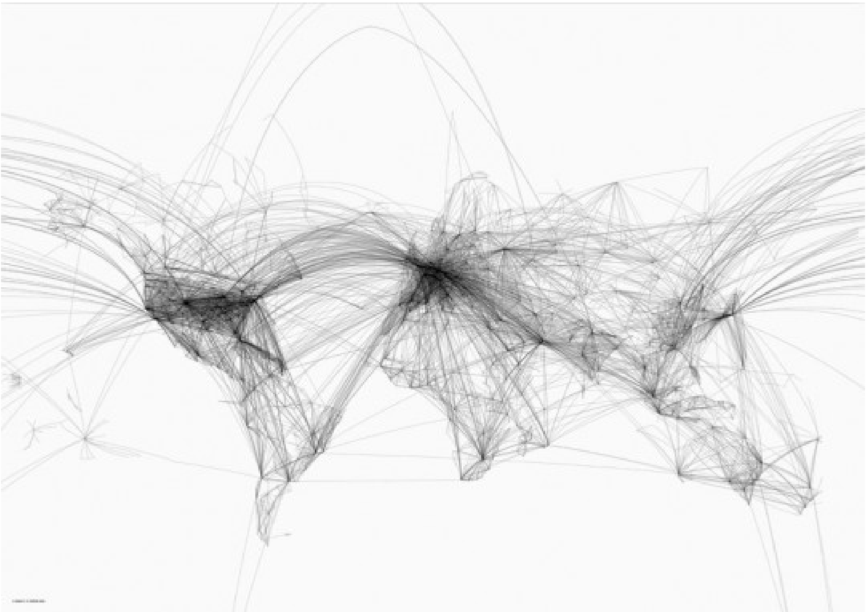

FEASIBILITY STUDY OF INTRODUCING SMART TECHNOLOGIES IN BARCELONA AIRPORT

REPORT

Final project degree
22/06/2016

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Chapter 1

Executive summary

Air traffic growth has been one of the largest revolutions that have changed the world in recent years. As a part of the process of globalization and worldwide connexion nowadays is easy to go from one point to another of the world in a couple of hours. Bussiness and echange of goods and people from one country to another are possible thanks to these network of worldwide connexions with the logistic points located at the airports.

These air traffic growth has been followed by technological changes. The market liberalization [4.1] and the different facilities which the traveller can use provide airports with characteristics of big cities whith everything who anyone can need. However, actually this is not enough for the expected trafic growth and is necessary that more changes and investments are introduced [4.2] in order to make all the process before the flight more fast, economic, comfortable and efficient for both travellers and airport infrastructures. The passenger experience [4.2] should be as perfect as possible because in fact, the travellers are those who are going to support the airport services and therefore, the air traffic growth.

The airport of Barcelona [5] is one of the airports that represents perfectly the explained tendency and the huge importance of having the proper technologies and infrastructures to provide with good services to incoming passengers. It has the characteristics to be considered as the future European hub and is one of the most importants in Europe owner of low cost flights. It seems impossible to belive that in future years the new Smart Technologies that are implemented in so important airports like Heathrow or Munich will not be located also at this economic potentially point [6].

The aim of this project is make a first approach about what will be the direct effects of the implementation of passenger experience new Smart Technologies in terms of time, economic benefit or traffic capacity. The baggage drop off, the security check, the border control or the process of boarding are intended to be changed [7] and the results show an already known secret: the investment is worth it. Less terminal passage time, a higher customer satisfaction, less personal needed, more space and longer life for those infrastructures that are damagged, better economical rates, increase of capacity [7.3] or the possiblity to recuper the initial investment in almost two years.

From the point of view of the passenger, the sensation is better due to the automatization of the process that gives hime more autonomy and control over its flight. There are also less stressful moments [7.2] and the time involved in the terminal seems to be more peaceful. From the point of view of the airport stakeholders, is a future change that more lately or not, needs to be done and that represents a secure investment that will avoid to the airport problems of capacity, delays or unlikely experience processes.

Chapter 2

Objectives

Actually, air traffic is one of the most used transport method to travel from one place to another. The initial concept that people had about airplane travel has been increasingly changed and the exclusivity of this way of transport has gone down in history. Nowadays there is more and more people that use the air traffic quite often in this live and they benefit form the flight offers and low prices from certainly air companies. That tendency implies a high increase of the air traffic demand because more airplanes, airports and all the systems involved in the flight process and in the airport infrastructure are needed. It seems that this is not going to change and for the future is predicted a notable increasing of the air traffic demand.

These traffic forecasts with high values of flights every day mean that in a near future the space, the infrastructure and the airport systems in so many airports probably will be insufficient to absorb the demand and satisfy the consumers necessities. This problem is aggravated by the fact that actually several airports (some of them the major platforms of each region) are close to their full capacity.

The airport Barcelona El Prat is not an exception. The growing demand of traffic on it could be a problem in a near future if no changes and investments are introduced. The construction of new facilities to absorb the flux of passengers and flights and then ease the problem is not always available: there is more concern and social pressure about the environmental impact of new infrastructures, the noise pollution, the destruction of natural and protected territories or the economic factor because these kind of expansions are too expensive and amounts of money are needed.

The aim or the objective of this project is clear: find the best way to optimize and solve this problem in the airport of Barcelona. A study of the viability of the implementation of different technologies will be done and then, some conclusions will be extracted considering the different results. Principally, the study will be focused on the implementation of Smart Technologies in the landside in order to solve different problems that passengers have to face since they arrive to the airport to they enter the airplane. The study and the optimization of those procedures in the landside will be determining to organize the dimension and the structure of the passenger terminal.

Finally, after using all the provided facilities and after implementing all the described methodology, the objective is that in the airport of Barcelona some different key points could be achieved and demonstrated:

• Provide to Barcelona Airport with two passenger terminals with a better structure and dimension with the best optimization of space.

• Arrive to a gain of passenger capacity on both airport terminals (A and B)

• Have a better coordination between the landside and the airside.

• Reduce considerably the passenger lines and waiting times in the following processes:
-Bag drop off / Facturation
-Document Check
-Security check
-Airplane boarding
-Bag recovery

• Demonstrate the availability of the implementation of Smart Technologies in both terminals (A and B) and for national and international destionations.

• Achieve a better coordination between the airport and all the airlines operating on it that benefits the passenger interests.

• Show the considerable economical benefit that could be achieved with the implementation of all the described points.

• Provide the airport with a document of the impact of benefit assessment after the implementation process.

• Show a new distribution of the airport terminals with the new smart facilities implemented on them.

Chapter 3

Scope and methodology

The different tasks are intended to show the big change that nowadays is happening on the way airports are considered. If these changes are not implemented correctly and are not understood by all the population, probably in the future the air transport is going to be collapsed and without any possibility of reaction.

1) Establishment of the theoretical background
In order to understand the actual situation and the changes which are intended to be implemented is important to show a brief overview about the principal systems involved in the airports management, the principal stakeholders and then, the future tendencies.

2) Barcelona El Prat airport context
The second part will consist on place the Barcelona airport inside all the theoretical background exposed before. The explanation of which are its principal necessities of management, air traffic, capacity and also the principal problems that it is facing will be the two fundamental parts exposed here.

3) Smart solutions in Barcelona airport
The solution to the necessities and problems that the Barcelona airport is facing is the implementation of smart technologies in both passengers terminal. This third part will present the average of possibilities that could be implemented there explaining each one and exposing the requirements needed for doing it.

4) Elaboration of case study to test the proposed Smart Solutions
Inside the context of Barcelona Airport, the study of the availability of the Smart Solutions will be done through proposing different travel situations and then see if there is an increase of benefit applying it. Each situation or process will be named "Case study" and in each one will be different key parameters or indicators that will help to measure this impact and benefit assessment.

5) Study of the impact and benefit assessment
The key parameters established in the previous task for each case study will be analysed before and after the implementation of the smart technologies and then, a comparison will be done in order to extract the conclusions and the economical benefit (if it exists).

6) Results analysis and conclusion
Brief explanation about which are the most important conclusions that could be extracted from the study.

Chapter 4

Airport management and future tendencies

In the last decades, mobility has undergone a progressive growth. Transport connections are necessary to drive trade and economic growth and to create employment and prosperity. The transport network is considered one of the most important parts of a country and allows people, enterprises and economic stakeholders to go one way or another and establish different kind of exchanges. Definitely, these strong connections allow goods to be distributed efficiently and make places accessible, bring and bind people together and allow the population to travel and have a good quality of life.

During recent years the tendency is clear: the objective is have a strong and developed transport infrastructure and having a single transport network without obstacles between the State members. The final objective so, is understand that not only the market liberalization is useful and also expanding, modernising and streamlining the infrastructure is necessary to create a modernized network with capacity for all the predicted traffic growth.

4.1 Airport management and liberalization of the market

Due to the high risks of death if an accident occurs and the high costs of producing and maintaining airplanes, the air transport was organized since its creation based on national public regulation of competition conditions rather than on the free market. The fact that each country at first had his own regulation with his prices and taxes made that the air market started being a fragmented market with national monopolies and very high tariffs.

That initial situation has changed because of the gradual and progressive liberalization of the market. This liberalization is produced by the action of three successive packages of measures: the air carrier licensing, market and fares. These introductions removed the restrictions that limited the air transport markets in Europe and were responsible of the cross-border investment by the European airlines.

The consequence of this transport policy is that today the users have more choice and also pay much lower prices. The security procedures in the airports are being each time more common between similar countries and the objective is that in the future, all the air traffic in the world could be reguled under the same normative. Because of that, is important that the management of the airports and the air traffic control is adapted to the new trends and evolves with time.

The liberalization of the air market will continue with the action of different packages related with the transport infrastructure:

1. Three airway packages to help with the liberalization of the market and strength security requirements to enter into the airplane in order to void terrorist attacks.
2. Two single European sky packages (SESAR): the aim is create one European airspace under a set of common aviation rules.
3. Infrastructure (TEN-T): nowadays the transport infrastructure is unequally developed across Europe. The trans-European transport network (TEN-T) is the project that has to deal with it. The objective is modernise and knit together all the corners in Europe making the best use of the existing infrastructure and creating others in the zones less developed. The final "smart network" is wanted for the year 2030.
4. "Smart, green and integrated transport": include all the necessary technological advances for having one of the best transports networks in the world but reducing also the carbon emissions that transport produces. The innovation and progress have to improve efficiency which will help to fulfil that. The reduction of oil dependency, greenhouse gas emissions and local pollution is the priority. To achieve that there will be cuts and reducing in emissions from transports.

The principal european package that affects in a direct way to the airport investment is the implementation of the SES program, which is essential to ensure a feasible air transport structure for the future.

The future liberalization of the market should take into account the european regulation changes and the SES program, which will lead the future of the air transport trend (see Annex 1).

4.2 Future Airport Smart Technologies

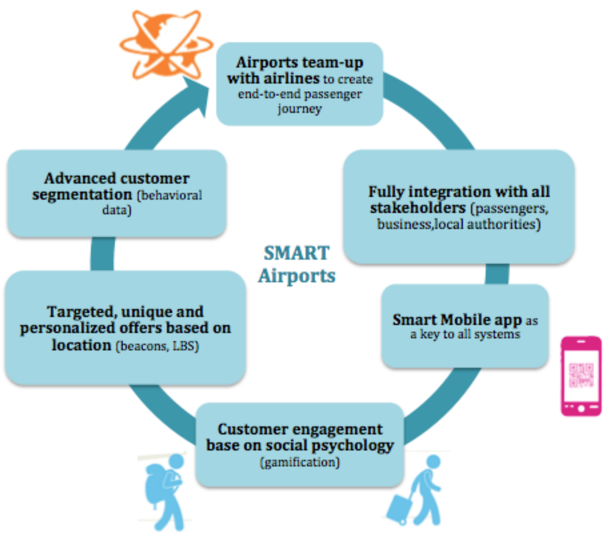

Figure 4.1: Smart airports principles

The introduction of smart technologies in the future air navigation network and also airport infrastructure is essential for achieving a passenger experience which is easy, comfortable and unforgettable for the airport users.

Actually, the majority of the airports offer services tat are technically correct but the experience is far from being memorable or desired to be repeated by the travellers. If they do that, is because there is no alternative and there is a necessity of movement for different reasons: business travel, holidays... Thus, the actual situation inside the airports is not promoting or encouraging the traveller to spend time inside the infrastructures or to use all the services offered. The majority of them just go there to pick the plane and then arrive to the final destination. This fact means that the opportunities that the installations have are not being used and the economical benefit is less than the expected in some cases.

The objective of the introduction of Smart Technologies is change the way airports are conceived nowadays. The airport is desired to be considered as an independent city where the traveller can find everything he needs and where spending time is confortable and agreeable. The passenger will be constantly in contact with the airport through his mobile phone where he could find all the necessary information: flight details, average waiting time in the security area, local merchandisers offers, basic checklists considering the passenger preferences...

The airports of the future will fully exploit the power of new technologies, including sensors, processors, mobile apps and behavioural analytics. The integration of all the elements in the airport domain is essential to achieve this. The baggage treat is also important in order to assure the less level of stress to the passenger. In conclusion, the objective is the transformation of the airport into an aerotropolis or also called Smart Airport.

The application of the Smart Technologies is focused principally in two aspects: improve the passenger experience and provide the airport with better installations that represents saves of money.

Smart Technologies related with passenger experience

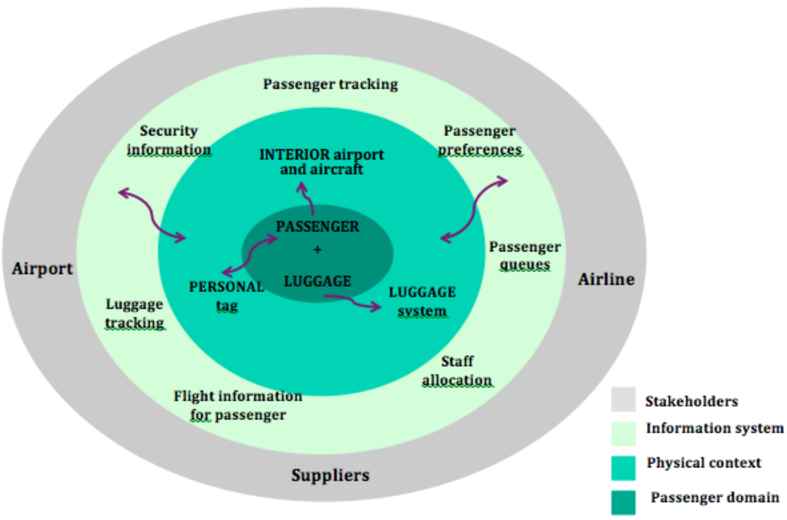

Figure 4.2: Smart Airports environement

•Check in and baggage drop off

The majority of the travellers nowadays start their journey online. The flight tickets are always booked via Internet on the different airline webpages. The travel arrangements are done there also and only few of them have to contact with the corresponding customer service to do it. This tendency has to be kept for the future and the baggage drop off has to follow also this self-service device.

To speed up the check-in, the industry is planning the instauration in the majority of the airports the self-service kiosks. That kind of investment will provide passengers with more autonomy during all the process but represents also a gain of time and save of money costs. The idea is that the passenger by himself could drop off the bag in a self-service kiosk giving to the informatics system some information like the airline, the destination and the booking number. For the future is also expected that each passenger could have a personal electronic tag to follow his baggage and which could be refilled with new information each time that the customer buys an airplane ticket.

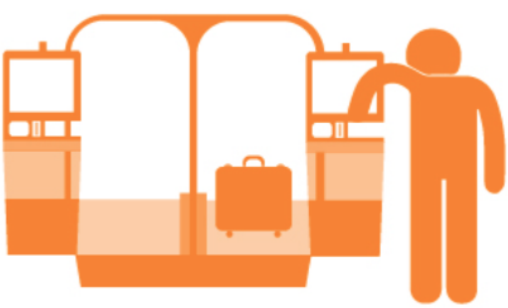

Figure 4.3: Self-service baggage drop off

Figure 4.4: Automatic identity validation

•Boarding and security check

One of the other stressing processes inside the airports is the pass through the security check. Amounts of security procedures combined to the constant flux of passengers cause big lines, delays and important waiting times that stress the airport users. The current procedure actually is changing and some innovations like the ABC control or the biometrics identification are appearing. However, is important that in the future in all the airports the identity validation is done without the necessity of an officer to check it manually.

The principal contribution of Smart Technologies to this part of the passenger experience is the validation of the identity of each passenger via different procedures that differ from the traditional one: biometrics, tokens, ABC border control, databse in the airports... With that, the amount of lines are reduced because the process is more fast and there is also more security because is more difficult that the passengers could change their identity. Finally, some changes are desired to be introduced also in the security procedures in order to fasten the time involved there, principally promoting different queue configurations, giving more information to the passenger or provide notifications via mobile app informing the user when is the optimum time to pass through the control or giving him some kind of prizes or advantages if he passes between a determinate period of time.

Figure 4.5: Traditional procedure before boarding

•Baggage claim and self-reebooking

In some cases unexpected things could happen during the travel, before or after it. One of these cases are the lost of the baggage or the change or annulation of one flight. Passengers should be able to manage to solve these kinds of problems without the necessity to contact with airline operators and that way, save time and money in comparison with the actual procedures, which are difficult, long and require the supervision of the airport or airline operators.

If passengers are able to change an annulled flight in the same installations of the airport or from their home the capacity and flux of passengers in the airport will improve because less lines will be formed in the terminals. The same thing for the baggage, if instead waiting at the arrival hall the passengers could be able to locate their luggage thanks to some kind of tags located at their bag or with the help of other airport baggage claims, the wasted time will be less and the level of satisfaction better. In conclusion, the two mentioned solutions are the ones that are intended to be implemented thanks to the Smart Technologies.

•Smart connection

The installed new facilities and technologies in the airports are going to be directly accessible to the passenger through his smartphone. The objective is that the corresponding airport application will send the passenger different messages informing him about any case of disruption, flight information, boarding time, average time in the security check, possibility of reeboking, special offers in the shops considering the preferences of each customer…

Considering all the things exposed before is clear that the essential element in the airports is going to be the mobile phone and all the different steps and additional procedures are going to be treated directly from there. With this Smart connection the relationship between the passenger and the airport is so much closer and the sensation of comfort and the feeling of a good experience is more present. The principal effect of that is that the passenger will enjoy more the travel and the airport experience and then, he will want to repeat it more times.

Figure 4.6: Duty free devices with the passenger

•Access to the airports

The form that the passengers arrive to the airport is also intended to be changed by the implementation of Smart Technologies.

