UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Tècnica Superior d'Enginyeries
Industrial i Aeronàutica de Terrassa

DEGREE IN AEROSPACE VEHICLES ENGINEERING

STUDY OF THE OPTIMUM FLEET FOR A LCC (LOW-COST-CARRIER)

REPORT

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1. Introduction

1.1 Objective of the study

The main objective of this project is to make a selection of the optimum fleet for a low cost airliner operating in a specific geographical area, and then scheduling an initial timetable for this fleet. In this way, it will be obtained which type/s of aircraft/s are the most suitable for the airliner, as well as the quantity of them, the aerial routes that will be covered and an initial weekly timetable in order to programme the flights of the selected fleet.

1.2 Scope of the study

This study has been organised in different tasks and deliverables in order to reach its main objective. These different tasks and deliverables are divided in the following ones and should be followed according to the Gantt's diagram of the project's charter:

1.2.1 Tasks and activities

The list of tasks and activities that will be carried out in the study are the following:

1. **Defining the requirements of the company**. Reading up on the typical characteristics of a low-cost company and deciding the ones of the new company, so as to make it to belong to the low-cost category.

2. **Writing of the project charter**. Writing of the aim, scope, requirements, background and calendar of the study.

3. **Writing of the report introduction**. Writing of the objective, scope, requirements and justification of the study.

4. **Selection of the geographical area of the study.**
   - 4.1 **Establishment of the central base airport**. Selection of the most suitable airport for acting as nucleus airport.
   - 4.2 **Establishment of the aerial routes**. Searching for information, deciding the strategies at the time of selecting the flight routes and making the final decision of these routes.
   - 4.3 **Report contribution**. Writing of the selection of the geographical area of the study in the proper report's section.

5. **Decision of the optimum airplane.** Selection of the optimum model of the different existing airplanes for the company.
   - 5.1 **Search for different models of the existing airplanes**. Search between turbofan and turboprop airplanes that accomplish with the flight routes requirements.
   - 5.2 **Search for the operational costs and other characteristics of the different airplanes**. Search for the necessary DOC's and IOC's of the different airplanes, as well as other characteristics, which are going to be analysed in order to reach a final decision.
   - 5.3 **Selection of the optimum model of airplane**. Carrying out the OWA method, giving the desired weights to each required aspect searched in 5.2.
   - 5.4 **Report contribution**. Writing of the decision of the optimum airplane in the proper report's section.

6. **Selection of the optimum number of airplanes.** Determination of the optimum number of airplanes for the company.

   6.1 **Fleet feasibility study**. Carrying out a study in order to choose the optimum number of airplanes.

      6.1.1 **Establishing a target in terms of passengers**. Estimate the number of passengers in each flight.

      6.1.2 **Establishing a target in terms of the ticket prices**. Estimate the flight price in order to accomplish the established target of passengers.

      6.1.3 **Decision of the number of airplanes**. Obtaining of the optimum number of airplanes required by carrying out a fleet feasibility study.

   6.2 **Iteration process**. Recalculation of the optimum number of airplanes by changing some parameters on the feasibility study.

      6.2.1 **Redefinition of the flight routes**. Adding or taking out routes from the initial decision in order to obtain a feasible fleet (if necessary).

      6.2.2 **Reestablishing a target in terms of passengers and tickets price**. Redefinition of the number of passengers per flight and flight ticket's cost (if necessary).

      6.2.3 **Recalculation of the optimum number of airplanes**. Carrying out the feasibility study with the modified parameters in order to obtain the optimum number of airplanes (if necessary).

   6.3 **Report contribution.**

      6.3.1 **Alternative decisions and development of the best one.** Writing of the optimum number of airplanes in the required report's section.

7. **Definition of an initial flight schedule.**

   7.1 **Decision of the flight schedule.** Once having decided the fleet of the company, determining the flight plan for each airplane and day of the week.

   7.2 **Report contribution.** Writing of the flight schedule in the proper report's section.

