the door would not open if the passenger is at the wrong gate and would automatically display the gate number and time with a map where the passenger is supposed to board. While the passenger is crossing the boarding gate, the system is automatically checking if its baggage was already loaded or not, if not it knows where it is. At the end of the boarding procedure the system indicates to the flight agent whose baggage is already loaded but the owner hasn't passed yet the boarding gate and who boarded already but his baggage is still not loaded.
- If the passenger has an RFID tag with the same data as his baggage, the passenger-baggage check at the customs – before leaving the airport – could be effectively completed. The possibility that a baggage is taken away by another passenger by accident or intentionally stolen would be almost zero. It would be checked automatically, so it would be quick and it would not influence or slow down the passenger flow. Costs generated here for the airline could be reduced enormously.

Of course the passenger's privacy must be protected. The personal information of the passenger and his location should only be accessed by the flight coordinator if there is a problem. Until the system is not sending an alarm to the flight coordinator, the staff is only monitoring RFID tag numbers. To avoid mishandling of the personal data a one-way code must be applied and the tag of the passenger should be only activated when the passenger enters the transit hall of the airport at the security or passport check. In the exit doors of the airport an extra reader could be implemented: in case of leaving the airport after checking-in a baggage and not returning on time to reach the gate punctually, the system could send an alarm to the flight coordinator.

5.1 Reuniting passenger and their baggage at the baggage claim

Normally at the exit of the baggage claim nobody is checking if the baggage was taken by its owner or another person. Only at some American airports or at the Hanoi airport in Vietnam, dedicated service people are checking the bag tags manually right before travelers leave the customs area.

Nowadays on some airports the passenger-baggage check at the baggage claim is either a totally manual process or does not exist at all. But in case a baggage gets stolen, the airline is responsible for the compensation. It is not possible to manually check if the baggage belongs to the given passenger. It would simply cause enormous queues. There are not many security checks of the passengers leaving, so this problem is not dealt with.

If the passenger has an RFID tag containing baggage data, the passenger-baggage check at the customs – before leaving the airport – could be effectively completed. The possibility that a baggage gets taken away by accident or stolen by another passenger would be almost zero. It is not manually checked, so it would be quick and it wouldn't influence or slow down the passenger flow.

The realization of this check depends on whether the RFID tag is a one-time used tag or capable of reuse.

In case of a single use tag the check is very easy: In the exit door an antenna is placed which identifies the tags and in case of a problem a signal would be automatically forwarded to the security. Of course a couple of seconds are necessary to complete a check and the passenger