The ideal situation is that the passenger will approach the airport in a comfortable express train, bus or metro. The user will have already checked the bag at the railway or bus station in the city centre and won't have to worry about it anymore because the same airport facilities connecting the Smart City with the Smart Airport will do it for him. The train or transport public will arrive on time and just at the moment where the boarding has to start in an average time between 60 or 95 minutes. Everything is controlled and the passenger mobile phone will inform him about the boarding door, the security check time or the duty free offers.

In case the approach to the airport is done by car, the staff of the airport will have to assure a previous available parking space situated in the best comfort zone for the flight and destination choose by the user.

Chapter 5

Barcelona El Prat

5.1 Context

General information and infrastructures

The airport of Barcelona is located in the platform of Delta de Llobregat, where there are different multimodal infrastructures of transport: port, airport and zone of logistic activities.

The airport is part of the business group ENAIRE who manage almost the totally of the airport network in Spain. Is the second largest airport in Spain, after Madrid Barajas, and in the year 2015 was the number ten in passenger traffic. Concerning the world, is the number twenty seven in the list of best airports worldwide and the second best airport in south Europe according to Skytrax awards.

Infrastructures

The airport has three zones for take of and land, three runaways in service, two in parallel (07L/25R) and (07R/25L) and one cross (02/20).

There are two terminals, T1 and T2 (T2A, T2B and T2C). The airport is accessible via train, subway, bus and car from the centre of Barcelona. Inside both terminals, there are different shopping centres, restaurants, bars and plenty of facilities and comfortable zones for the passengers. There is also a corporative terminal and an space for the air cargo.

5.1.1 Airlines

Actually there are 90 airlines operating from the airport of Barcelona. To see more detailed information about the name of the companies and the terminal which they operate for see Annex 2.

Destinations

From the airport of Barcelona is possible to flight to differrent European and no European destinations. To obtain more detailed information go to Annex 2.

5.2 Needs and requirements

The airport of Barcelona is an airport with a huge potential for becoming one of the biggest airports of Europe with considerable number of flights and good provided services. The airport has one of the best taxes of growth and the number of passengers has increased considerably each year.

Nowadays, the airport is quite near to the airport of Madrid Barajas, which is the most important airport in Spain: in 2015 the number of passengers of Madrid Barajas was 46.828.279 and in Barcelona the amount was 39.711.276. During 2016, the tendency of approach has been kept and in March the difference of passengers was over 300.000 passengers, 3.989.324 for Madrid and 3.301.296 for Barcelona. The average of growth is one of the best of Europe.

All these facts and developments have demonstrated that Barcelona El Prat is an airport that in the future will need better installations and facilities in order to be able to give an appropriate service for all the incoming new traffic. Actually, the airport has some limitations that can be solved with efforts, but in the future the situation will get worse if any solution is proposed.

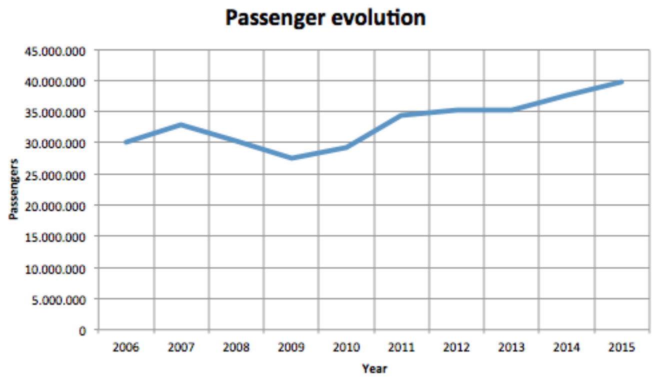

Figure 5.1: Passenger evolution in El Prat

Management

The maximum responsible of the airport El Prat is ENAIRE, the company that controls and manage all the airports and airspace located in Spain. However, and considering the future tendencies is important that the airport and the community (Catalonia) could be able to have more autonomy and decision over the operations inside the airport.

Actually, the airport of Barcelona in certain periods of the year has more number of passengers than the airport of Madrid Barajas and that fact will imply for the future that the management of the installations and the installed facilities will be more complicated and has to be more efficient to absorb the growing demand. The implementation of new Smart Technologies is intended to help and improve the situation but is important that the managers of the airport know the situation and get adapted to the new tendencies.

10/07/2014 02:25 CEST

"El Aeropuerto de Barcelona puede y debe ser más"

JORDI MUMBRÚ ESCOFET | Barcelona

El arquitecto y planificador urbano Kees Christiaanse participa en el Workshop organizado por el área metropolitana de Barcelona

Figure 5.2: Airport management new

06/09/2014 14:54 CEST

El aeropuerto de El Prat supera de nuevo a Barajas

EL PAÍS | Madrid

Barcelona logra un récord de pasajeros en agosto con 4,2 millones de personas

Figure 5.3: Airport management new

The idea is that the airport could provide a serial of procedures which depend on the airport legislation and domain but in agreement with the airlines that will help to manage better with the punctual growth of air traffic.

- Revise the implementation of Smart Technologies.
- Installation of Document Check machines which provide the passengers with all the documents necessary for the trip considering the legislation of the other countries.
- Creation of a database for the most usual travellers.

Installations

The installations of the airport in Barcelona have been able to manage and provide good services to the growing number of passengers since the airport was opened. However, during the periods of more inflow of passengers certain number of problems has appeared.

First of all, the lines in the check in desks are quite important certain times because the distribution of the counters is not the optimum one ad the check-in procedures and baggage drop off are slow. In addition, when a flight is cancelled the time of reaction and ree booking of all the passengers is so long and because of that the situation gets worse with amounts of people uninformed and without a place for staying quietly. The security check is not exempt of problems and when the amount of passengers increases, the lines are considerable and create important delays. If in the future the passenger traffic continues with the growth the situation could get worse and in the periods of more passenger influx the airport could not be able to provide a good service.

LA VANGUARDIA | Barcelona

Los vuelos Vueling acumulan retrasos en el aeropuerto de El Prat

LA VANGUARDIA | Barcelona

Largas colas en El Prat para facturar en vuelos de Germanwings

Figure 5.4: Airport installations news

The solution goes directly through the implementation of Smart Technologies in order to improve the existing spaces and installations and enhance a better capacity for the airport:

- Baggage Drop Off
- Document Check
- Flight re-booking
- Self-boarding
- Baggage Recovery
- ABC Control
- Usual travellers database
- Mobile phone app

Operations

13/11/2013 13:01 CET

Vueling vuelve a potenciar El Prat con siete aviones y 14 rutas más

DANI CORDERO | Barcelona

"Para nosotros Madrid es un destino, no un origen", señala el presidente de la aerolínea de bajo coste, Álex Cruz

Figure 5.5: Airport operations new

18/06/2015 17:19 CEST

Easyjet abrirá en El Prat una base operativa tras cerrar la de Madrid

DANI CORDERO | Barcelona

La compañía aérea basará tres aviones en el aeropuerto barcelonés y contratará a 120 personas

Figure 5.6: Airport operations new

13/01/2016 00:03 CET

El Prat roza los 40 millones de pasajeros gracias a las 'low-cost'

DANI CORDERO | Barcelona

Las aerolíneas de bajo coste copan mueve dos terceras parte de los pasajeros del aeropuerto, con Vueling y Ryanair a la cabeza

Figure 5.7: Airport operations new

16/04/2016 00:02 CEST

Ryanair apuesta por el aeropuerto de El Prat como 'hub' europeo

DANI CORDERO | Barcelona

La compañía irlandesa empezará a ofrecer el servicio de transfer desde Barcelona y Stansted para competir con su gran rival en la capital catalana, Vueling

Figure 5.8: Airport operations new

The airport of Barcelona is positioning as one of the most important in Europe considering the number of operations because the big presence of low-cost airlines that are offering high number of connections with other European cities. To absorb and give proper service to the passengers the installations have to be better and the implementation of Smart Technologies efficient:

- Baggage Drop Off
- Document Check
- Flight re-booking
- Self-boarding
- Baggage Recovery
- ABC Control
- Usual travellers database
- Mobile phone app

Chapter 6

Barcelona El Prat Smart Technologies

These case study are the different processes that the travellers have to go through since they book their trip to they exit the airport at their final destination. All of them have been taken into consideration in order to study and improve the efficiency of the general process.

The final objective is to provide an end-to-end passenger experience that is secure, seamless and efficient and assures that the expected traffic growth is going to be assumable by the worldwide crowded airports. All the case studies that are going to be presented and that conform the passenger experience are under the Simplifying the Business (StB) program[**??**].

6.1 Bags ready to go

THE PROBLEM

The baggage check-in is a process that should be reconsidered and remodelled as a process non-depending of the airline operational service. It remains as a difficult process because if a passenger has to drop his bag he has to wait a long queue to do it and that means that the passenger should arrive early to the airport and he will have to wait in a long and unpleasant queue.

THE SOLUTION

The solution involves significant increase of the passenger responsibility making them pass through a drop-off automatic kiosks where they could manage all the process. The passengers should be allowed to print and apply their bag tags themselves and then, they should be able to follow the bag through different informatic systems or sensors. In conclusion, the process will be more computerized.

REQUIREMENTS

To validate the Bags Ready to Go project the airline must have implemented two processes with supplementary material. That two processes could be done separately (two-step) or at the same time (one-step).

-Self-Tagging: the self-tagging means the possibility for passengers to print and apply their baggage tags themselves using the facilities in the airport or from their home. There could be dedicated or shared kiosks at the airport or at a remote location. The possible bag tags could be printed at home or could be permanent electronic tags.
-Fast Baggage Drop Off: this is the facility designated for the purpose of baggage acceptance. This function could be an agent facing the baggage or the self-service kiosk in the airport terminal.

In this case is also important that the informatics system of the airline and the airport is capable to manage and connect all the information that the passenger enters with the destination of the baggage. In case of a failure in the system is important also a good response for repairing it and a good client claim service and information about alternative ways to drop the baggage for that cases.

IMPLEMENTATION

The implementation of the process starts with the system transformation to the Self-Tagging and Fast Baggage Drop Off. However, is necessary also some supplementary material: the BCBP and the CUSS are the needed facilities and with that and the two project facilities mentioned before, all the process can be implemented perfectly and will provide a huge amount of advantages and benefit assessment to the passenger experience.

The implementation of the Bags Ready to Go will provide low operational costs both the airlines and airports and will improve also the use of the existing infrastructures and space in the terminal. The management of the bag will be also digitalized and controlled by the informatics machines and that fact is better for the general security. The passengers will gain also better comfort, reduce of stress due to the queues and lack of information and a consistent services which provide them the control over their baggage and more flexibility and combination.

BARCELONA SITUATION

Actually, we can find some airports and airlines worldwide that are using the process of self-tagging bags and have kiosks or installations for it located in their terminals. The idea is that finally all the airlines operating in El Prat use this technology and due to this the communication with the others airports in the world would be more efficient and easy.

Iberia became the first airline to launch home printed bag tags globally in July 2013. This new product allowed and still allows passengers who check-in online to print their luggage tags along with their boarding pass. The tag is printed on an A4 sheet of paper and the passenger simply has to attach it to their bag. Upon arrival at the airport passengers simply have to go to bag drop point where is verified by an agent of the company (this last almost 30 seconds) and then the baggage is deposited into the baggage system. Nowadays the airline is using this service in all the Spanish airports including Barcelona and also in all the international point-to-point services.

Figure 6.1: Qantas,Iberia and British airways are the pioneers of permanent Bag Tags.

Figure 6.2: Sydney airport

In October 2013 **British Airways** and **Qantas** were the other airlines that changed the market with the introduction of their permanent Bag Tags. Qantas launched the Q-Tag and British Airways his digital Bag Tag. Concerning that digital bag-tag, it was electronic and eliminated the need of a new paper version every time the passenger had to flight. The passengers only have to use the app of the company to send there the check-in details and then the app automatically updates the digital bag-tag with a unique barcode containing the flight details just by holding the phone over it and via wireless. The Q-Tag functioned also with the same philosophy. Those initiatives started to be tested in the airports of Doha and Heathrow but nowadays they are not used in Barcelona.

After these three first airlines that introduced the concept, another airlines have joined them like Norwegian airlines, Alaska Airlines, Air NZ, Austrian Airlines, Emirates, American Airlines, Brussels Airlines, Hawaiian Airlines, **Air France-KLM**, easyJet or Lufthansa. The collaboration between Air France and KLM is one of the most important because they developed a permanent bag tag that can be filled with information from the phone with the particular information for each flight and passenger and which helps considerably with the Fast Track process.

However, the major part of this technology is not totally implemented and developed yet in Barcelona airport and the tests and trials are done in another airports that have considerable number of self-tagging kiosks like Charles de Gaulle, Heathrow, Miami, Las Vegas McCarran, Doha, Munich, Sydney, Stockholm Arlanda, Edinburgh, Geneva, Changi, Copenhagen, Incheon or Vienna.

In the case of Barcelona only Iberia, American Airlines, Egyptair and TAM airlines have machines of self service for the baggage drop off.

Concerning the future, is clear that in Barcelona there is a huge need of investment in that technology with the implementation of the kiosks and the operation there of airlines that offer that service from that point of flight. The baggage revolution will continue and the airport has to be ready for it. The incoming technologies are the **DS BAGTAGS**, a new generation of permanent Bag Tags designed as an airline independent solution that means it can be used by any passenger regardless of which carrier they are flying with and with full support interlining. The mobile app phones for tracking the baggage with this electronic Bag Tags are increasing also and normally at the same time the airline offers the possibility for self-tagging, there is also the possibility of following the track in the corresponding mobile phone app.

Figure 6.3: DS BAGTAG

Figure 6.4: "Scan and Fly" located in Charles de Gaulle

6.2 Document Check

THE PROBLEM

Travel document verification is a process strictly necessary to enter the airplane to get from one country to another. Is useful in order to validate the identity of the passengers, assure the security of all the flight and try to identify criminals or persons not allowed to enter or exit from determinate places. In the majority of the airports the process is still done through an officer that validates manually the identity of the ID document and the ticket for the flight with the person that have in front of him. Airlines are facing also heavy fines if documents are not properly verified.

THE SOLUTION

The solution pass through the international standardization of some travel documents by the European organisms or also the offer of some standard models by the airlines or the same IATA. However, is important also to offer the possibility for passengers to self-scan their travel documents (passport, ID cards, Driving licences...) and verify automatically that the travel document data are compliant with the destination or transit requirements.

Once the documents are self-scanned or the passengers have filled those proposed by the airlines, the informatics systems connected to the intranet or database of the airport have to verify the identity corresponding to each passenger. That process can be done in common with the official authorities of each country which could give also information about the conflict terrorist, the requirements to enter through the borders or the special conditions that have to be fulfilled.

REQUIREMENTS

The airline has to provide the passengers the possibility to scan the documentation and validate it. Some changes have to be introduced and the passengers in the future must be used to introduce their personal data in an informatics network that connects the different airports and countries and assures the security of travelling. The digitalization of the travelling and personal data is a fact which is expected to growth in a future and is necessary that there are some classificatory and normative criteria which assures that the process is efficient and useful.

The database could be divided considering the geographical regions (Europe, Asia, America. . .) and for each region several criteria could be established having on consideration also the characteristics of each country. When the passenger choose a flight the key parameters of the origin country and destination country could help the system to find easily if the documentation presented is right or not.

IMPLEMENTATION

To implement that system is necessary also the implementation of the supplementary materials like the BCBP and the CUSS. Once all is done, the passenger could start the process by himself easily.

The final result of the implementation can be traduced into low operational costs either for airports and airlines, the best profit of the existing infrastructures and space, the reduction of departure delay and congestion in the airports and for passengers a reduced risk of denied boarding or being inadmissible on arrival. The passengers also will have more control and better convenience over their travel.

BARCELONA SITUATION

The airport of Barcelona has a high number of destinations all over the world and in some occasions could be necessary to expedite a visa document in order to be able to travel inside the borders of the country.

Actually, if a visa document is required is necessary to demand it through different web pages of different organisms or travel agencies that will check if the documents are correct and then, will give or not the permission. The paper of the airport here is only to check once the customer has arrived if all the documentation is correct and let the traveller cross the border. Because of that, it can be said that the airport of Barcelona is no providing any service related with that nowadays.

However, is possible to find an initiative of IATA that helps the travellers to expedite the necessary travel documents like passport, visa or health information. The huge advantage of a system like that is the standardization of the process in order to facilitate the expedition of the documents and the unification. That way, it would be more easy for the travellers to fill the documents, to assure that they have all the necessary things to fly and they will not have any problem in the airport or they will not have to spend time verifying the documents.

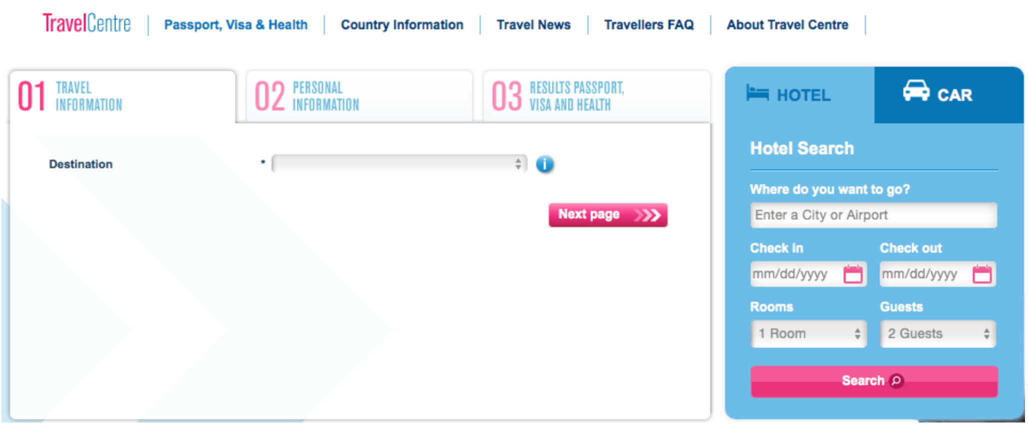

Figure 6.5: IATA travel documents check

The idea is to provide the airport of Barcelona with an initiative like that, in order to let the passengers to demand and expedite the visa documents through its webpage and then obtain a regularized and unified document that will let them to enter into the final destination. For doing that is necessary to identify the actual destinations that need a visa document and then negotiate with them the terms of the visa documents, the required information and the format of the final document.

6.3 Flight re-booking

THE PROBLEM

Several airlines give the option to their users to re-book a flight if the initial one is cancelled. This procedure can be done easily through the webpage and in the majority of cases it does not have additional cost. However, in some cases there are some complications or problems in the same airport that could cancel a flight the same day it was planned. This fact can affect the passengers on their way to the airport or in the same one, and in some cases change the flight then is not possible and they have to wait in long lines in order an operator of the airline could do this procedure for them.