8. **Report contribution.**
   - 8.1 **Summary of results.** Writing of the section that contains the summary of results.
     - 8.1.1 **Economical feasibility study and final budget.** Carrying out the economical feasibility study of the company and elaborating the final budget required by the new company.
     - 8.1.2 **Environmental study.** Writing of the environmental aspects of the study.
     - 8.1.3 **Planning and programming.** Writing of the possible next steps to follow in the study in order to make it more complete or improve it.
     - 8.1.4 **Conclusions and recommendations.** Writing of the conclusions deduced by carrying out the study and possible recommendations to improve it.
     - 8.1.5 **Bibliography.** Writing of all the bibliography consulted during the study in a proper way.
   - 8.2 **Final report retouches.** Final reading of the report in order to correct any written mistake or improving its presentation.

1.2.2 Deliverables

The deliverables consist on a set of milestones which have to be delivered during the project at the indicated date:

i. Project Charter on the 6th of March, 2015
ii. Follow-up report 1 on the 20th of March, 2015
iii. Follow-up report 2 on the 10th of April, 2015
iv. Follow-up report 3 on the 1st of May, 2015
v. Draft of the Report on the 29th of May, 2015
vi. Report on the 12th of June, 2015

1.3 Requirements of the study

It is necessary to define the requirements that make the new company belonging to the low-cost category, which are the next ones:

i. The company will offer a star type network:
   a. There will be an airport acting as a central base (nucleus airport).
   b. Routes will be go and back routes, always returning to the nucleus airport. No flight connections will be assured.
ii. The fleet is based in a determined number of airplanes, all of the same model.
iii. Prices will be established according to the low-cost company standards and have to be competitive in the low cost companies market.

1.4 Justification of the study

Nowadays, there are more people who decide to set up a new enterprise or company, but many of them are obligated to close the business due to a wrong initial management and administration. At the time of setting up an enterprise is very important having knowledge of certain economic aspects, as carrying out a proper benchmark analysis and have a good command of feasibility studies, in order to assure that the company will be feasible and able to go ahead.

This work pretends to study the initial strategies that should be followed by a new aerial low-cost company when choosing the routes and the optimum fleet which the company is going to enter to the aerial market with. In this manner, this study will help to acquire knowledge of general economic aspects, as well as the economic aspects of the aerial market and its airworthiness regulations, legislations and codes.

2. Development

2.1 State of the art

The concept of low cost airline was started in the seventies by the American domestic carrier Southwest with the sole objective of offering cheap airfares to the consumers [1]. In this way, a low cost carrier or low cost airline is an airline that generally has low fares and few comforts.

In Europe the low cost concept was originated in the UK and Ireland based on the Southwest model with the introduction of Ryanair in 1985 and EasyJet in 1995 [1]. First Spanish low cost, Vueling, appeared in 2004.

Ryanair

Ryanair is an Irish airline, considered Europe's largest low-cost company. Established in 1985 and based at Dublin, the company counts with two nucleus airports: Dublin-Waterford and London-Stansted. It serves 186 destinations in Europe and 1 to Morocco and in 2013 has carried around 81,7 million of passengers [2][3].

Ryanair commenced operations on July 1985 with a flight between Dublin and London. Its initial fleet consisted of various 15-seat Embraers EMB 110 Bandeirante turboprop aircrafts, serving daily flights between Dublin Waterford and London Gatwick [2].

Between its history until the recent days, *Ryanair* has counted with the following fleet:

Airplane model	Active	Stored	Ordered	Written off	History
EMB 110 Bandeirante	-	-	-	-	No Data
BAE748 turboprop	-	-	-	-	2
BAC 1-11	-	-	-	-	11
ATR 42-300	-	-	-	-	4
Boeing 737-200	-	-	-	-	8
Boeing 737-800	304	-	175	1	55
Total	**304**				

*Data consulted from [2], [3] and [4].