Fig. 9. Exit with reusable chips

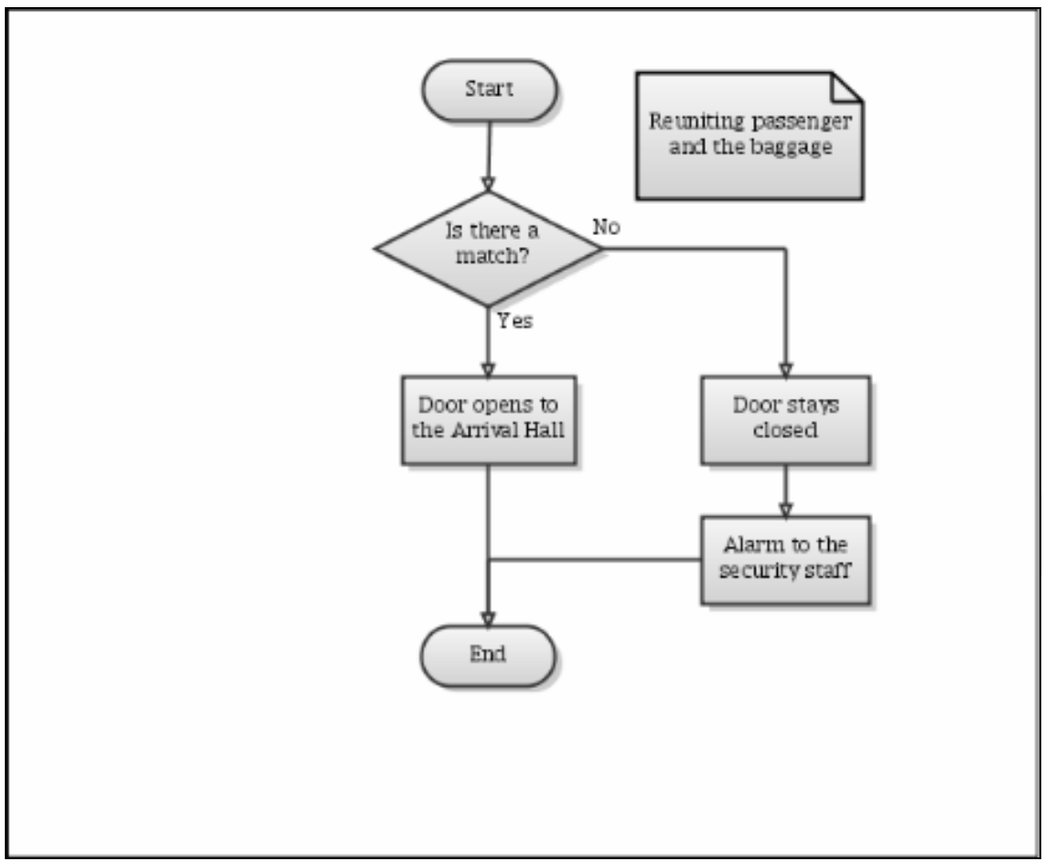

Fig. 10. Simplified flowchart diagram for Passenger and Baggage Identification machine at the Baggage claim

must walk into a narrow lane in order to do this. However the system to be implemented must be capable of handling all the ways passengers bring their luggage (besides, pulling behind etc.). It also has to be ensured that the reader is capable of identifying many passengers (and their luggage) exiting at the same time. After leaving this area the RFID chip should be de-activated to avoid mishandling of personal data and the chip itself.
In case of reusable chips, they must be returned at the airport. This can be processed with a box, where the passenger has to put the bracelet in a holder at the box, while pulling the luggage through. In the box the identification can be made and the chip removed. The exit door is opened if everything goes well. If there is a problem the door stays shut. To save time and space at the airport this identification procedure could be made at the customs.
If a passenger has more baggage it is encoded in the tags so the system knows that several baggage are coming through the box.
In case a baggage did not arrive on time, a tag writer could be used at the Lost and Found desk to overwrite the data so that exit problems are avoided.
As an additional service for the passenger, an information appliance at the arrival side could be used to inform the passenger where his baggage belt is located and other important information such as shops or money exchange, etc.
In case of RFID boarding pass integrated into the passport the passenger has to go through a door like at the boarding gate and has not even to take out his/her passport.

5.2 Combining passport with the boarding pass

The next step in the technology's innovation is the spread out of the biometrical passports with an RFID tag implemented storing the biometrical information. There are 2 possibilities for using the passports as a boarding pass too:

1. Passenger holding the new RFID tagged passports, with the passport having a small display, because then all the boarding information could be automatically stored in the travel document and no extra kind of boarding pass would be needed.
2. Following the trends of saving costs everywhere where it is possible, another option is that the passport's RFID has all the actual boarding information required, and the passenger simply memorizes or copies it to a small paper and the boarding pass would be absolutely paperless. It is only necessary to memorize the flight destination and the time because with these information any flight information display can provide further important information, or the passenger can proceed to a passenger kiosk proposed above.

At check-in desk the data of the flight would be written into the chip. With web-check-in becoming more common the passenger can check-in through the web and if he has no tag writer at the computer where he processed the check-in he just goes to the baggage drop (if he is having a baggage to check-in) and there he can write it to the passport's chip or simply at the border control (like the above mentioned solution of Swissair with the change that the officer is telling the information to the passenger and no pick-up is needed).
In case this is too complicated to apply for each person, then it would be definitely feasible to apply this method for diplomats, VIP person, frequent flyers, business persons etc. They would have their chips and their check-in would be much quicker. To implement a chip writer at home is just a question of time. As after a long period the CD/DVD and USB

drivers and the paper printers spread out and now almost everyone has one, it is just question of time that the chips are getting more common and home tag writers can be used. And with the home chip writers the new problem (and the possibility of) printing the boarding passes at home can be solved too.
The Self-Check-in desks at the airport could have a chip writer and not a barcode printer. With this the tendency of Simplifying the Business wouldn't be stopped. No further boarding pass is needed; it reduces the cost and investigation for airlines and airports. There would be one unique technology, not like what the situation is now, each airline and airport having its own solutions. All nowadays applied technologies for passenger handling can be dealt with using the RFID tag as boarding pass whether implemented into a bracelet or in a passport. The next step is that the security check and the border control could be combined. As the security check technology can have RFID and biometrical identification integrated only by passing through the security check all necessary data can be checked. And only if there is a visa or "black list" kind of problem, then those persons would need to proceed to an extra check. This could speed-up the flow within the transit area.
RFID implemented into a passport with biometrical data as a boarding pass could be not only used within the aviation sector. A boarding pass can be lost easily but everyone is taking much care of the passport. It could be used for each transportation tool and no more ticket would be needed as everyone has only to refresh his own one. Furthermore, it could be used in hospitals and other applications too.
Where the passport check is not needed anymore, the passenger would receive his boarding pass as a bracelet and would return it at the baggage claim before exiting after the passenger-baggage identification.
In case the passport would contain the passenger-baggage information as well, the identification at the baggage claim could be combined with the passport check or simply the exit door would delete the fight data from the passport's chip after identifying. The before mentioned box wouldn't be necessary for the passenger's, there would be simply a reader, where the passenger has to show the chip. While the luggage's chip is a multiple used chip which remains at the airport flow and at the exit the before mentioned box the passenger has to pull his baggage through.