THE SOLUTION

The solution also passes through giving more independence to the passenger and more competences to allow him to do the change by itself. The airline should offer the possibility for passengers to be pro-actively re-booked and to obtain new booking options or boarding token via self-service channel (kiosk/web/mobile). Is important that the airport gives the necessary machines or facilities to allow the users to change efficiently and in the same location the flight tickets without the necessity of seeing an agent.

REQUIREMENTS

To validate the explained project, is not necessary that 100% of the passengers could use it. Normally for any change that has to be done referring to change of flight, validate documentation or pay some extra fee or service is necessary to see an agent of the airline. For that reason, even if the Flight Re-Booking is only accessible to a limited number of passengers it could be considered an exit because will avoid so much congestion in some airlines stands.

Similar to other case studies mentioned before, the principal requirements are related to have a good informatics system and database that could offer rapidly and efficiently the best option to the passenger and is actualized with the current situation and scheduled flights in the Barcelona airport. Some codification could be used to identify rapidly the airline, the destination or the origin country and that way help the system to offer the flights with the same conditions which are more properly for the desires of the client.

IMPLEMENTATION

The implementation has an important part related with the staff of the airline and the airport that has to enter into the informatics system the actualized information about the cancelled flights, the new offered flights, the number of available seats, the price differences, the additional fees... Each time that an user makes a modification because he chooses a new flight or he changes some conditions of its ticket that staff have to be sure that the system works properly and this change is introduced in the system and the following client will receive the correct information. In case of errors or misunderstood, they have to solve also the problem and re-actualize the situation.

After applying this implementation the airlines will have less problems with the re-accommodation and compensation costs and also low operational costs related with the staffing, ticketing... The service will be more consistent also and the capacity will be improved because more passengers would be able to find rapidly another flight.

BARCELONA SITUATION

The situation in the Barcelona airport is not different from the previous exposed scenario. If a flight is cancelled or delayed the same day it is planned, the only option for the passenger is wait to be re-booked in another day or ask for the money back, and anyway all the procedures have to be done through an operator. For this reason, the proposed Smart Solution is to provide the airport with self re-booking machines in order to allow the passengers to solve the problems by themselves.

For doing that, is necessary that an agreement between the airlines and the airport is done. The airport will have to be in constant contact with the interested airlines and propose through the self-service kiosk the most efficient and fast solution. That way, the quantity of passengers waiting in the terminal will be reduced and the airport will gain more capacity and efficiency.

6.4 Security Access Improvement

THE PROBLEM

Every time that there is an accident which involves a passenger airplane the fear and panic spreads around the civil population and there are questions as to whether the airplane is a secure way of transport. The different stages of the security check are intended to protect the passengers from any danger during the flight but they had to reduce their inconsistency also and generate less stress and queuing time to the passenger.

THE SOLUTION

The most important thing that has to be done is the reduction of the waiting time in the security screening. A way to obtain it is the improvement of the passenger flow at security checkpoint with the existing technology and infrastructure in order to support the passenger growth, reducing waiting times and reduce delays caused by the security. That solutions that are going to be proposed consists on the improvement of the passenger information, the repositioning of some elements in the security check or the establishment of passenger benefits if they follow some "timed passes" through the control.

REQUIREMENTS

The principal requirement is the establishing of the program Simplifying the Business (StB) mentioned before. Following the requirements presented which are based on a scaled process divided in different phases, the passenger flow is expected to gain rapidity and efficiency. Both qualities are expected to increase the capacity of the airport because more passengers could pass in the same amount of time through the security check.

The security area has to be divided in two zones (access and egress) and each zone has to be formed by a set of subdivisions where a determinate procedure is established.

1.Security Checkpoint Access

Pre-screening and queuing zone
The pre-screening is defined as the area where the passenger find information on security regulations and is located before entering the queue. Is important to locate before the queue zone some indicators that may assure an orderly approach to the security checkpoint.

In that zone, another important fact is inform the passenger about all the process which is going to pass through and all the things that he has to do in each stage. The first BCBP scanning [**??**] is done in this first phase too.

Divest zone and tray feeding
Divest is defined as facilities to allow the passenger to unpack necessary items as required at time (liquids, shoes, belts, laptops. . .) in order to pass through the metal detectors without problems. The tray feeding can be described as a system integrated in the checkpoint infrastructure for trays to be rolled back efficiently.

In that zone probably the most important thing is have a good geometry with a roller bed aligned with the x-Ray and considerable space to allow people to unpack things without generating queues.

2.Security Checkpoint Egress

That zone is defined between the place where the passengers have already proceeded through primary and secondary screening to the point where they collect their belongings and move away to re-pack their things. The subdivisions are established:

Composure zone
Zone where the passengers re-pack all belongings and leave the checkpoint area.

Egress seating area
This area is where the passengers may have tables and chairs to repack the hand luggage and put their shoes back if is required.

Tray recovery system
Area where a system is integrated for trays to be rolled back efficiently.

3.X-Ray and Walk-Through Metal Detector (WTMD)

This is the zone between the two previous described zones. The standard configuration established is the 2 X-Rays to 1 WTMD [fig. 6.6]. This configuration provides great efficiency and flexibility but if is not integrated correctly with all other elements, great queues and delays can be produced. That configuration has a minimum recommended dimensions for each area and function, but in each case that dimensions can be changed if it is considered properly.

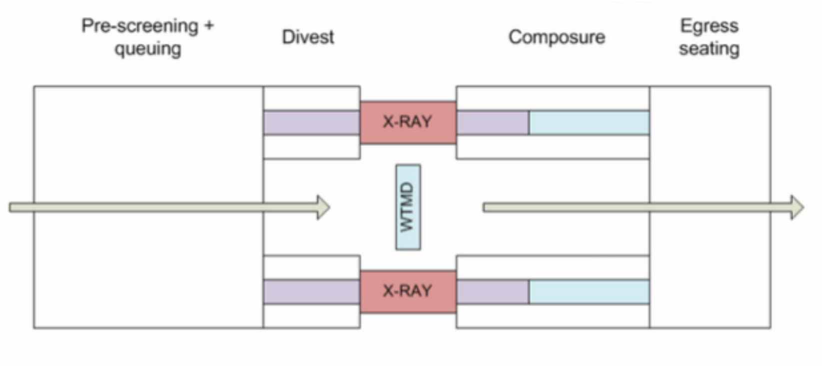

Figure 6.6: Standard configuration 2 X-Rays to 1 WTMD

Alternative Passenger Screening Configurations could be possible like the shown below [fig. 6.7].

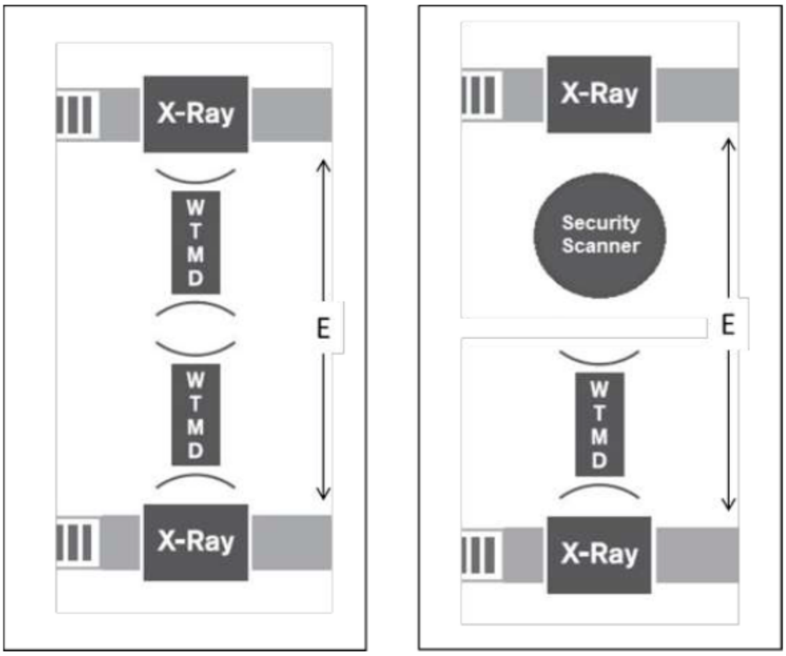

Figure 6.7: Alternatives configurations

With independence of the system used (conventional or alternative), is important to define correctly several aspects if a new configuration wants to be defined or an existing configuration wants to be modified in order to try to optimize the process for having less time spent in the security check:

-Efficient 2D Bar code Scanning: an efficient Bar Code Scanning will help to determine the passenger eligibility and separate the queue in different areas depending on the requirements fulfilled for each traveller. The areas can be separated considering if the passenger is a frequent traveller or has fast track or premium boarding pass.

-Information to accelerate the process: if each passenger knows in each moment what he has to do the process will gain fluidity and the staff will not has to waste time and generate queue explaining the procedure to the travellers who do not know what has to be done in each moment.

-Queuing Arrangements: it is important to have security lanes for different categories of passengers at the point of entry to the queue. There are different possibilities of tracks which have to be located at the dimension process: fast track (premium passengers, frequent travellers), passengers with special needs, families with children, last minute lane, airline crew and airport staff and register travellers.

The queue could have multiple configurations, and the most appropriate has to be chosen (see figure 6.8,6.9 for example):

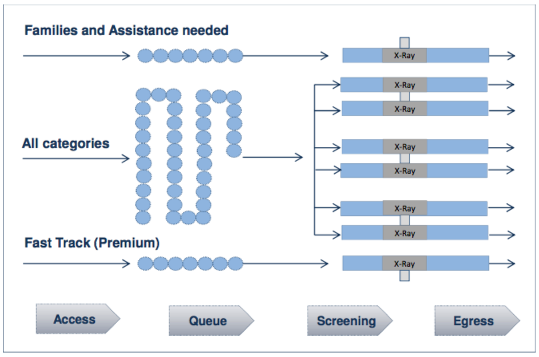

Figure 6.8: IATA proposed separated line

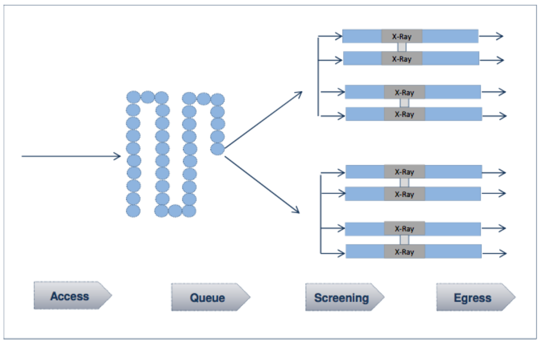

Figure 6.9: IATA proposed single queue, two exits

-Dimensions: between each element has to be enough space in order to admit the passenger flow and manage it correctly.

IMPLEMENTATION

The implementation of a more efficient queuing system will involve in a more efficient security check.

The benefits from applying these kinds of modifications and about investing in more efficient security processes are shared by the different stakeholders of the airport and the companies which work there (airlines, airport, passengers, governments...).The reduced queue length and times will facilitate the more efficient use of space, the improved time of departure and the maintaining of the same level of security with the same existing ressources.

BARCELONA SITUATION

The airport of Barcelona needs to have a good service in the security check in order to ensure the security of all the passengers and also provide a good and fast service that will allow the users to pass trough it without spending there so much time. Actually, the security checks in both terminals have the standard configuration and the average time in each one depends on the hour of the day or the complications that could appear.

Outside the Barcelona airport, some changes have been applied. One example is the implementation in **Dublin** of the automatic tray return system (ATRS) which has helped to gain space and less queuing time. Also another initiatives are in use or in period of evaluation. In the **Melbourne** airport for example, some trials with passenger screening are being done trying to mechanize it and direct it without the necessity of intervention of an agent. The cabin baggage screening needs to be changed also trying to send all the images to a central place where at the same time all could be analysed. Finally, in Europe the **Amsterdam Schiphol** airport is the one that has a centralized security experience for the passenger considering the implementation of all the technologies explained before. The implementation of e-gates is considerably frequent also in order to fasten de process and nowadays the travellers could find e-gates in Oslo, Budapest, Gatwick...

The proposed solution for the future in the airport of Barcelona is improve the actual security checks and try to study the benefit of different configurations. The lanes and locations of the security checks in the airport terminals are:

Terminal T1

Security checks located in floor 3 and floor 1:
• Floor 3: normal lanes, one fast lane, one preferential access for families and one preferential access for PRM.
• Floor 1: one lane for the zone C (national flights) and one lane for the connexion Madrid-Barcelona

Security check for passengers who need to do a connexion in the airport located in the floor 2:
• Floor 2: normal lanes

Terminal 2

Security check located in the floor 1:
• Floor 1: one fast lane, one preferential access and normal lanes

Security check for passengers who need to do a connexion in the airport located in the floor 1:
• Floor 1: normal lanes

6.5 Self-boarding

THE PROBLEM

Once the passenger has passed through the security check most of the time spent after it is related with boarding the airplane. The majority of the doors are announced early and when the airplane is not in the airport and after the door is announced the passengers stand in long lines without any separation criteria and they have to attend long time to start boarding the plane to their destination. At the same time, airlines try to minimise aircraft turnaround times and reduce operational costs at boarding and the procedures are the same for both narrow and large body aircrafts. All of that results in dissatisfaction and potential departure delay.

THE SOLUTION

If the passengers are allowed to self-scan their boarding tokens or tickets at the gate to gain entry to the aircraft in a controlled manner the total boarding time until the departure will be reduced and the waiting time will be less extended. However, is important to do it under supervision in order to maintain the security and the order for both airplane and airport.

REQUIREMENTS

To validate that project the airline must offer the possibility for authorised passengers to self-scan their boarding token at the gate to entry to the aircraft. However, is not required that all the passengers on the same flight follow the same process because the boarding token could be simply the paper boarding pass but also the mobile BCBP boarding pass, NFC boarding pass, the passport, biometrics or specific tokens used by the airline.

The airport must ensure also that the boarding gates are in perfectly state and don't allow to pass any passenger that has not the valid documentation. Finally, an important requirement is also the boarding gate devices used to check the documentation.

IMPLEMENTATION

The implementation of the self-boarding and BCBP will provide low operational costs to the airlines and airports but the improvement will be also notable in the boarding gates because the use of the expertise and time of the agents will be better and will reduce the aircraft turnaround time. In the airport infrastructure that will be traduced into a reduction of congestion areas and better management inside the terminal. For passengers also a huge amount of advantages appear because they get quicker entrance to the aircraft and a reduction of time and queues before entering the plane.

BARCELONA SITUATION

Some airports have already implemented some technology related with the self-boarding for passengers. In Europe and around the world, each time is more common the investment in order to apply this new Smart Technology.

The **Vienna airport** was the world first airport to common use self-boarding gates in order to increase the service quality and passenger experience. Another important trial is located in **Heathrow airport** with South African Airways. In the terminal 1 of the airport two-month self-boarding trial is implemented and the passengers can use the biometrics to ensure more efficient and speedier boarding. They pass through an automatic electronic barrier which take and infrared scan to verify the identity. Finally, is important to mention also another airports like **Boston Logan Airport, Amsterdam Schiphol, Miami Airport or Changi**... as another places where the passengers can find the self-boarding gates.

Figure 6.10: Heathrow terminal 1 self-boarding gates

Figure 6.11: Amsterdam Schiphol e-gates

Actually in Barcelona no technology related with self-boarding is being considered or implemented. For this reason, is important to analyse which are going to be the benefits of that implementation for the future and if the implementation is available or not. The airport in common with airlines help should initiate the process for the installation of this new technology.

6.6 Bag recovery

THE PROBLEM

Once the passenger has landed in the final destination is important that he can recover its bag in a rapid way and without any problem. Having their bags mishandled is already a great factor of stress for passengers. If the bag is lost, having then to stand in a long line to get information and to complete a claim report is even more stressful. Processing these claims also costs a lot of money to the airlines.

THE SOLUTION

Promote the proactive communication with passengers and allow them to avoid waiting at the baggage carousel if their bag is not there. Provide self-service channels to report a missing bag instead utilising the traditional method. In the future, also the solution of controlling the destination of the bags through the home printed/electronic tags could be possible and in that way, the user could know where is its bag without asking to the agent of the airline.

REQUIREMENTS

To start up this project is necessary an alliance between the airline, a handling agent for the airline customers and for the luggage and the airport on a common use of environment. Also the instauration of the BCBP and the self-service channels kiosks are necessary and a standard informatics process for claiming if there is a bag lost.

IMPLEMENTATION

After the implementation of the process the operational costs will be lower for airlines and airports, the use of claim agent's expertise and time will be more efficient and the recovery cost of the bags will be lower. From the passenger point of view, they will have better comfort, reduced stress and no queues at the claim area.

BARCELONA SITUATION

One of the worst experiences that a passenger can suffer is the lost of its baggage at the final destination. In some cases the procedure to recover it is hard and long and sometimes the airline is not able to find the mishandled bag and the passenger lost all its pertinences.

The principal proposed solutions that have been tried outside the Barcelona airport are related with the track of the baggage during the entire trip through a mobile app which is connected with a sensor in the suitcase. If the bag is mishandled or doesn't arrive to the final destination, with that tracking device is easy to find it. Some examples of that are the **Aribus2Go or the Lufthansa** investments, two solutions implemented by a manufacturer and an airline but that need to have the approval of an airport. Some airports have also provided the passengers with automated kiosks to reclaim the lost baggage. The **Domodedovo Airport, the airport of Geneva or Madrid Barajas** have actually self-kiosks to reclaim. Finally, it has to be said that this service can be provided also by some airlines through its webpages.

Figure 6.12: Bagg claim self-kiosk

Figure 6.13: Iberia kiosk at Madrid Barajas

The airport of Barcelona doesn't have self-kiosk implemented and the bag recovery follows the traditional rules with the passengers waiting in the arrivals hall for the baggage in the ribbons.

6.7 ABC (Automated Border Control)

THE PROBLEM

The engagement with Public Authorities at border crossing points is one of the parts of the travellers' journey that has a considerable spend of time in order to control de security of the flights, the human identity and check if each passenger has all the documentation regularized and without any illegality. The kind of model that has been operating since now is not compatible with the existing growth of the passenger traffic because the long queues at airports present a poor image to visitors, there could be considerable delays and both airport and airline companies request faster and smoother passenger flows for shorter connection times and faster check in and boarding. Therefore, increase security and speed up travel flows by increasing the number of border guards alone is not a viable option.

THE SOLUTION

One of the proposed solutions is the named Automated Border Control (ABC). The ABC is an automated control system that authenticates travel documents and tokens [**??**] and permits or denies admission to a traveller according to different requirements. This system has to verify additionally the passenger biometric data against the travel document, the token or a pre-existing database containing that biometric data. It may also register the entry or the exit of the country.