Table 1. Ryanair fleet characteristics

easyJet

easyJet is the first British low cost airline, and the second largest low cost carrier in Europe, behind Ryanair. It was established in 1995 and has its base, as well as its hub airport, at London Luton. It serves 149 destinations between Europe and Africa, and in 2014 has carried nearly 65 million passengers [5].

easyJet started operations on 10th November 1995 with a flight from London-Luton to Glasgow and London. Its initial fleet consisted of 2 wet leased Boeing 737-200 aircraft, covering the routes from London-Luton to Glasgow and Edinburgh [6].

Analysing the fleet the company has had between the past until the recent days:

Airplane model	Active	Stored	Ordered	Written off	History
Airbus A319	135	-	-	-	4
Airbus A320	67	-	-	-	19

Airbus A321	-	-	-	-	8
ATR 42-300	-	-	-	-	4
Boeing 737-200	-	-	-	-	2
Boeing 737-300	-	-	-	-	56
Boeing 737-700	-	3	-	-	30
Boeing 757	-	-	-	-	5
Total	**202**				

*Data consulted from [4].

Table 2. easyJet fleet characteristics

Vueling

Vueling is the first Spanish low cost airline, established in February 2004. Based at El Prat de Llobregat and with hubs in the airports Barcelona-El Prat and Rome-Leonardo Da Vinci-Fuimicino, the airline serves 155 destinations in Africa, Asia and Europe having carried in 2014 nearly 17,2 million passengers [7] [8].

Vueling commenced operations on 1st July 20014 with a flight between Barcelona and Ibiza. Its initial fleet consisted of 2 Airbus A320 and served flights from Barcelona to 4 other cities: Brussels, Ibiza, Palma de Mallorca and Paris [7].

Analysing the fleet of the company from its early years until the present days:

Airplane model	Active	Stored	Ordered	Written off	History
Airbus A319	5	-	-	-	1
Aribus A320	84	6	25	-	33
Airbus A320neo	-	-	33	-	-
Airbus A321	-	-	5	-	-
Total	**89**				

*Data consulted from [4] and [7].

Table 3. Fleet of Vueling characteristics

2.2 Main alternatives and decision of the best one

First two steps when creating a new low cost airliner are deciding the geographical area where the company will operate, in other words, the flight routes that will be covered; and the model/s of airplane the company will count with. In both steps, it will be necessary to choose between a series of different alternatives, which will be seen in this section.

2.2.1 Geographical area of the study: Selection of the routes

The geographical area of the study will be determined by the cities selected to be part of the star-type network of the company.

At the time to establishing the star-type network, it is necessary to select one central airport to act as a nucleus airport, an after, choosing the airports where the company is going to fly to.

Selection of the central airport

Barcelona-El Prat has been selected as the central airport due to its large infrastructures and great movement of travellers per day.

Selection of the flight routes

When making the decision of which will be the airports that will form the tips of the star-type network, the following two strategies have been taken into account:

i. The chosen airports will have to be European airports and if possible, they should be relatively near from Barcelona-El Prat airport. As low-cost companies are often known by their low prices but not by their comfort and facilities provided to passengers in the cabin during the flight, it has been decided to establish short distance routes. In this way, cabin services and comfort will not be as demanded as it the flight took many hours and passengers will value the low cost of tickets above the previous aspects.

ii. It has been carried out a benchmark analysis in order to have knowledge of the European airports with more transit of people. In this manner, it can be selected the destinations that attract the major number of the travellers from Barcelona's airport, and so, increasing this offer of flights at a competitive price. This strategy pretends to assure a higher number of passengers per flight and so, more profits, than if airports of minor destinations where fixed.

These two strategies then should be followed so as to achieve a competitive position in the low-cost aerial market and a considerable number of flight sales, in order to assure the company permanence in the market.