5.3 Advantages of the system

Integrating the RFID tool into a GIS system allows a very good visualization of the passenger and baggage flow, their connectivity, their way within the terminal, where they have spent much time. Many automatic recordings, reports, maps, statistical data information for further improvement can be generated from the GIS software emphasizing the strength and weak points of the infrastructure. Emergency alarm can be sent out and later analysed and visualised. In emergency situation a map is also helping the staff to find the place. Giving passengers and baggage RFID tag their tracking and tracing within the whole flight procedure can be visualized by map. The way of the baggage is seen: the weak points of the used infrastructure can be recognised (e.g. congestions) and corrected. Seeing the passengers flow within the transit hall the airport can see what type of shops, bars, services the passengers like, where they spend their time while waiting for the plane. All data is stored in a database, any type of queries can be made. The system can be connected with the border control and airport security services too.

Another advantage is for the passengers and for the airline and operator is that paper is minimally used. The passenger has only to take care of its passport (in case the passport is the boarding card) or only of the bracelet. As it is contact less, it is only important that the passenger has it, but doesn't really matter where it is. In the long term when everything will go with biometrical identification maybe not even the passport will be necessary, just an RFID tag.

The RFID technology is totally adoptable in currently industrial trends. Into any kind of check-in desk, boarding gate, security screening it can be integrated. It is fast, reducing the queuing times and congestions.

Airports and not airlines should be the owners of the new technology and issue the baggage tags in future. If only the airline was the owner they would only use it for their own baggage flow. Different airlines are applying different systems, and the main importance is the link between the airports and the standardization in this technology. It complicates the system if each airline signs a contract of cooperation with each other airline. If each airline applies its own solution it results in a very complicated baggage sorting that is much more time-and-space consuming.

The implantation costs and the chip prices are too high for the airlines. The airlines are using only a part of the airport and not the whole airport; this technology could be applied for the many airport operations. And it is unnecessary that each airline develops and implements its own technology. It is much more efficient, less complicated and cheaper if the airports develop and implement the applied technology and the airline is only renting it. The most efficient is to work out a strategy for the RFID bracelet for all the world's airports, and the airports are given a time period to implement the whole technology.

6. Conclusion

RFID technology can be used for identification, tracking, locating and monitoring both people and items. As the cost of the RFID technology has begun to fall, currently the baggage tracking is the field in the aviation sector where RFID has proved most useful, and is becoming widely adopted.

Using RFID for passenger and baggage handling makes the processes fully automated and minimises the manual tasks made by assistants, reduces the costs for airlines, airports and operators. As the system enhances the efficiency and service level, unnecessary costs of the paper-based technology can be minimised, and the return on investment will be payback in long term. The system is faster, needs less manpower, the maintenance is cheaper and the resources can be allocated elsewhere. It is following the current trends as it is environment friendly too as it is paperless, no printing and paper is needed which is a very important issue currently in the aviation industry. Another important issue is to make the air travel more customer friendly, less time consuming, hassle free, with less queuing, but the security of the passenger must be guaranteed. Airlines want to use less space and less infrastructure of the airport to save costs. The airports are tending to use more space for retails, bars & restaurants or other facilities for customers. The RFID printing can be integrated into check-in desks, self-check-in kiosks, it is not influencing the recent trend of using less space, and allow better use of resources for airports.

RFID can be used in the aviation industry not just for passenger and baggage tracing, furthermore for the better resource allocation of the Ground Support Equipment (GSE), inflight catering, couple of airlines (e.g. American Airlines) are using it to prevent unauthorised drivers accessing restricted areas of the airport, for access control and airport security, in the cargo handling (it is already commonly used). By giving passengers and baggage RFID tags, their identification and tracing can be combined with the security and immigration issues and together integrated into a GIS system for mapping (e.g. in real-time and non-real time, the points and flows depending on the RFID tag type) and reducing false security alerts, etc. RFID technology is a good method to increase the security, safety, and customer satisfaction. The technology could increase passenger throughput because baggage handling could be quicker, flight schedules could be kept more, and there would be fewer delays, all of which can be quantified as cost savings.

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Radio frequency identification (RFID) is a fascinating, fast developing and multidisciplinary domain with emerging technologies and applications. It is characterized by a variety of research topics, analytical methods, models, protocols, design principles and processing software. With a relatively large range of applications, RFID enjoys extensive investor confidence and is poised for growth. A number of RFID applications proposed or already used in technical and scientific fields are described in this book. Sustainable Radio Frequency Identification Solutions comprises 19 chapters written by RFID experts from all over the world. In investigating RFID solutions experts reveal some of the real-life issues and challenges in implementing RFID.

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