The ABC can improve the management and control of travel flows at the border controls with the use of electronic machine that can read and verify the travel documents and identify the biometric parameters of each passenger. A secure process at borders that relay on machine-assisted control and biometric data facilities are needed in order to assure an effective and reliable procedure. With the use of a traveller scheme, which would use biometrics, the reduction of illegal immigration, the more effective deployment of resources and the obtaining of additional advanced information on travellers are intended in order to reduce the time involved and the lack of security.

REQUIREMENTS

To establish that kind of system a network of a International Traveller Scheme is needed. Those schemes could be based in a registered system or in a non-registered system.

- **Registered travel scheme**

The schemes of the registered travellers follow three steps: first of all, check that the passenger has a valid travel document or token; secondly there is a verification of the passenger biometric data against the travel document, the token or the pre-existing biometric identifier for ensuring the travel document is presented by the rightful owner and finally, the admission is denied or accepted according with the previous requirements.

1.Completing data requirements
That registered traveller scheme is established by the Government and has to be filled by the passenger. Another information can be demanded if the legislation of the country requires it.

2.Conducting in-person interview
These interview allow authorities to verify the information provided and collect the biometrics of the applicant

3.Final approval
The Governments use the information requested to the passenger and use another information to ensure that the applicant meets its criteria and can be considered a low-risk traveller. To consider that one passenger conforms the low-risk group will need to not have been convicted of a criminal offense, have not violated any immigration, custom or agriculture laws...
That investigation could be re-vetted periodically in order to ensure that no new information is discovered.

- **Non-registered travel scheme**

In that kind of schemes no pre-registration is required and in order to ensure that the e-Passports system delivers high levels of accurate verification it is important that the biometric image taken at the time of applying for the eMRTD [**??**] is of the highest quality.

1. eMRTD system

There are different kind of eMRTD systems, like the ICAO eMRTD [**??**] or the EAC eMRTD [**??**].

2. e-Passport Gates

That kind of gates utilize eMRTD. They may operate on the basis of e-Passports alone but may also use e-ID cards and e-Residence permits as tokens when considering entry or exit.The data contained in the chip of the eMRTD is read by the gate and used to aid verification of the identity.
When a passenger arrives or enters through a border of one airport, if the gate reads the database and everything is correct, the verification would preceed and the enter or the exit is allowed.

IMPLEMENTATION

The process for establishing the ABC system into an airport can be very long and hard and can differ from one airport to another depending on the airport operator. In some cases the airport is completely run by the government and in other cases privately owned companies operate the airports.

The principal benefits of the implementation of the ABC control are the less processing time for passengers, the reduction in the operating costs of the border control authorities, a better usage of space and the achieving of some service level standard.

The airport and the governments are the two principal organizations involved in that decision-making process, but there are also influences in the airlines and in the passenger. The airlines are not involved in the decision making process but they should work as an active stakeholder to support implementation and usage communicating the changes to employees and passengers, offering payments for the pre-registration of the ABC system, offering support in the border area in order to solve the possible problems which may appear and communicating and marketing the product through announcements, inflight entertainment, website...

BARCELONA SITUATION

Actually there are many countries that are using the ABC system in some of the airports of their region. Depending on the case, the system could be based in a registered or non-registered principle and there are different kinds of methods for the authentication: eMRTD, a permanent resident card or a national registered traveller scheme card.

The ABC system is considered the main method of processing passengers through border control in the future. Some examples of the airports that have that kind of systems at the arrival or departure gates are the **Curaçao Airport, Naples Airport, Auckland Airport, Prague Airport, Brisbane Airport, Gatwick Airport, Varna Airport, Burgas Airport, London City Airport. . .** and even **Barcelona** for the arrivals.

Figure 6.14: Electronic gates for the ABC control

Actually at El Prat, the ABC system is used at the arrival zone as it has been said. The idea is to implement also that system at the departure zone with more electronic gates in order to give rapidity to the passport control and the passenger entry to the terminal

6.8 El Prat airport database

THE PROBLEM

Actually, the majority of the airlines offer the possibility to travellers to pay an extra amount of money in order to have a preferential pass, better seats or avoid queues and crowded situations before entering the airplane and also when it lands and is necessary to recover the bags and go out of the airplane. However, some times this is not useful because is only achievable for some travellers, is not implemented in all the airports and there are no specific installations only reserved for those who wants to travel with the least possible time.

THE SOLUTION

The establishment of an airport database in Barcelona El Prat reserved for those usual travellers who flight from Barcelona to any destination. This database will help the frequent travellers to avoid the queues and pass through all the necessary steps before entering the plane in a more efficient way and with les necessary time for it. If the space is enough this database will be implemented through specific installations and machines reserved only for the travellers that are registered in it.

REQUIEREMENTS

The principal requirement for that is to find a way to ensure the privacy and security of the client information that is going to be putted inside the database in order to avoid mistakes in the expedition of travel documents, the verification of identity or the destination of the baggage. Is important also to ensure that anyone who is not allowed to have access to the database will have the possibility to steal or find compromised information about the travellers and could use it for economical benefits, change of identity or threatens.

Having on consideration all the things exposed before, the security of the digital information is the principal requirement for that process and is combined also with the necessity of establish an space in the airport with good and advanced technology that controls, actualize and verifies all the information in the database and supply the clients if they have any problem.

IMPLEMENTATION

After the implementation the principal advantage will be the less amount of time that the passengers will have to spend in the airport and that fact will imply also an advantage for the airport installations due to the increase in capacity. The idea is that all the airlines operating in Barcelona el Prat will join that database and the particular "fast travel" procedures of each one get unified and all the installations will be the same for the travellers. This fact could represent a lost of money or identity for those airlines but really this represents an advantage because the service offered will be the same and the amount of passengers that could use it could be higher due to the increase of capacity and better installations. Therefore, more passengers are going to spend their money in flight tickets and the benefits for the airline will increase.

El Prat currently doesn't have any database with the finality explained before. The fast lanes of the security checks or the preferential accesses are used by the users of the airlines that have paid certain amount of money to have a preferential treat in order to avoid queues in the baggage check, the security check or the boarding. For that reason, the creation of this type of database will be useful because the installations and facilities are already in use and can be profited for a major number of users that will help to give the airport more fluent traffic of passengers.

6.9 Barcelona mobile phone app

THE PROBLEM

The communication between passengers and airport some times is hard due to the lack of information canals and some times the passengers could not be informed about the real time situations that are happening in the airport while they are there.

This fact makes that the way the installations are used is not the most efficient way and some times the passengers have to deal with long queues or overcrowded places or flights because their necessities have not been identified correctly and there is not a good solution for them.

THE SOLUTION

The creation of a mobile phone application specific for the airport of Barcelona will help to manage all the situations involved there and will improve the communication between the passenger and the airport infrastructures.

Each passenger could create its specific account with its necessities: fast traveller, user of the database, the check-in information, the booking information, the localization of their luggage... Depending on the requirements of each passengers the app could inform about the offers that could be more interesting for its tastes and likes, the time in the security check, the estimated time of boarding, the ideal moment and gate to pass through the security check, some normative about the procedures... Definitely, the app should be a way of giving facilities to the travellers in order that they could stay in the terminal the less time possible and in that time, they could use in the most efficient way all the installations.

REQUIREMENTS

In order to develop an useful and efficient application for the smart phones, is necessary that in the installations of the airport there would be some electronic devices which could register the necessary data to send it to be processed and presented in the mobile phone app to the passenger. For example, video cameras will be necessary in the security check in order to count approximately the number of passengers and the time in the lines.

So, is necessary to study which are the services offered to passengers and then plan which are going to be the necessary technologies to offer them.

IMPLEMENTATION

After the implementation passengers will have more autonomy in the airport because they will have the option to manage and plan their trip from their mobile phone. They will have benefits and special offers adapted to the data that they have introduced and if they follow the recommended routes and times, the time spent in the airport will be less than the expected. They will have also the possibility to book flights and receive offers adapted to their expectations and in some cases they could dispose of some discounts.

BARCELONA SITUATION

The airport of Barcelona don't have any mobile phone app specific for their installations and the objective of this case study is propose the creation of one following the initiative that there is in some airports.

There are European airports that actually have an own mobile phone app to improve the communication with passengers and frequent users. The Munich Airport, the airport of Manchester or the Stanstead airport are some cases of reference.

Chapter 7

Case study indicators and impact benefit assessment

7.1 Summary

The best way to study the feasibility of the implementation of Smart Technologies in the airport of Barcelona and analyse the impact and benefit assessment is the use of some key parameters or indicators in each case study situation.

Since the passenger arrives to the terminal he has to face some concrete steps or processes before entering the airplane. The idea is to study different aspects related with this processes (time, commodity, involved personal, cost...) and then make a comparison between the numerical result obtained before and after the implementation of the Smart Technologies.

The first step to do the analysis is determine which is the flux of passengers in the airport of Barcelona that is going to use the installations and in consequence, the facilities that are being studied. Some key parameters or indicators depend directly from that flux of passengers like the time involved in the security check, the baggage delivery time or the document check or ABC control. In addition, make an estimation of the flux of passengers will help to have an initial idea about the magnitude of the airport, its importance inside the European traffic and the capacity and possibilities of growing.

7.1.1 Passenger flow

The inflow of passengers in the airport of Barcelona depends directly on the number of flights scheduled each period of time (normally the reference is an hour) and the season of the year. The period with more affluence of passengers is the summer because it coincides with the holiday time. However, normally at the start of the year is not possible to know the exact number of flights each month because for so many reasons there is a possibility of variation.

For the present analysis the flux of passengers is going to be calculated following the initial hypothesis:

- The season of the year and the month analysed are going to be the periods of more affluence of passengers in order to dimension the airport for the worst case. The month of major affluence is the month of August during the summer season. However, a study for the month of May is going to be done also in order to have last data more actualized.

- The flux of passengers is going to be divided in two terminals, having on consideration the number of passengers that each airline transport that month and knowing which are the airlines that operate in each terminal. This data is going to be recollected from the webpage of the AENA-ENAIRE, which is the organism that controls the airport in Spain.
- A flight profile is going to be elaborated in order to divide the passengers having on consideration the number of scheduled flights each hour. From this information, the rush hour of operations and the rush hour of departures/arrivals can be found.
- The dimensioning of the different facilities in both terminals is going to be done for the worst case which is the case with more flux of passengers that corresponds to rush hours.
- For the study is important to have into account which are the airlines operating in each terminal, in order to dimension correctly the flow of passengers in each one. The information can be seen in Annex 2.

The data recollection in the tables [7.1] and [7.2] shows the flux of passengers for departures and arrivals in both terminals:

TERMINAL 1						
Departures						
	Europe No UE No Schengen	**International**	**National**	**Schengen No UE**	**UE No Schengen**	**UE Schengen**
August 2015	87.693	203.189	410.265	67.947	124.301	620.531
May 2016	42.889	149.076	427.274	52.557	97.188	532.615
Arrivals						
	Europe No UE No Schengen	**International**	**National**	**Schengen No UE**	**UE No Schengen**	**UE Schengen**
August 2015	70.927	202.272	-	56.025	117.083	-
May 2016	40.309	161.878		49.952	95.684	-

Table 7.1: Flux of passengers in Terminal 1

TERMINAL 2						
Departures						
	Europe No UE No Schengen	**International**	**National**	**Schengen No UE**	**UE No Schengen**	**UE Schengen**
August 2015	57.898	36.622	104.350	43.624	177.451	275.663
May 2016	27.267	14.618	100.223	45.817	177.175	323.977
Arrivals						
	Europe No UE No Schengen	**International**	**National**	**Schengen No UE**	**UE No Schengen**	**UE Schengen**
August 2015	48.015	19.126	-	40.573	177.450	-
May 2016	36.548	14.796	-	46.215	196.821	-

Table 7.2: Flux of passengers in Terminal 2

7.1.2 Passenger flow/hour

Once the estimated number of passengers in each terminal is know, is necessary to make an approximation about the inflow each hour. This fact is important because if the airport is capable to absorb the passenger traffic of the most crowded hours, the rest of the day the service and the installations will be able to respond with effectivity.

The number of passengers each hour depends on different factors like the season of the year, the hour of the day, the type of airplane, the month of the year, the scheduled flights, the delays or cancellations, the airlines… Is difficult to establish with 100% of probability the number of flights that could be each hour in the airport because this parameter could vary month by month or day by day, but is important to have some basic profile in order to be able to identify which are the most crowded days of the week or the hour of maximum request.

To obtain these flight profiles during a certain period of time the number of flights from the airport of Barcelona have been counted and then, an average between these different days has been done to obtain the final result. The final situation can be seen in figures [7.1] and [7.2].

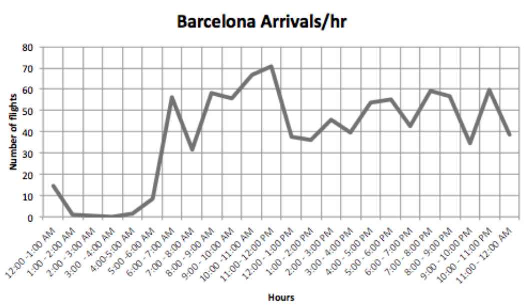

Figure 7.1: Barcelona arrivals

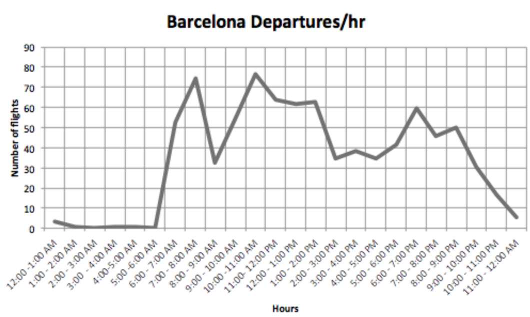

Figure 7.2: Barcelona departures

The figures above [7.1] and [7.2] show the flight profiles in the airport. It can be seen the hours with maximum affluence and the periods without any operation scheduled. The rush hour for departures is between 10:00 AM – 11:00 AM and the numbers of departures established are 77. For the arrivals the rush hour is between 11:00-12:00 AM and the number of flights is 71. The total average number of departures scheduled in one day is 842 and for the arrivals the number is 923.

Is important to remark that this numbers could vary some times a little bit because the flights scheduled and planned in one airport are submitted to so many changes which depend on different factors: delays, climate, technical problems, airline planning... However, these values are an average considering the different possibilities.

To do the dimensioning of the terminal facilities for the rush hour is necessary to establish which is the % over the total that these 77 and 71 operations represent. Then, this % is going to be applied to the number of passengers each day to calculate the maximum flow that the airport should manage and see if with the new technologies the situation will improve or not.

The rush hours identified previously represent the 9,1% and the 7,7% of the traffic of flights for one day in the airport. With that, the maximum obtained flows of passenger are in the table [7.3]. The flow for each hour according to the % of the rush hours can be seen un the Annex 4.

<table>
<tr><th>Rush hour</th><th>% of the total flights</th><th colspan="4">Max. passenger/hour</th></tr>
<tr><td rowspan="3">10:00-11:00 AM
(Departures)</td><td rowspan="3">9,1 %</td><td colspan="2">Terminal 1</td><td colspan="2">Terminal 2</td></tr>
<tr><td>August 2015</td><td>May 2016</td><td>August 2015</td><td>May 2016</td></tr>
<tr><td>4.437</td><td>3.815</td><td>2.039</td><td>2.020</td></tr>
<tr><td rowspan="2">11:00-12:00 AM
(Arrivals)</td><td rowspan="2">7,7%</td><td>August 2015</td><td>May 2016</td><td>August 2015</td><td>May 2016</td></tr>
<tr><td>1.104</td><td>860</td><td>705</td><td>728</td></tr>
</table>

Table 7.3: Dimensioning passenger flows

<table>
<tr><th colspan="2">Passenger departure flow</th><th>Passenger arrival flow</th></tr>
<tr><td>Traffic indicators</td><td>-Capacity
-Passengers</td><td>-Capacity
-Passengers</td></tr>
<tr><td>Time indicators</td><td>-Baggage delivery time
-Security check time
-Boarding to gate time
-Border control time</td><td>-Baggage Recovery time</td></tr>
<tr><td>Productivity /Cost</td><td>-Passengers per employee</td><td>-Passengers per employee</td></tr>
<tr><td>Financial cost Benefit analysis</td><td>-Economical benefit
-Aeronautical Revenue/passenger
-Economical losses</td><td>-Economical benefit
-Aeronautical Revenue/passenger
-Economical losses</td></tr>
</table>

Table 7.4: Indicators relation with passengers

The previous calculations of the flow of passengers are necessary to compute the different indicators. Each indicator is going to depend in a direct or indirect way of the number of passenger that arrive to the different terminals. The resume is shown in the table below [7.4].

In each case or indicator calculation a number of hypothesis has to be done in order to present the schema studied and the initial situation.

7.2 Time indicators

7.2.1 Baggage Delivery time

DEFINITION

This indicator shows the average time for leaving the bags at the check-in counters of each airline in the airport terminals. Two situations are going to be defined, tB1 and tB2 which are differentiated according to the implementation or not of Smart Technologies.

GENERAL HYPOTHESYS

The assumed hypothesis for the results implementation and the figures corresponding to each case can be seen in Annex 5 in section **??**.

IMPLEMENTATION

- **CASE 1**

-Number of passengers to check in: 40% (76 passengers)
-Number of check-in counters opened: 1 at first timing, 2 at second timing, 1 at third timing.
-At the first timing each minute one passenger is going to arrive.
-At the second timing the spread between passengers is going to be 2,6 minutes and they are going to be separated in two equal lines.
-At the third timing, the time between passengers is going to be 3,5 minutes.

Baggage time tB1
Case 1 calculations

-First timing (20 minutes)-10% of passengers
For this first timing only one check in counter is opened and the number of passengers arriving is fixed at 20 passengers.