In this sense, it have been researched the nearest European cities to Barcelona (less than $2h\ 30min$ of flight in a typical airplane), so as to reduce the time flight as much as possible; and the number of flights from and to Barcelona, which are detailed in *Annex 1*, in order to make a final decision of the routes where the company will operate [9].

Having a look so at *Table 1* of *Annex 1*, the company will start flying to the next four cities: Madrid, London, Paris and Mallorca, due to their high demand of flights per week. In this way, the company will provide more offer to this market area at competitive prices.

Selected routes characteristics so, are the following ones [9][10]:

Route	Distance (km)*	Flight duration	Destiny Airport(s)
Barcelona-Madrid Madrid-Barcelona	≈ 506	≈ 1h 10min	Adolfo Suarez-Madrid Barajas Cuatro Vientos
Barcelona-London London-Barcelona	≈ 1.147	≈ 2h 05min	London City London Gatwick London Heathrow London Southend London Stansted
Barcelona-Paris Paris-Barcelona	≈ 832	≈ 1h 35min	Paris Beauvais Paris Charles de Gaulle Paris Orly Paris Le Bourget
Barcelona-Mallorca Mallorca-Barcelona	≈ 201	≈ 40min	Palma de Mallorca Son Sant Joan

* Note that distances and flight times are an approximation due to they depend on which airport the airplane is taking off and landing, as well as the cruise speed of the airplane; and that flight routes and flight plans may vary depending on aerial and on-ground traffic or weather conditions.

Table 4. Characteristics of the selected routes

When deciding the destiny airport of each city, fees on each airport as well as overflight fees (on route fees) can be taken into account, in order to choose the cheapest one. Airport fees (from landing to taking off) are determined by each airport, and overflight routes strongly depend on the distance between the central and destiny airport, in means of that at higher distance, higher fee price.

Selection of the airport in Madrid

Madrid-Barajas airport will be the destiny airport of the company. Despite airport taxes in Madrid-Barajas are higher than in Cuatro Vientos, Cuatro Vientos is a very small airport that does not assure that the selected airplane could operate in it. In this way, Madrid-Barajas counts with better infrastructures, as well as a greater number of passengers per day [11].

Selection of the airport in Paris

Having a look on the possible airports of Paris and their charges [12], it is seen that both Paris-Orly and Paris-Charles de Gaulle are the two ones with lower fee prices. Then, if calculating the distance between Barcelona and these two airports, it is obtained [13]:

Destiny airport	Distance from Barcelona airport (km)
Paris-Orly	825,649
Paris-Charles de Gaulle	857,948

Table 5. Possible destiny airports and their distances from and to Barcelona

In this way, the company will fly to Paris-Orly airport due to it will have to be paid less on-route charges.

Selection of the airport in London

After analysing the different airports and their charges [14][15][16][17][18], as well as the distance from Barcelona [13], it has been decided to fly to Stansted airport because it has been considered that the average between its fees and overflight fees will be the lowest.

Selection of the airport in Mallorca

Palma de Mallorca-Son Sant Joan will be chosen airport to carry the airplane operations due to it is the only airport in the city.

Initial routes

In this way, the geographical area where the study will be carried out is determined by the four following routes:

Routes
Barcelona (El Prat) - Madrid (Barajas) / Madrid (Barajas) - Barcelona (El Prat)
Barcelona (El Prat) - London (Stansted) / London (Stansted) - Barcelona (El Prat)
Barcelona (El Prat) - Paris (Orly) / Paris (Orly) - Barcelona (El Prat)
Barcelona (El Prat) – Mallorca (Son Sant Joan) / Mallorca (Son Sant Joan) - Barcelona (El Prat)

Table 6. Routes covered by the company

This routes are the initial routes chosen by the company, but they can change through the study if it were necessary (see section *New LCC characteristics* to find the definitive routes).

2.2.2 Selection of the most suitable model of airplane

Once routes the company is going to cover are chosen, next step is selecting the most suitable model of airplane for it.