1)The spread between passengers is going to be:

$$Spreadtime = \frac{Nt}{Np} = \frac{20min}{20pax} = 1min/pax \quad (7.1)$$

2)Modelling the queuing time (n=1;n=20)

$$tq(n) = tq(n-1) + 0,5min \quad (7.2)$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=0 min
pax 1 (n=1)$\Longrightarrow$ tq(1)= tq(0)+0,5 = 0,5 min
pax 2 (n=2)$\Longrightarrow$ tq(2)= tq(1)+ 0,5 = 1 min
...
pax 20 (n=20)$\Longrightarrow$ tq(20)= tq(19)+0,5 = 10 min

3)Calculation of the indicator

$$tB1(n) = tdoc/pax + tdrop/pax + tq(n) \quad (7.3)$$

pax 0 (n=0)$\Longrightarrow$ tB1(0)=1+0,5=1,5 min
pax 1 (n=1)$\Longrightarrow$ tB1(1)= tq(1)+1,5= 2 min
pax 2 (n=2)$\Longrightarrow$ tB1(2)= tq(2)+ 1,5 = 2,5 min
...
pax 20 (n=20)$\Longrightarrow$ tB1(20)= tq(20)+1,5 = 11,5 min

-Second timing (60 minutes)-25% of passengers
In this second timing the two checks in counters are going to be opened and the number of passengers fixed is 46, 23 for each check-in counter. The queuing time is variable also:

1)The spread between passengers is going to be:

$$Spreadtime = \frac{Nt}{Np} = \frac{60}{23} = 2,6 min/pax \tag{7.4}$$

2)Modelling the queuing time (n=1;n=23)

$$tq(n) = tB1(n-1) - 2,6 min \tag{7.5}$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=5 min
pax 1 (n=1)$\Longrightarrow$ tq(1)= tB1(0)-2,6 = 3,9 min
pax 2 (n=2)$\Longrightarrow$ tq(2)= tB1(1)- 2,6 = 2,8 min
...
In this case the spread of the passengers is enough and when the passenger number 5 arrives, there is no queue and the situation is conserved until the last one in each check-in counter. Because of that, the tq(n=5,n=23)=0.

3)Calculation of the indicator

$$tB1(n) = tdoc/pax + tdrop/pax + tq(n) \tag{7.6}$$

pax 0 (n=0)$\Longrightarrow$ tB1(0)=tq(20)(first timing)+1+0,5=6,5 min
pax 1 (n=1)$\Longrightarrow$ tB1(1)= tq(1)+1,5= 5,4min
pax 2 (n=2)$\Longrightarrow$ tB1(2)= tq(2)+ 1,5 =4,3 min
...
In this case the spread of the passengers is enough and when the passenger number 5 arrives the situation is the same with the queuing time, there is no queue and then the value is fixed at tB1(n=5,n=23)=1,5 min.

-Third timing (30 minutes) – 5% of passengers
In this third timing only one check in counter is open and the number of passengers fixed is 10.
1)The spread between passengers is going to be:

$$Spreadtime = \frac{Nt}{Np} = \frac{30}{10} = 3 min/pax \tag{7.7}$$

2)Modelling the queuing time
In this case, the queuing time is always tq(n=0,n=10)=0 min because the spread between passengers is 3 minutes and the time involved for doing the check in is 1,5 minutes.

3)Calculation of the indicator
In this case, because the queuing time is always tq(n=0,n=10)=0 min the indicator is fixed also to tB1(n=0,n=10)=1,5 min.

<table>
<tr><th colspan="3">First timing</th><th colspan="3">Second timing</th><th colspan="3">Third timing</th></tr>
<tr><td>Pax</td><td>Arrival</td><td>Check-in counters</td><td>Pax</td><td>Arrival</td><td>Check-in counters</td><td>Pax</td><td>Arrival</td><td>Check-in counters</td></tr>
<tr><td>20</td><td>160 min</td><td>1</td><td>46</td><td>140 min</td><td>2</td><td>10</td><td>80 min</td><td>1</td></tr>
<tr><th colspan="9">Total time involved</th></tr>
<tr><td>Limit time</td><td colspan="2">First timing</td><td colspan="3">Second timing</td><td colspan="2">Third timing</td><td>TOTAL</td></tr>
<tr><td>115 min</td><td colspan="2">19 min + tB1(20)
31,5 min</td><td colspan="3">60 min + tB1(23)
61,5 min</td><td colspan="2">30 min + tB(10)
31,5 min</td><td>111,5 min</td></tr>
</table>

Table 7.5: Results Case1 methodology 1

With this first analysis it can be seen that no important queuing time in the baggage drop off could cause serious problems for the airport or the flight scheduled because all the passengers are going to be able to board the airplane. However, there are some important key parameters or hypothesis that should be changed because are negative from the economic point of view or the total time involved.

The first reason is that the first passengers have to arrive over 2:40 before the flight and the second group over 2:20 hour before, and this is so early for a Smart Airport. The second reason is that the passengers are spread in a logical order and the passengers arrive with a couple of minutes of difference and this situation is far from the reality,where they arrive in groups and with no logical order. Because of that, the total time involved is almost the time of the timings. This hypothesis, is going to be changed in the Case 2 in order to make a better approach.

Baggage time tB2
Case 1 calculations

-First timing (20 minutes)-10% of passengers
1)The spread between passengers is going to be:

$$Spreadtime = \frac{Nt}{Np} = \frac{20min}{20pax} = 1min/pax \tag{7.8}$$

2)Modelization of the queuing time

$$tq(n) = tB2(n-1) - 1min \tag{7.9}$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=0 min
pax 1 (n=1)$\Longrightarrow$ tq(1)= tB2(0)-1 =-0,65 min

For this case is clear that in this first timing, with one or two self-service kiosk opened there is no queue to do the baggage check-in because the time between the passengers is enough to do the baggage check-in without passengers lines.

3)Calculation of the indicator
In this case, because the queuing time is always tq(n=0,n=20)=0 min the indicator is fixed also to tB2(n=0,n=20)=0,35 min or tB2(n=0,n=20)=0,45 min.

-Second timing (60 minutes)-25% of passengers
1)The spread between passengers is going to be:

$$Spreadtime = \frac{Nt}{Np} = \frac{60min}{46pax} = 1,3min/pax \tag{7.10}$$

$$Spreadtime = \frac{Nt}{Np} = \frac{60min}{23pax} = 2,6min/pax \tag{7.11}$$

2)Modelization of the queuing time

Two self-service kiosks:

$$tq(n) = tB2(n-1) - 2,6min \tag{7.12}$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=0 min
pax 1 (n=1)$\Longrightarrow$ tq(1)= tB2(0)-2,6 =-2,25 min

. . .

One self-service kiosk:

$$tq(n) = tB2(n-1) - 1,3min \tag{7.13}$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=0 min
pax 1 (n=1)$\Longrightarrow$ tq(1)= tB2(0)-1,3 =-0,95 min

In the second timing the situation does not change respect the first one. The baggage check-in through the kiosks is considerably fast and the spread of the passengers is enough to start each time, in both cases, with a queuing time of zero. Because of that, tq(n=0,n=23)=0 and tq(n=0,n=46)=0.

3)Calculation of the indicator
In this second timing, because the queuing time is always tq(n=0,n=20)=0 min the indicator is fixed also to tB2(n=0,n=20)=0,35 min or tB2(n=0,n=20)=0,45 min.

-Third timing (30 minutes) – 5% of passengers
In the third timing the situation is the same and the queuing time is fixed to zero (tq(n=0,n=10)=0 min for all the passengers and the baggage check-in time to tB2(n=0,n=10)=0,35 sec or tB2(n=0,n=10)=0,45 sec depending on the necessity or not of printing the baggage tag.

<table>
<tr><th colspan="3">First
timing</th><th colspan="3">Second
timing</th><th colspan="3">Third
timing</th></tr>
<tr><td>Pax</td><td>Arrival</td><td>Check-in
counters</td><td>Pax</td><td>Arrival</td><td>Check-in
counters</td><td>Pax</td><td>Arrival</td><td>Check-in
counters</td></tr>
<tr><td>20</td><td>160 min</td><td>1</td><td>46</td><td>140 min</td><td>2</td><td>10</td><td>80 min</td><td>1</td></tr>
<tr><th colspan="9">Total time
involved</th></tr>
<tr><td>Limit
time</td><td colspan="2">First
timing</td><td colspan="3">Second
timing</td><td colspan="2">Third
timing</td><td>TOTAL</td></tr>
<tr><td>115 min</td><td colspan="2">19 min + tB1(20)
19,35 min
19,45 min</td><td colspan="3">60 min + tB1(23)
60,35 min
60,45 min</td><td colspan="2">30 min + tB(10)
30,35 min
30,45 min</td><td>110,35 min
110,45 min</td></tr>
</table>

Table 7.6: Results Case1 methodology 2

The analysis of this first case shows that the efficiency of the baggage self-service kiosks is considerably higher than the conventional baggage check-in counters. The passengers with the established hypothesis do not have to wait and the necessity of arriving early to the airport disappears. Moreover, the airlines do not have to pay to an employee for attending the clients and they do not have to control neither the entire process because is more digitalized. The client could also control its baggage from its mobile phone and the baggage could be kept in a safe place before the flight starts event couple of hours before. The rapidity and efficiency of the process is higher and more number of passengers could do the baggage check-in without problems in a less amount of time. In conclusion, more restrictive hypothesis could be established because there is a high margin of success.

This total check-in time is almost the same showed in the Case 1 of the tB1 , but in fact here the kiosks are without queue and not in use and the time is summed because the spread of the passengers is established that way. Here it can be seen the waste of time and money because the check in self-service kiosks are opened but not in use due to the rapidity of the process.

- **CASE 2**

-Total passengers: 189 (Boeing 737-800)
-Number of passengers to check in: 40% (76 passengers)
-Number of check in counters opened: 2 (1 for Case 2*)
-Only one timing of 75 minutes (120-45 minutes), the recommended time to arrive to the airport in case of baggage check-in need.
-The passengers will not arrive following a logic order of spread. The first 10 minutes 10 of them will arrive (4+6) and the following 55 minutes the number will be 66 passengers (17+29+20).

Baggage time tB1
Case 2 calculations

1)Modelling the queuing time
In this case, there are two check-in counters and the space is enough to guarantee that each group of passengers will start with a queuing time of zero seconds. Because of that, in each queue the passenger has to wait in the queue the total boarding time of the passenger that has before him.
The total time involved in the process has to be less than 75 minutes and corresponds to the maximum boarding time of each group of passengers, so, the total boarding time of the last one.

$$tq(n) = tB1(n-2) \tag{7.14}$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=0 min
pax 1 (n=1)$\Longrightarrow$ tq(1)=0 min
pax 2 (n=2)$\Longrightarrow$ tq(2)=tB1(0)=1,5 min
pax 4 (n=4)$\Longrightarrow$ tq(4)=tB1(2)=1,5 min
...
pax 8 (n=8)$\Longrightarrow$ tq(8)=tB1(6)=3 min
pax 9 (n=9)$\Longrightarrow$ tq(9)=tB1(7)=3 min
...
pax 10 (n=10)$\Longrightarrow$ tq(10)=0 min
pax 27 (n=27)$\Longrightarrow$ tq(27)=0 min
pax 56 (n=56)$\Longrightarrow$ tq(56)=0 min
...
pax 26 (n=26)$\Longrightarrow$ tq(26)=tB1(24)=12 min
pax 55 (n=55)$\Longrightarrow$ tq(55)=tB1(53)=21 min
pax 75 (n=75)$\Longrightarrow$ tq(75)=tB1(73)=13,5 min

2)Calculation of the indicator
The total baggage check-in of the last passenger who arrives with the last group should be less than 65 minutes. The established hypothesis is that the check-in counter is opened 120 minutes before the flight starts and closes 45 minutes before it. The margin is 65 minutes to do all the boarding plus 10 minutes which are left for any occasional change.For each passenger the total baggage check-in is calculated as in the other cases.

$$tB1(n) = tq(n) + 1,5min \tag{7.15}$$

All the procedure explained before is the same for computing the Case 2* with only one check-in counter.

In this second case, the passengers are not spread in a logical order and the consideration is that they arrive in groups of certain number of customers.
The last passenger 75 finishes its baggage check-in after 58 minutes. This fact indicates that the airport is capable to absorb the demand without problems with the established hypothesis.

$$\textit{TotalCheck-in}{=}tB1(3) + tB1(9) + tB1(26) + tB1(55) + tB1(75) = \mathbf{57{,}5\ min} \tag{7.16}$$

If the number of check in counters is changed to only one, the situation changes and the fact is that not all the passengers will be able to do the baggage check in befoure the boarding starts (limit case).Concretely, tB1(75)>65 min , the value is tB1(75)=117,5 min

$$\textit{TotalCheck-in}{=}tB1(9) + tB1(26) + tB1(43)... = \mathbf{69\ min} \tag{7.17}$$

Baggage time tB2
Case 2* calculations

In this case 2* only one self-service kiosk will be opened in order to present the worst possible scenario.

1)Modelling the queuing time (n=1;n=99)

$$tq(n) = tB2(n-1) \tag{7.18}$$

pax 0 (n=0)$\Longrightarrow$ tq(0)=0 min
. . .
pax 35 (n=35)$\Longrightarrow$ tq(35)=tB2(34)=15,75 min
pax 57 (n=57)$\Longrightarrow$ tq(57)=tB2(56)= 9,45 min
pax 99 (n=99)$\Longrightarrow$ tq(99)=tB2(98)= 18,45 min

2)Calculation of the indicator
The baggage check-in indicator of the last passenger will be the limit to establish in this general situation which is the advance the passenger should have before the flight starts.

$$tB2(n) = tq(n) + 0,45min \tag{7.19}$$

pax 0 (n=0)$\Longrightarrow$ tB2(0)=0,45 min
. . .
pax 99 (n=99)$\Longrightarrow$ tB2(99)=45 min

It can be observed that for the Case 2* the passengers will be able to complete the check-in of the baggage if they come 80 minutes before the flight starts (considering that the check-in counter closes 30 minutes before). However, this case considers only one self-service kiosk available, and in fact this is an unreal situation because for each flight any of them could be used for completing the process. In conclusion, probably the total involved time in the process for one flight will be less than a couple of minutes and for sure, the passengers will be able to arrive much closer to the departure hour.

$$\textit{TotalCheck-in}{=}tB2(99) = \mathbf{45\ min} \tag{7.20}$$

Is important to remark this huge change because in the tB1, with the actual technology established in the airport, is not possible to complete this kind of baggage check in before the boarding starts and with the new implementations, the situation changes radically.

- **CASE 3 (limiting case)**

-Number of passengers: 517 (Airbus A380 - Emirates)
-Number of passengers to check-in: 45% (233 passengers)
Number of self-service kiosk opened: 1
-Only one timing for all the passengers considering that they could arrive in groups and they will have to wait in the queue.
-The processing time will be 0,45 minutes considering that all the passengers have to print the baggage tag in the kiosk.

Baggage time tB2
Limiting case calculations

The situation described in this limiting case is the same as the Case 2* from above but using the model of airplane with the highest capacity of passengers which flights from the airport in Barcelona.

The modelling of the queue and the calculation of the indicator are the same, and the total time involved for doing the baggage check-in of this amount of passengers with only one self-service kiosk is the time involved for doing the boarding of the last passenger. This limiting case represents an unrealistic situation because is not possible that for each flight only one kiosk is opened, but in fact the idea is show the worst possible scenario at first and then, analyse a complete process with the data and informations of the airport.

In the worst of the possible scenarios, the total time necessary for doing the baggage delivery of an airplane with considerable dimensions is 1:45 hours, a time that does not represent nothing if it is compared with the recomended time that nowadays a passenger has to arrive to the airport if he has the need to pass through the baggage drop off (1:30h).

$$TotalCheck\text{-}in{=}tB2(233) = \textbf{105,3 min} \qquad (7.21)$$

RESULTS ANALYSIS

The results that show which is the time involved in the baggage drop off have been obtained following the general hypothesis and calculations from section [7.2.1 .Two different configurations have been studied using the actual service rates and then, the fulfilled service rates after the implementation of the new technologies.

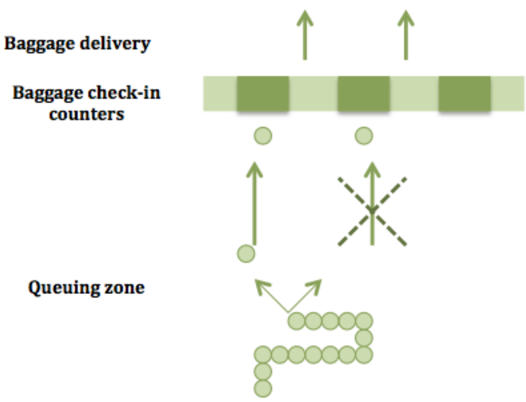

Figure 7.3: General configuration

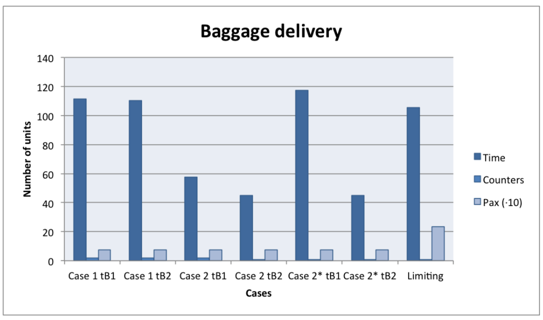

Figure 7.4: Results analysis Baggage time

The three cases studied follow the general configuration [fig: 7.3] at least in one of the moments of the study. This configuration is a limiting case for the tB2 because is known that with the implementation of the Smart Technology more than one self-service kiosk is going to be opened and the times will be reduced considerably even more.

- **CASE 1 (tB1/tB2)**

-Almost the same time involved but in tB2 in an inefficient way because the kiosks are empties the majority of the time. There is a huge possibility to compact the passengers and do the boarding in almost 45 minutes (the same as Case 2).
-In tB1 are necessary two operators, and in tB2 only the machines and one responsible to make them to work properly. Economical benefit for the airline and the airport.

- **CASE 2 (tB1/tB2)**

-Huge difference of time. With only one counter opened with tB1 is not possible to finish the baggage check-in for the flight and with tB2 all the process is finished in 45 minutes (only with one kiosk).
-With more than one self-kiosk opened the baggage check in time could be reduced considerably without the necessity of an operator attending. Great possibility of reducing time and costs in tB2.
-The traveller could arrive to the airport one hour before the flight with the luggage.

- **LIMITING CASE - tB2**

-With only one self-kiosk opened the biggest airplane operating in Barcelona can be filled with the baggage with only 106 minutes. If more kiosks are opened all the process could be done in less than one hour.
-The number of passengers is almost the double of the Case 2 and all of them can do the baggage check-in with only 50 minutes of difference (considering only one self-service kiosk opened).
-Huge possibility of increase the efficiency and the benefit if more kiosks are opened in the analysis.

7.2.2 Security Check time

DEFINITION

This indicator measures the average security clearing time from entering queue in the security check to completion of all the process. The time is going to be measured at average and peak times. The indicator is going to be calculated in each terminal (T1 and T2) and before and after the implementation of the Smart facilities.

GENERAL HYPOTHESIS

The assumed hypothesis for the results implementation and the figures corresponding to each case can be seen in Annex 5.

IMPLEMENTATION

Security Check time-tS1

Once all the parameters of the law that express the arrival rate and the time involved in the service facilities are defined, the computing of the final results can start.

The first step is the λ calculation, which is the mean arrival rate for passengers.To compute this parameter is necessary that it is in the same units as μ (service rate).

In this case study of the security check the service rate is going to be defined for the set of two X-Ray machines. This set of two X-Ray machines have one metal detector in the middle and because of that, the number of channels are defined as K=2,4,6... For this set of elements the service rate established and measured in the real situations and flights from the airport of Barcelona is between μ= 14pax/5min and μ=22pax/5min. Therefore, the λ should be defined also in number of passenger arrivals during 5 minutes. To compute this number, the maximum flow of passengers encountered in the rush hour should be divided between 60 minutes and then, multiplied for 5.

After the value of λ and μ are computed, the different indicators of the times involved in the queue could be calculated following the equations showed in the section "General Hypothesis"[7.2.2]. However, there is one restriction that needs to be fulfilled in order to assure that the system will be capable to absorb all the incoming inflow of passengers: the average $k \cdot \mu$ has to be higher than the mean arrival rate λ. ($k \cdot \mu > \lambda$)

The details of all the calculations can be found in the attached Excels files and in the tables 7.7 and 7.8. The hypothesis assumed for each value of lambda and mu explained step by step can be found in Annex 5.

August 2015-T1								
K=18,Mu=22			K=20,Mu=20			K=22,Mu=18		
P(0)	3,63·10^(-8)		P(0)	5,43·10^(-9)		P(0)	6,57·10^(-10)	
P(15)= 0,066	P(25)= 0,040	P(100)= 0,00024	P(15)= 0,041	P(25)= 0,032	P(100)= 0,00009	P(15)= 0,025	P(25)= 0,021	P(100)= 0,0002
Lq	14,078 pax.		Lq	7,986 pax.		Lq	9,571 pax.	
L	30,89 pax.		L	26,47 pax.		L	30,11 pax.	
Wq	0,190 min/pax		Wq	0,108 min/pax		Wq	0,129 min/pax	
W	0,418 min/pax		W	0,358 min/pax		W	0,407 min/pax	

Table 7.7: T1 results - Security Check

August 2015-T2								
K=8,Mu=22			K=10,Mu=18			K=12,Mu=18		
P(0)	0,000097		P(0)	0,000029		P(0)	0,000069	
P(15)= 0,0238	P(25)= 0,0167	P(100)= 0,0012	P(15)= 0,035	P(25)= 0,019	P(100)= 0,0002	-	-	-
Lq	25,41 pax.		Lq	13,807 pax.		Lq	1,256 pax.	
L	33,14 pax.		L	23,25 pax.		L	10,71 pax.	
Wq	0,747 min/pax		Wq	0,406 min/pax		Wq	0,037 min/pax	
W	0,975 min/pax		W	0,684 min/pax		W	0,315 min/pax	

Table 7.8: T2 results - Security Check

Security Check time - tS2

With the implementation of new technologies, the total time involved in the security check is expected to decrease. The principal ones are the Automatic Tray Returning System (ATRS), the centralization of the security points in the airport and the Scanning system.

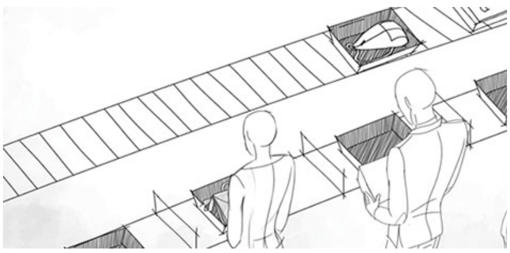

Figure 7.5: ATRS system

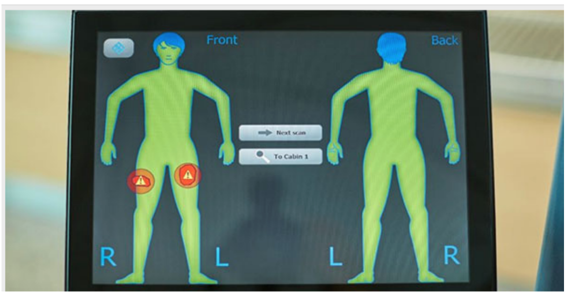

Figure 7.6: Scanning system

-ATRS [fig:7.5]: this system consists basically in an automatic ribbon that returns the tray to passengers once these have passed through the metal detector and the scan.

-Scanning system[fig:7.6]: the scan can be used in common with the metal detector or as the only method to control the foreign objects in the airport. The passengers have to go through it in order to verify they do not have any dangerous object.

The principal parameter that is going to change with these new implementations is the service rate, because in the same period of time a huge amount of passengers is going to be able to pass through the security zone. More service channels could be opened also if the useful space is used with more efficiency.

The service rates defined at first were between 18 and 22 passengers in 5 minutes. With these new implementations the service rate could arrive to 26 or 28 passengers in 5 minutes.

Considering the improvements caused by the implementations of the changes the new final parameters are shown in the tables 7.9 and 7.10:

August 2015-T1					
K=18,Mu=22		**K=15,Mu=26**		**K=22,Mu=26**	
P(0)	2,57·10^(-8)	P(0)	2,66·10^(-7)	P(0)	8,07·10^(-6)
Lq	10,22 pax.	Lq	14,60 pax.	Lq	0,875 pax.
L	26,92 pax.	L	28,23 pax.	L	15,11 pax.
Wq	0,14 min/pax	Wq	0,20 min/pax	Wq	0,01 min/pax
W	0,36 min/pax	W	0,39 min/pax	W	0,20 min/pax

Table 7.9: T1 results - Security Check

August 2015-T2					
K=8,Mu=26		**K=7,Mu=26**		**K=7,Mu=28**	
P(0)	0,0011	P(0)	0,0005	P(0)	0,0014
Lq	2,23 pax.	Lq	1,07 pax.	Lq	4,19 pax.
L	8,77 pax.	L	7,61 pax.	L	10,26 pax.
Wq	0,066 min/pax	Wq	0,032 min/pax	Wq	0,123 min/pax
W	0,258 min/pax	W	0,224 min/pax	W	0,302 min/pax

Table 7.10: T2 results - Security Check

RESULT ANALYSIS

After the implementation of the terminal security facilities it can be seen in figure 7.9 and figures 7.10 and 7.11 that the security check is able to manage almost the same quantity of passengers or even more but with less service channels opened (K) and with a better service rate (μ). In consequence, the numbers of passengers waiting for service and in the system (see fig:7.7) are reduced.

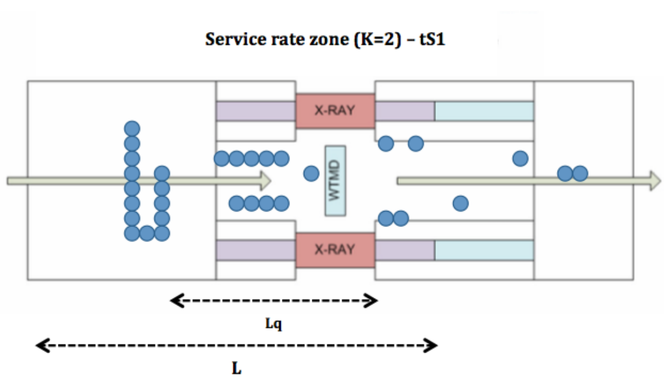

Figure 7.7: Schema tS1

For example, in the Case 2 of T1 with only 15 service channels opened in tS2 in front of the 20 in tS1 the quantityt of passengers treated in one hour is almost the same. Therefore, the Case 3 shows that in T1 is possible to manage over 6.000 passengers in one hour if 22 channels are opened and the service rate is 24 or 26 passengers every 5 minutes. These investments are necessary for the predicted traffic growth in order to save time in the security zone.

Respect the T2, the situation is the same, with less time involved (better service rate) and possibility of treating more passengers with more channels but with less waiting passengers for the service. The Case 3 in tS2 for example, shows that with only 7 channels opened the quantity of passengers treated is almost the same (due to the good service rate) in comparison with the same Case in tS1.

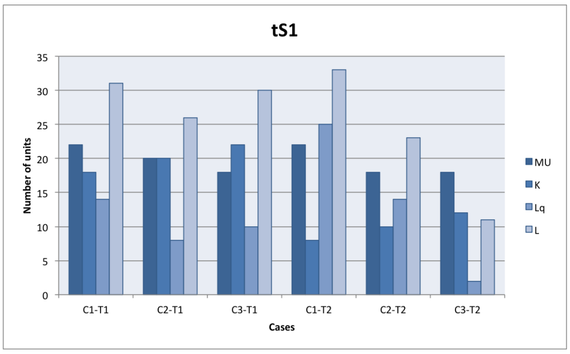

Figure 7.8: tS1 cases

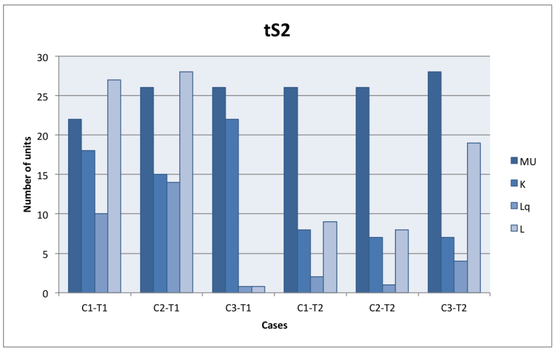

Figure 7.9: tS2 cases

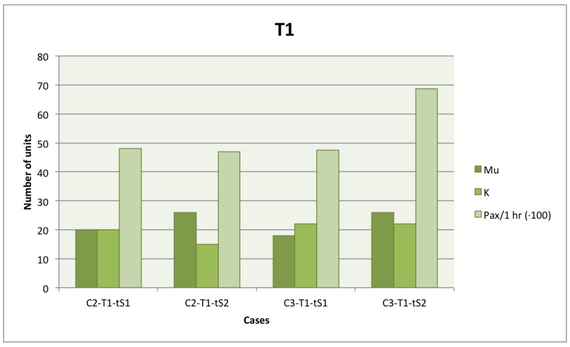

Figure 7.10: T1 cases comparison

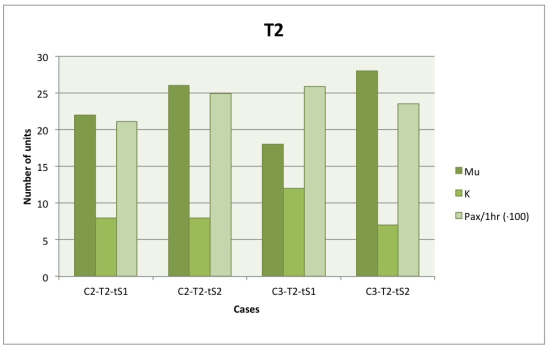

Figure 7.11: T2 cases comparison

7.2.3 Border control time

DEFINITION

This indicator shows the total time involved in the validation of the documents at the passport controls of the airport. The study will show the total time involved before and after the application of Smart Technologies modelling the queuing system and having into account the number of international departures from the airport that need to check the documentation. The ABC system has been already implemented for the arrivals in the airport of Barcelona.

GENERAL HYPOTHESIS

The assumed hypothesis for the results implementation and the figures corresponding to each case can be seen in Annex 5.

IMPLEMENTATION

The results obtained from the time analysis of the Border Check time have been computed following the continuous hypothesis:

-The service rate time is defined for each border office that is checking the passports. In that case, if there are six border office working, the value of K will be K=6. -The period of time in which the parameters are defined is 5 minutes. (service rate, lambda).

-Only the international departures of the rush hour of departures are taken into consideration because the AMB system is already implemented for arrivals in Barcelona.

-The rate $K \bullet \mu > \lambda$ in order that the system will be able to absorb all the incoming inflow.

Border Control time -tCh1

August 2015-T1					
K=6,Mu=10		**K=7,Mu=10**		**K=7,Mu=11**	
P(0)	4,65·10^(-3)	P(0)	0,0063	P(0)	0,010
Lq	3,026 pax.	Lq	0,835 pax.	Lq	0,430 pax.
L	8,03 pax.	L	5,83 pax.	L	4,98 pax.
Wq	0,303 min/pax	Wq	0,083 min/pax	Wq	0,043 min/pax
W	0,803 min/pax	W	0,583 min/pax	W	0,498 min/pax

Table 7.11: T1 results - Border Control

August 2015-T2					
K=2,Mu=6		**K=3,Mu=4**		**K=3,Mu=5**	
P(0)	0,0909	P(0)	0,0449	P(0)	0,111
Lq	3,788 pax.	Lq	3,51 pax.	Lq	8,681 pax.
L	4,45 pax.	L	6,01 pax.	L	10,68 pax.
Wq	1,894 min/pax	Wq	1,756 min/pax	Wq	4,340 min/pax
W	2,727 min/pax	W	2,140 min/pax	W	5,340 min/pax

Table 7.12: T2 results - Border Control

Border Control time -tCh2

The checking time of the passports at the border is reduced considerably after the implementation of the Smart Technology. The principal cause is that the ABC gates make that the service rate increase considerably: there is a 60% of reduction in wait times and the average of passengers that the gate could manage is 7 passengers each minute.

August 2015-T1						**August 2015-T2**	
K=2,Mu=35		**K=3,Mu=35**		**K=7,Mu=35**		**K=2,Mu=35**	
Lq	1,50	Lq	0,194	Lq	1,88·10ˆ(-4) pax	Lq	0,001 pax
L	2,93	L	1,62 pax	L	1,43 pax	L	0,29 pax
Wq	0,150 min/pax	Wq	0,019 min/pax	Wq	0 min/pax	Wq	0,00007 min/pax.
W	0,293 min/pax	W	0,162 min/pax	W	0,143 min/pax	W	0 min/pax

Table 7.13: T1 and T2 Border Check - tCh2

RESULTS ANALYSIS

Is easy to see that in both cases after the implementation of new technology the situation gets considerably better. With this high service rate (μ=35 passengers every 5 minutes) with only 2 or 3 channels opened (K=2,K=3), which means 2 or 3 automated border machines, the number of passengers that could be treated in one hour is the same or higher as if there were 6 or 7 channels opened in the first situation before the ABC implementation.

In figures 7.12 and 7.13 the results can be observed.

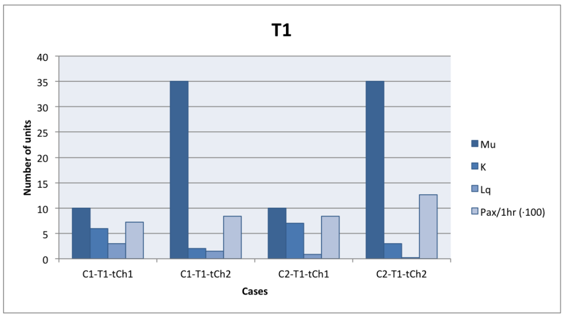

Figure 7.12: T1 cases comparison

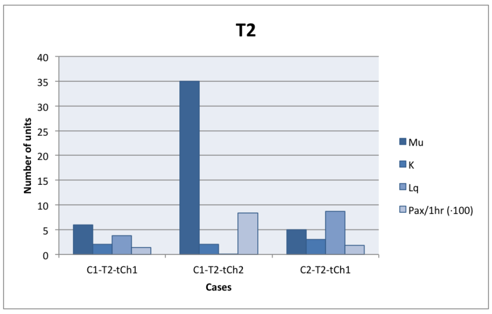

Figure 7.13: T2 cases comparison

7.2.4 Boarding to gate time

DEFINITION

This indicator shows the averaged time between the boarding of the airplane starts until all of the passengers are seated and the airplane start moving.

GENERAL HYPOTHESIS

The possible boarding configurations are analysed in Annex 5 section 7.2.4. Then, some hypothesis are established before the results computation (see Annex 5).

IMPLEMENTATION

The total time involved on boarding the airplane as it has been said depends on different parameters. The tG (time boarding Gate) could be computed as the sum of different spread times:

$$tG = tCheck + tQueue + tAirplane + tBaggage \tag{7.22}$$

The parameter *tCheck* is referred to the previous step to enter the gateway of the airplane when the airline officer validates the travel document (boarding) and the identity card. Then, there is the *tQueue*, which is the time involved in the queue inside the gateway or finger. There is also *tAirplane*, which is the total time involved inside the airplane until the passenger arrives to the seat and finally, the tBaggage which is referred to the time spend putting the hand baggage in the cabin and therefore, obstructing the pass to other passengers through the airplane corridor.

All of the presented parameters are variable for each passenger because for example, the first ones that starts the boarding are not going to have any queue in the finger or inside the airplane but after certain minutes the boarding has started, the situation will change and these two indicators will start increasing its value. The *tBaggage* is also different depending on the size of the baggage, the quantity, the space...

tG1

$$tG1 = tCheck1 + tQueue1 + tAirplane1 + tBaggage1 \tag{7.23}$$

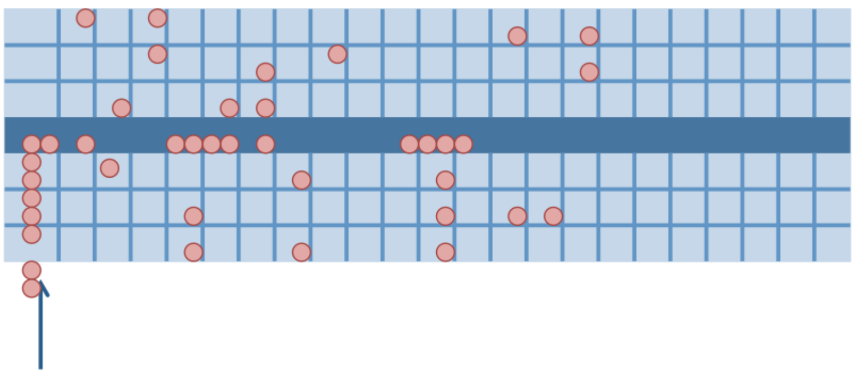

Figure 7.14: Random boarding system

Actually, the majority of the boarding processes are done following a random distribution (fig: 7.14), which means that all the passengers form a queue and then when the airplane is ready the boarding process start. Sometimes the airline officers try to divide the passengers in two queues depending on the zone where they are seated, but this process without a strict control could be inefficient.

Advantages
-The passengers don't need to arrive at a certain hour to board the airplane.
-The airline officers don't need to control the order of the passenger entrance.
-There is multiple people seating at the same time in the airplane, and this fact in theory speeds and simplifies the process for the airline.

Disadvantages
-The airline officers should check the identity of the passengers and the boarding pass. (no e-Gates are used).
-The first passengers could enter without queue in the finger and inside the airplane but after a few minutes a queue for entering is formed.
-The disorder causes obstructions in the lane inside the plane, disorder in the baggage cabin positioning and stress for the passengers.
-The trip is not available to move free inside the plane because is it occupied by disordered passengers.
-The total time involved is more compared to an ordered distribution.

tG2

The principal fact related to the Self-Boarding system or the implementation of Smart Technologies is the use of the named e-Gates to make the passengers board the airplane. These gates allows the airlines and the airport to control the boarding process, check the identity of the travellers and fasten the process.

- Back to front boarding

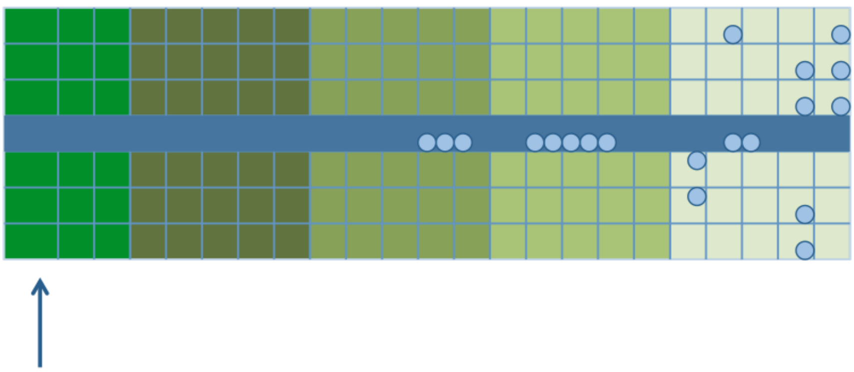

Figure 7.15: Back to front boarding system

Advantages
-Using the e-Gates the boarding pass and the identity could be validated immediately. Therefore, is possible to control also the order of boarding not allowing the passengers from the other zones to pass through the system.
-No queue along all the lane inside the plane, only in the zone corresponding to the moment of the boarding.

-The boarding is done progressively, considering the different zones in which the airplane is divided.
-Less queuing time before entering the plane and less time involved inside the airplane.
-Not a high level of stress for the passengers that can be helped also by the trip.

Disadvantages
-The zone that is being under the boarding process could be overcrowded and a queue can be formed there.
-Is more useful in larger airplanes.
-There could be situations where only one person is available to board at one instant of time.
-Some passengers should be at a certain time in the boarding gate in order to have access to the airplane.

- Outside in boarding

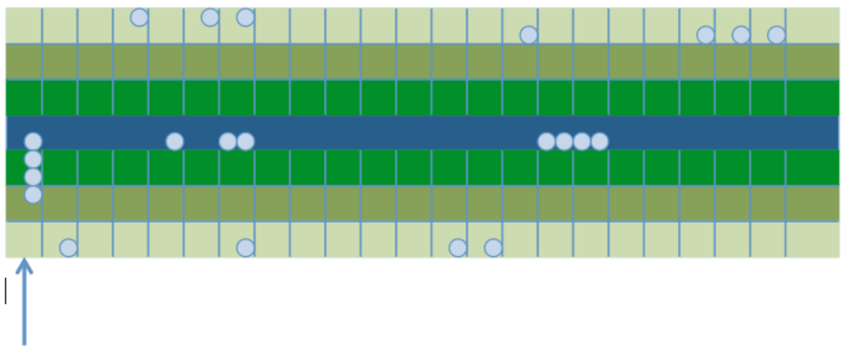

Figure 7.16: Outside in boarding system

Advantages
-Through the e-Gates the order of boarding could be controlled and also the boarding pass and the identity.
-Les queue along all the airplane because all the passengers go through different zones and in the same row.
-The boarding is done progressively considering the represented zones.
-Less stress for passengers who don't have to wait long times to enter.
-People could be seating and putting the baggage at the same time without obstructing the pass.

Disadvantages
-Passengers should be at a certain time at the boarding gate in order to have access to the airplane.

RESULTS ANALYSIS

Once some of the possible boarding configurations are analysed , is important to determine which is the most efficient method of boarding in order to save space, time and money.

tCheck (self-boarding gates)

The self-boarding gates in comparison with the traditional method fasten the process and allow the airline to control the process of boarding.

The fact is that the boarding passes should have a certain code or colour in order to spread the passengers having on consideration which is the zone of the airplane they have (see figure 7.17). Once this is done, they should be prevented that those who have the seats in the window or the rear seats should be at the boarding gate before the rest. In order to achieve that, the boarding time should be divided and if one passengers misses it period of time, he should wait until the end in order not to disrupt the entire process.

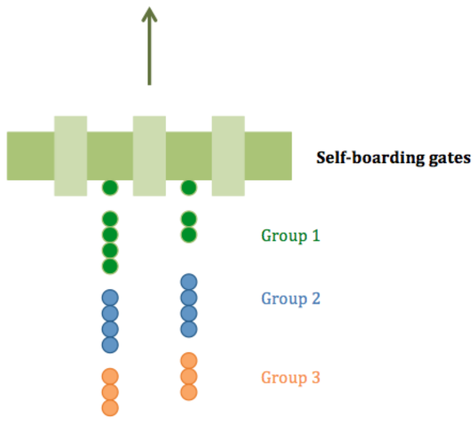

Figure 7.17: Outside in boardin passenger spread

The self-boarding gates could help with all of this process because all the information could be stored in the same boarding pass.

	Average time	**Boarding time**	**Airline officers**
tG1	25-30 minutes (189 passengers)	One timing	2
tG2	15-18 minutes (189 passengers)	Time division (minutes) 4+4+4(+3) 4+6+5(+5) ...	One or less, just to ensure the good functioning of the machines

Table 7.14: Boardint to gate implementation

7.2.5 Baggage recovery time

DEFINITION

This indicator shows the average time involved in the claim for a baggage recovery if it has been lost.

RESULTS ANALYSIS

The baggage recovery indicator is intended to make easier the process to recover a baggage in case of disruption or loss. However, inside the implementation program there is an important part that will change considerably the way we travel: the tracking of the luggage.

The objective fixed is that each passenger could check where is its baggage from the print of a receipt in a kiosk or from the mobile phone. That way, the time involved in case of lost or the time involved in a recovery kiosk will be less.

	tR1	tR2
Tracking	NO -Bag lost: more difficulty to find it -Lost money in pertinences	YES -Bag lost: possibility of find it thanks to the track location -Save money: it can be tracked from the mobile phone or with systems like "Airbus2Go" which cost 8 euros.
Time to recover	Uncertain -Airport Claim Baggage, up to 40 minutes.	Tracking systems allow to fins it easy. Reduction in 40 minutes the baggage claim.
Mishandled bags	Yes	Yes, but with a reduction up to 30%

Table 7.15: Bag recovery parameters

In the figure7.18 the number of passengers that could experience a good baggage recovery in the airport of Barcelona are shown according to the expected times and the actual level of implementation in other airports of Smart Technologies.

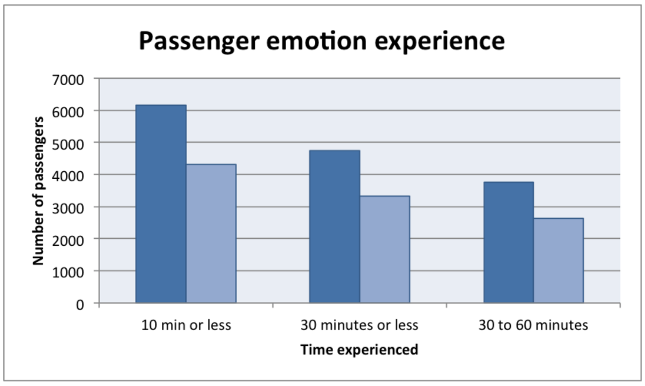

Figure 7.18: Passenger baggage recovery experience

BAGS LOST OR INJURED

Problem definition

Baggage handling continues to be one of the single largest problems to a streamlined passenger process and an efficient air transport business model.

The number of passenger traffic increases year by year but at the same time is important that the total number of bags lost each year continues to decrease in order to give tranquillity to the passengers and benefits to the system.

From 2003 to 2015 the baggage handling has experimented huge changes that makes that nowadays the expectations for the future are hopeful.

Baggage Handling			
	Total passengers (billions)	Total bags mishandled (millions)	Mishandled bags per 1.000 passengers
2003	1.89	2.48	3.5
2007	24.9	46.9	23.1
2015	13.2	18.88	6.5

Table 7.16: Baggage handling information

Key parameters

The key parameters that affect this indicator and have improved the situation are those related to the baggage dropp off (see REF) and the baggage recovery and tracking (see REF).

- Misshandled bags cost the aviation industry 2.3 billion $ in 2015.This means that for each passenger the cost is 0.65 $.These rates have been reduced considerably from the situation in 2007, where the total costs for the industry were 4.2 $.
- The baggage self servie drop off is being more used in comparison to last year.
- 77% of airlines intend to implement the self-tagging baggage by 2018.
- 88% of the airports are willing to implement the self-tagging by 2018.
- The baggage tracking initiatives are each time more common between airport users.

Barcelona airport

For the estimation of the number of bags losts in the airport of Barcelona the flux of passengers computed (see section 7.1.1) for the arrivals in Terminal 1 and Terminal 2 is used. In this case, the number of passengers for National arrivals and UE Schengen arrivals is added too.

Arrivals-August 2015 (T1+T2)	Before Baggage Recovery and Tracking system (tR1)		After Baggage Recovery and Tracking system (tR2)	
2.149.977	40% facturation	50% facturation	40% facturation	50% facturation
Number of bags lost (month)	5.590	6.987	3.913	4.891
Cost (month)	3.633 $ (3.211 eur)	4.542 $ (4.015 eur)	2.035 $ (1.799 eur)	3.633 $ (3.211 eur)

Table 7.17: Barcelona Baggage loses

It can be observed in table 7.17 that after the implementation of the baggage Smart technologies, there are some kind of benefits. From the actual situation (2015), for the future in the same conditions an average of 30% of baggs less than actually is expected to be lost and a reduction of 20% of the costs for each passenger is also achieved.

All of these aspects are positive for both passenger and airport, but also for the airlines and the stakeholders of the airport. The customers are going to be more satisfied, with tranquillity and the punctuation of the airport and the experience will be more satisfactory.

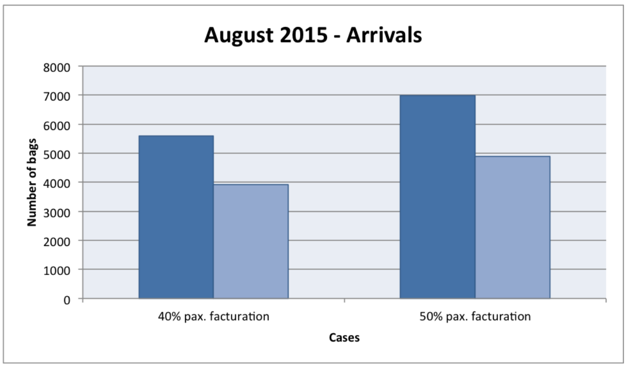

Figure 7.19: Baggage loses decrease

7.3 Traffic and capacity indicator

One of the main goals of the implementation of Smart Technologies is try to increase the capacity of the airport terminal without the necessity of more space or new infrastructures. This fact will involve directly an economical benefit and less costs for each passenger.

7.3.1 Actual traffic growth

If the traffic of passengers and operations the following years continue with the expected growth, the airport terminals could have serious problems due to the excess from its capacity.

In order to estimate which are the previsions for Barcelona airport, the following indicator which calculates the average tax of growth during a certain period of time (5 years for example), has been used:

$$CAGR(\%) = \frac{V(t_n)}{V(t_0)}^{\frac{1}{t_n - t_0}} - 1 \tag{7.24}$$

Estimation Passenger Traffic		
	Passengers CAGR(10-15)-6,33%	**Operations CAGR(10-15)-0,78%**
2015	39.711.276	288.878
2020	53.988.719	300.363
2025	73.399.349	312.305

Table 7.18: Traffic growth Barcelona

It can be seen in the table 7.18 that in 5 years, the number of passengers in the airport of Barcelona will be around 50 millions (almost the total capacity of Terminal 1) and in 10 years the growth situates the traffic around 70 millions.

7.3.2 Terminal capacity

The terminal capacity is defined as the number of passengers/hour. If the number of passengers each hour is increased because different processes in the terminal are done faster than actually, the capacity in the terminal will increase.

However, there are nother factors that could influence the estimated capacity like the kind of acces to the airport, the number of baggage check-in counters, the number of fingers or gateways available for using them for boarding, the handling for passengers...

- **tF1**

CASE 1
-Regional destination (no passport control)
-Baggage drop off
-tW is referred to the time spend walking in the terminal or doing some changes to one place to another.
-Study of the worst case, considering the maximum time involved for each process.
-The calculations and procedures to obtain the showed averaged time for each process can be seen in sections **??** , **??** and **??**.

$$tF1 = tB1 + tS1 + tG1 + tW \tag{7.25}$$

tB1	**tS1**	**tCh1**	**tG1**
-Case 2 Boarding time -76 passengers check in -75 minutes check in opened before flight -2 check in counters opened -Arrival last 55 minutes before check in closes -Terminal 1	-Security Check indicator -Terminal 1 security check	-No passport control.	-Random boarding -A320/B 737 -No passenger order -Hand baggage
tB1=57,5 min	See table 7.20	No	tG1=25 minutes

Table 7.19: Traffic calculation parameters

tS1 time estimation - T1			
	K=18 Mu=22	K=20 Mu=20	K=22 Mu=18
Lq (pax)	14,09	7,98	9,57
L(pax)	30,89	26,47	30,11
Wq (min/pax)	0,19	0,108	0,129
W (min/pax)	0,418	0,358	0,407
Time in (min)	**12,91**	**9,48**	**12,15**
Time wait (min)	2,67	0,86	1,23

Table 7.20: tS1 time estimations

1)

$$tF1(min) = tB1 + tS1 + tW = 57,5 + 12,91 + 15 = 85,41min \tag{7.26}$$

$$tF1(min) = tB1 + tS1 + tG1 + tW = 57,5 + 12,91 + 25 + 15 = 110,41min \tag{7.27}$$

2)

$$tF1(min) = tB1 + tS1 + tW = 57,5 + 9,48 + 15 = 81,98min \tag{7.28}$$

$$tF1(min) = tB1 + tS1 + tG1 + tW = 57,5 + 9,48 + 25 + 15 = 106,98min \tag{7.29}$$

- **tF2**

CASE 1
-Regional destination (no passport control)
-Baggage drop off
-tW is referred to the time spend walking in the terminal or doing some changes to one place to another.
-Study of the worst case, considering the maximum time involved for each process.
-The calculations and procedures to obtain the showed averaged time for each process can be seen in sections **??** , **??** and **??**.

$$tF2 = tB2 + tS2 + tG2 + tW \quad (7.30)$$

tB2	**tS2**	**tCh2**	**tG2**
-Case 2* Boarding time (modified) -76 passengers check in -75 minutes check in opened before flight -2 check in counters opened -Arrival last 55 minutes before check in closes -Terminal 1	-Security Check indicator -Terminal 1 security check	-No passport control.	-Outside in boarding or Back to front -A320/B 737 -Passenger order -Hand baggage
tB2= 22,5 min	See table 7.22	No	tG2=15 minutes

Table 7.21: Traffic calculation parameters

tS2 time estimation - T1			
	K=18 Mu=22	K=15 Mu=26	K=22 Mu=26
Lq (pax)	10,22	14,6	0,875
L(pax)	26,92	28,23	15,11
Wq (min/pax)	0,14	0,2	0,01
W (min/pax)	0,36	0,39	0,2
Time in (min)	**9,69**	**11,01**	**3,02**
Time wait (min)	1,43	2,92	0,01

Table 7.22: tS2 time estimation

1)

$$tF2(min) = tB2 + tS2 + tW = 22,5 + 11,01 + 15 = 48,51min \quad (7.31)$$

$$tF2(min) = tB2 + tS2 + tG2 + tW = 22,5 + 11,01 + 15 + 15 = 63,5min \quad (7.32)$$

2)

$$tF2(min) = tB2 + tS2 + tW = 22,5 + 3,02 + 15 = 40,52min \quad (7.33)$$

$$tF2(min) = tB2 + tS2 + tG2 + tG2 + tW = 55,52min \quad (7.34)$$

- **tF1**

CASE 2
-International destination (passport control)
-Baggage drop off
-tW is referred to the time spend walking in the terminal or doing some changes to one place to another.
-Study of the worst case, considering the maximum time involved for each process.

$$tF1 = tB1 + tS1 + tCh1 + tG1 + tW \tag{7.35}$$

tCh1 time estimation - T1			
	K=6 Mu=10	K=7 Mu=10	K=7 Mu=11
Lq (pax)	3,03	0,84	0,43
L (pax)	8,03	5,83	4,98
Wq (min/pax)	0,303	0,083	0,043
W (min/pax)	0,803	0,583	0,498
Time in (min)	**6,45**	**3,40**	**2,48**
Time wait (min)	0,92	0,07	0,02

Table 7.23: tCh1 time estimation

1)

$$tF1 = tB1 + tS1 + tCh1 + tW = 57,5 + 12,91 + 6,45 + 15 = 91,86min \tag{7.36}$$

$$tF1 = tB1 + tS1 + tCh1 + tG1 + tW = 57,5 + 12,91 + 6,45 + 25 + 15 = 116,86min \tag{7.37}$$

2)

$$tF1 = tB1 + tS1 + tCh1 + tW = 57,5 + 9,48 + 3,40 + 15 = 85,83min \tag{7.38}$$

$$tF1 = tB1 + tS1 + tCh1 + tG1 + tW = 57,5 + 9,48 + 3,40 + 25 + 25 + 15 = 110,38min \tag{7.39}$$

- **tF2**

CASE 2
-International destination (passport control)
-Baggage drop off
-Study of the worst case, considering the maximum time involved for each process.
-The calculations and procedures to obtain the showed averaged time for each process can be seen in sections **??** , **??** and **??**.

$$tF2 = tB2 + tS2 + tCh2 + tG2 + tW \quad (7.40)$$

tCh2 time estimation - T1			
	K=2 Mu=35	K=3 Mu=35	K=7 Mu=35
Lq (pax)	1,5	0,194	0,00019
L (pax)	2,93	1,62	1,43
Wq (min/pax)	0,15	0,019	0
W (min/pax)	0,293	0,162	0,143
Time in (min)	**0,86**	**0,26**	**0,20**
Time wait (min)	0,23	0,0	0,00

Table 7.24: tCh2 time estimation

1)

$$tF2 = tB2 + tS2 + tCh2 + tW = 22,5 + 11,01 + 0,86 + 15 = 49,37min \quad (7.41)$$
$$tF2 = tB2 + tS2 + tCh2 + tG2 + tW = 22,5 + 11,01 + 0,86 + 15 + 15 = 64,37min \quad (7.42)$$

2)

$$tF2 = tB2 + tS2 + tCh2 + tW = 22,5 + 3,02 + 0,26 + 15 = 40,78min \quad (7.43)$$
$$tF2 = tB2 + tS2 + tCh2 + tG2 + tW = 22,5 + 3,02 + 0,26 + 15 + 15 = 55,78min \quad (7.44)$$

7.3.3 Final comparison

As it can be seen in figure 7.20, the time involved for each operation is reduced almost a 50% the estimated value that actually has the airport. This fact affects directly the future growth because with the implementation of Smart Technologies the possibility to manage more passengers (see table 7.18) and flights with the existing facilities and infrastructures is possible.

Probably an investment will have to be done, but if the rate (time passenger)/operation decreases due to these investments, more passengers will be able to finish one operation (departure or arrival) in one hour and indirectly, they will allow the airport to manage more operations in the same period of time.

$$\frac{Timepax}{Operation} \downarrow = \frac{Pax}{Hour} \uparrow \quad (7.45)$$

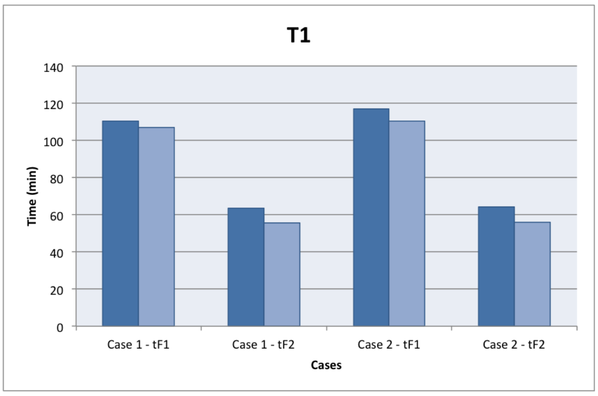

Figure 7.20: Time involved for each operation

7.4 Economic indicators

7.4.1 Passengers per employee

DEFINITION

This indicator shows the number of employees from the airport or the airline that are necessary to give a good service to the passengers and let them to complete all the pre-flight processes without problems. The comparison is going to be done before and after the implementation of the Smart Technologies.

This study is going to be done following the hypothesis that the airport is working at its full capacity in the terminal installations and facilites during the high period (May to September) and at 60% the rest of the year.

IMPLEMENTATION

The comparison is going to be done taking into account the pre-flight process that involves more staff in each step. After the rate passenger/staff, an economical comparison of the economical benefit obtained will be done.

The table 7.25 shows the rate passengers/employee. To compute this indicator, the total departure passengers in both terminals are taken (see 7.1 and 7.2) and then, each passenger is divided by the total number of employees that participate in one operation of departure.

The two terminals have been studied and even two cases: one without border check control and another with it.

Passengers	T1(D):1.513.926			T2(D):695.608			
	tB1	tS1	tG1	tCh1	tR1	**Total**	**Passenger/employee**
Process 1-t1	2	7	2	-	1	12	**0,083**
Process 2-t1	2	7	2	1	1	13	**0,077**
	tB2	tS2	tG2	tCh2	tR2	Total	
Process 1-t2	0	5	1	-	0	6	**0,167**
Process 2-t2	0	5	1	0	0	6	**0,167**

Table 7.25: Passenger/employee rate

Another results analysis that could be interesting are the rates that relate the total number of passengers with the time indicators (see 7.2). In that case, the total number of passenger in each terminal is used and then, divided by the total number of employees corresponding to each step.

RATES-T1					
Total pax./tB1 empl.		**Total pax./tG1 empl.**		**Total pax./tS1 empl.**	
Number of counters	144	Boarding gates	50	Security check lanes	20-22
Number of employees	144	Number of employees	100	Number of employees	30-35
T.pax/tB1 empl. =10.513		T.pax/tG1 empl, = 15.139		T.pax/tS1 empl. = 33.643	

Table 7.26: Economic indicators-T1

RATES-T1					
Total pax./tB1 empl.		**Total pax./tG1 empl.**		**Total pax./tS1 empl.**	
Number of counters	58	Boarding gates	67	Security check lanes	10-12
Number of employees	58	Number of employees	134	Number of employees	15-20
T.pax/tB1 empl. =11.993		T.pax/tG1 empl, = 5.191		T.pax/tS1 empl. = 34.780	

Table 7.27: Economic indicators-T2

The first tables 7.26 and 7.27 show the actual situation with the terminal facilities and fixed number of check in counters, boarding gates... Then, the tables 7.28 and 7.29 show which will be the new situation if the proposed Smart Technologies are implemented. The tendency is clear and each employee will be able to manage more quantity of passengers due to the digitalization of the process and the automatization. The passenger has more autonomy and because of that, less attendance is needed.

RATES-T2					
Total pax./tB2 empl.		**Total pax./tG2 empl.**		**Total pax./tS2 empl.**	
Number of counters	144	Boarding gates	50	Security check lanes	20-22
Number of employees	60	Number of employees	50	Number of employees	30
T.pax/tB1 empl. =25.323		T.pax/tG1 empl, = 30.279		T.pax/tS1 empl. = 50.464	

Table 7.28: Economic indicators increased-T1

RATES-T2					
Total pax./tB2 empl.		**Total pax./tG2 empl.**		**Total pax./tS2 empl.**	
Number of counters	58	Boarding gates	67	Security check lanes	10-12
Number of employees	20	Number of employees	67	Number of employees	15
T.pax/tB1 empl. =34.780		T.pax/tG1 empl, = 10.382		T.pax/tS1 empl. = 46.374	

Table 7.29: Economic indicators increased-T2

COST ANALYSIS

The following cost analysis has been done taking into account the following hypothesis:

- Only the employees that have relation with the time and service quality indicators studied have been taken into account. This means that only the baggage service, security check, border control and boarding gate employees are studied.
- The salary of each one depends on the type of airline, the position inside the enterprise and another complementary factors. Because of that, a medium salary is estimated and its value is 8 euros/hour.
- The airport works almost 19 hours a day. However, is clear that not in all these hours all the employees are avaliable. However, in order to study the worst case, the consideration will be that during 8,5 hours a day all the mentioned employees are working.

Cost analysis (employees)				
	T1-before	T1-after	T2-before	T2-after
Baggage	303.552	126.480	122.264	42.160
Boarding Gate	210.800	105.400	282.472	141.236
Security	73.780	63.240	42.160	31.620
Passport Control	16.864	4.216	8.432	2.108
TOTAL COST (euros)	604.996	299.336	455.328	217.124

Table 7.30: Cost analysis for employee

The table 7.30 shows which is the cost in the month of August due to certain employees in the airport of Barcelona. It can be seen that after the implementation of all mentioned technologies, the cost are considerably low and the economical benefit for the airport will be higher. In section 7.4.2 the relation with the total airport costs could be seen.

7.4.2 Economical benefit/loses

DEFINITION

This indicator corresponds to the economical analysis and study of the benefits and losses in the airport of Barcelona. The principal activities developped on it are going to be identified and then, related to an economic gain or loss. Finally, the activities with new changes introduced due to Smart Technologies will be identified and its impact in the general economy will be studied.

IMPLEMENTATION

To implement this indicator in the most efficient way is necessary to know with exactitude which are the benefit and cost operations of the airport during one year. However,obtain this information could be difficult and hard and even more if the implementation of new technologies is nearly starting in the infrastructures of El Prat. Because of that, some **reference values** are going to be taken from alternative airports that have already done high investments to implement and provide to its passengers with these new Smart Technologies.

The study of the airport to obtain these economical investments with exactitude is difficult to do because some of the exposed case studies and Smart Technologies during all the project are not now in Barcelona and its implementation depends on another factors which are out of the goals or objectives of this project.

The reference values that are going to be taken will provide this economical analysis with an initial investment that represents an expense for the airport but that the airport should do in order to have the machines, systems or service facilities to provide the service. The objective is that with the benefits obtained from new Smart Technologies this initial amount of money could be recuperated in a certain amount of years.

The economic analysis sheet of the airport has two parts:

OPERATING INCOME
This term is referred to the income or earning due to the activity of the airport. The principal terms that contribute to this item are:

- Airport services: all the things related to give a good service to customers in order they arrive properly to their flight destination.
- Commercial services developed inside or outside the terminals: service shops, duty free, fast tracks, VIP zones, consign, the transport to arrive inside the airport...
- Others: this item is related with the work that a company does for itself, the excess of provisions and other economical facts.

OPERATING EXPENSES
The principal items in the airport related with the expenses are:

- Personal
- Amortizations
- Others: sourcing, deterioration...

RESULTS ANALYSIS

- **-Baggage self service delivery**

Necessary initial budget: 36 millions of $ (32 millions of euros). Reference from Gatwik airport Baggage Drop off investment.
Operating income contributions: airport services and personal.
Terminal 1 analysis

The implementation of the Baggage Delivery service makes that one baggage self-service can be useful for more than one airline.The only requirement is that the code of the luggage and the destination should be well printed and clear in order to let the automatic machine and the later systems to process correctly the baggage.

In T1 there are over 144 check-in counters. Each airline has assigned certain number of them. If the baggage self-service system is implemented, the fact is that each machine will be able to process the luggage from customers of different airlines. In fact, actually, the current machines that already exist in the airport of Barcelona are able to process the luggage of Iberia, Egyptair and American Airlines for example.

Passenger analysis
Hypothesis:
-Every airline will provide an officer in order to advise the customer if he has any problem during the baggage drop off or in order to solve any unlikely event if the machine doesn't work. Becaouse of that, after the implementation the number of officers will be the same as number of airlines operating in T1.
-During the five months that represent the highest rates of traffic for the airport (May to September), the consideration will be that the airport works with te 90% of the estimated rate of officers. The rest of the year this assumption will fall to a 60%.
-The number of officers working in the baggage delivery system, apart from the maintenance service and the other officers after the baggage drop off are 48. However, the rate estimated is not exact and could be that in some moments or certain periods of year, the officers will be not distributed following that assumption.

BAGGAGE DELIVERY COSTS		
Salary (euros)		**Total salaries costs for the airport each year(euros)**
2.108		2.639.216 (before)
Salaries each year (euros)		**Total salaries costs for the airport each year (euros)**
(90%-48) 453.220	(60%-29) 427.924	881.144 (after)

Table 7.31: Baggage Delivery economic impact

The table 7.31 shows the differences in the personal costs that the implementation of the system will cause. Is important to remember that also the **time**, the **efficency** and the **customer satisfaction** increase due to this changes.

Capacity analysis
If the Gatwik airport implementation is taken as a reference, it represented an increase of capacity from 3.000 passengers to 4.500 passengers in one hour. This increment represents a 50% of passenger increase, which means that the airport could manage the baggage handling of almost 8 more flights of 189 passengers each hour.

Hypothesis
-A low cost airline is chosen because these kind od airlines represent the major part of the traffic in the airport of Barcelona. The kind of airplanes they work with are those with 189 passenger capacity.
-The average flight ticket price for passenger is 40 euros. From 189 passenger 76 are going to do the baggage check in in those cases the price will be 60 euros.
-Only the contribution of passenger increase is going to be considered. There are no data for the other economic computations (electricity,material...).In conclusion, only the benefits are going to be computed against the losses due to the maintenance service.
-The period of time where this increase is valid is from 6:00 AM to 22:00 PM.
-These rates are going to be considered constants during all the day and all the days of the month.

BAGGAGE DELIVERY COSTS (euros)			
Total benefit for flight	Total benefit in one hour	Total benefit in one day	Total benefit in one month
9.080	72.640	1.162.240	36.029.440
Salary costs in one month		Total salary costs in one year	
31.620		379.440	

Table 7.32: Baggage Delivery economic impact

- **Border control (ABC system)**

Necessary initial budget: 500.000 $. Reference from the ABC implementation in JFK airport. The estimated price of each machine is 100.000 $
Operation income contributions:personal
Terminal 1 and 2 analysis

The implementation of the ABC control system represents an investment for the airport because has direct effect in the time involved in the border check and has also an economical impact.

From the economical point of view, each machine of the ABC system implemented can operate the same way as three border officers. That means that the number of passengers that can treat in the same period of time is the same and the efficiency is higher because the system used to verify the identity is better, more secure and faster.

Following the study presented in section 7.2.3 actually the number of ABC machines that should be implemented for the departures of the airport (both terminals) are 3 in T1 and 2 in T2. The economical impact is shown in table **??**:

ABC SYSTEM COSTS	
Salary (employee) (year)	**Total salaries costs for the airport each year**
2.108 (x3)= 6.324	379.440 This is the estimated cost in one year due to implementation of five machines
Salaries of maintenance	**Total salaries costs for the airport each year**
2.635	126.480 This is the cost of maintenance of the machines
Salary (employee) (year)	**Total salaries costs for the airport each year (11 employees)**
2.108	834.768

To compute the value of the salary the consideration is that each employee earns 8 euros in one hour and the working time is 8,5 hours.For the maintenance service the salary is a little bit higher as the work is a little bit more qualified. For the maintenance service also the quantity of officers is established to two for each terminal.

RECOVERY TIME

- Baggage recovery time

The table 7.33 shows the costs and the benefits for the first month and can be seen that if only the benefits of the airport services are cosidered due to the increase of the number of flights each hour, the first month the initial investment can be recupered. This fact exemplifies about the high benefits of the implementation of the system.

It should be reminded also that a part from the economical benefit there are benefits also related with the customer satisfaction, the efficiency of the system or the time involved in all the process.

ECONOMIC IMPACT	
Initial budget	32 million euros
First month benefits	36.029.440 million euros
First month costs	3.162 euros

Table 7.33: Baggage recovery impact

- ABC system

The table 7.34 shows the cost and benefitsfor the first month and then the total values for the year. The difference between the costs and the benefits is of 252.960 euros. Thus, the operate margin allows the airport to recover the initial inverson in two years.

Considering the relation between the benefits of the implementation and the involved costs, the conclusion is clear: the ABC implementation is the future technology in the airports to control and verify the identity of the passengers. The implementation of the service is effective and profitable for the air transport service and will provide the airport with positive expectations.

ECONOMIC IMPACT			
Initial budget	500.000 euros		
First month benefits	6.324	First year benefits	379.440
First month costs	2.635	First year costs	126.480

Table 7.34: ABC recovery impact

Chapter 8

Conclusions

The conclusions after this first approach study to the feasibility and impact assessment about the implementation of Smart Technologies in the airport of Barcelona could not be better for the possible stakeholders interests.

In this first estimation taking into account some hypothesis in order to let the study inside the limits of the final work project, almost all the desired objectives are fulfilled. For the worst case studied, due to the implementation of the Smart Technologies the time involved inside the terminal is reduced almost a 50% in comparison to the actual time involved. This fact means that without the necessity of building more installations inside the airport or extending the existing ones, the capacity of the airport could increase because the number of operations inside the terminal could be considerably higher. In the table 8.1 all the final values of the time indicators before and after the implementation can be seen.

Respect the quality indicators services, the tendency is the same. The effect of the implementation of Smart Technologies is direct, the customer is more satisfied and more sure about its trip because for example, he can control its own baggage or pass throug a security check more precise. Security and efficiency will help the airport to be atractive for more travellers and then, increase its airport services and benefits. The terminal services will have benefit also because the more flow of passengers with necessities and demands.

Finally, and maybe the most important part, there is the economical factor. All investment needs to be recupered at least in a certain period of time in order to ensure that the process is cost effective. The study that has been don from the point of view of the personal reduction and airport services increase show that at least with two of the most important implementations (Baggage Drop Off and ABC control) the initial amount of money could be recupered in one or two years.This fact comparing to some important similar constructions projects that are needed to gain capacity is very positive.

Having a look and a review on all the data, information and projects exposed before the best conclusion that could be extracted is that in a few years the best scenary for the airport of Barcelona is the implementation the passenger experience Smart Technologies.

Time (min)									
tB1	57,5	**tS1**	12,91	**tCh1**	6,45	**tG1**	25-30	**tR1**	30-60
tB2	22,5	**tS2**	9,69	**tCh2**	0,86	**tG2**	15-25	**tR2**	10
Capacity									
tB2	50% passenger capacity	**tS2**	13 pax each 5 min	**tCh2**	7 pax each min	**tG2**	Almost the same	tR2	6 pax every hour
Autonomy and comfort									
tB2	Yes	**tS2**	Same	**tCh2**	Yes	**tG2**	Same	**tR2**	Yes

Table 8.1: Indicators conclusions

The indicators that can be seen in the table 8.1 correspond to some cases studien during the study. The indicators with the number 1, correspond to the values before the implementation of Smart Technologies and for these that have the number 2, the values correspond to the steps once Smart Technologies are implemented.

The first indicator, tB is the indicator for the baggage drop off. Then, there is the indicator for the security check (tS) and for the border control (tCh). Finally, there are the indicators for boarding the airplane (tG) and for the baggage recovery at the final destination.

Bibliography

[1] Best,Hugh, "Fast Travel Program", January 2015

[2] The Psychology of Waiting.
Retrieved from *http:// www.cengage.com/resource uploads/downloads/0324237049 48187.pdf*

[3] ABC Implementation guide (IATA).
Retrieved from *http://www.iata.org/whatwedo/passenger/Documents/abc implementation guide edition1.pdf*

[4] 2015 Airport IT trends survey (SITA).
Retrieved from *http://www.sita.aero/surveys*

[5] 2016 Baggage Report (SITA).
Retrieved from *http://www.sita.aero/surveys*

[6] Smart Technologies for Smart Airports (SITA).
Retrieved from *http://www.sita.aero/surveys*

[7] 2015 Barcelona El Prat Report.
Retrieved from *www.aena.es*

[8] A Blueprint for the Single European Sky (IATA).
Retrieved from *https://www.iata.org/pressroom/pr/Documents/blueprint single european sky.pdf*

[9] Security Access & Egress (IATA).
Retrieved from *https://www.iata.org/whatwedo/stb/Documents/pf guide security 2012.pdf*

[10] General Information about the Airport.
Retrieved from *http://www.aeropuertobarcelona-elprat.com* and *http://www.aena.es/csee/Satellite/HomeAena*

[11] Statistics about Barcelona Airport.
Retrieved from *http://www.aena.es/csee/Satellite pagename Estadisticas/Home*

[12] Fast airports European project.
Retrieved from *http://www.passme.eu*

[13] Smart Technologies for passenger experience.
Retrieved from *http://www.futuretravelexperience.com*

[14] General Information about Barcelona Airport.
Retrieved from *http://www.lavanguardia.com/local/barcelona*

[15] General Information about Barcelona Airport.
Retrieved from *http://elpais.com/tag/aeropuerto el prat/a*