LCC are usually characterised by having a single model of airplane in their fleet which is able to cover all the routes and meet with all the requirements the company has. In order to find this most appropriate airplane, it will be carried out an analysis of the current airplanes to make after an OWA to know which airplane will best suit in (see *Annex 8*).

The most suitable airplane tends to be the more profitable for the company in terms of costs. In this sense, costs of the analysed airplanes will be a determinant aspect when taking the decision. However, there are few other aspects which are usually important and that will be considered at the time to carrying out the OWA method. In this way, for every model of current airplanes, there will have to be analysed:

i. Aircraft price
ii. Costs associated
iii. Passenger facilities
iv. Flight duration
v. Safety of the airplane
vi. Number of existences in the operating geographical area

Moreover, when analysing these current airplanes, not all the existing airplanes will be taken into account to carry out the OWA method, in this way it will be discarded the airplanes with the following characteristics:

i. The group of airplanes which are going to be studied must be able to cover the selected routes in a direct way, which means that their performances have to permit an equal or higher range to the ones of the selected routes. In this sense so, airplanes with a lower range than the longest flight distance the company has to cover will not be considered in the OWA method.

ii. Between all the current airplanes able to reach the distances of the routes chosen, the most newly airplanes in the market will be discarded due to their high prices, which do not interest to a LCC as they usually cannot afford them. In this way, for instance, all the Airbus A320neo family, Boeing 737NextGen and C-Series from Bombardier, will not be analysed during the study.

iii. Despite it would seem biggest airplanes would be able to carry more passengers and so offer very low CASM's to the company, this type of airplanes are not chosen by the current low cost companies, which leads to think that their reduced CASM's are not enough to LCC to compete with the price and direct costs of this kind of airplanes. This fact discards from the analysis wide-body airplanes such as the A380 or 747, or any other with similar dimensions.

Aircraft price

The price of the aircraft is a very important factor at the time to decide the most suitable aircraft. The followed strategies to analyse the price of the current airplanes will be the next:

i. Aircrafts will be dry leased instead of purchased, either at their market price or used price. This is because leasing an aircraft will be always more economic for the company, as well as more practical, due to it can pay monthly rates instead of having to pay all the aircraft price at once. Aircraft lease is one of the strategies of a typical low cost company, at least, on its first years on the market.

ii. As mentioned before, most newly airplanes have a very high market price which a LCC cannot afford, but in addition, most of them are not in the leasing market yet, which leads to totally discarding this type of models.

Having a look on the leasing prices of the different model of airplanes [19], it is observed that it exists a range of leasing prices between the same model of airplane.

The leasing cost of a same model of aircraft can vary depending on, for instance, its age, total flight hours done or the leaser conditions. On the one hand, minimum leasing price could refer to the most used airplane, which for this reason could need more maintenance works and have a minor number of remaining flight hours than a newly one. On the other hand, maximum leasing costs could be from an expensive leaser, which not either interests to the company. Due to these two reasons, it will be done an average between the minimum and maximum lease market costs, so the company will probably be considering leasing airplanes with a compromise between a proper number of flight hours and leaser price conditions (see *Annex 2*).

Airplane model	**Leasing cost** $(€/month)$
AIRBUS Family	
Airbus A318	75.000
Airbus A319	177.000
Airbus A320	186.000
Airbus A321	281.000
BOEING Family	

Boeing 717	111.000
Boeing 737-300	51.000
Boeing 737-400	65.000
Boeing 737-500	45.000
Boeing 737-600	111.000
Boeing 737-700	179.000
Boeing 737-800	280.000
ATR Family	
ATR 72-200	59.000
ATR 72-210	59.000
ATR 42-500	99.000
ATR 72-500	111.000
ATR 42-600	146.000
ATR 72-600	167.000
EMBRAER Family	
ERJ 135	52.000
ERJ 140	48.000
ERJ 145	54.000
E 170	156.000
E 175	175.000
E 190	203.000
E 195	96.000
BOMBARDIER Family	
Q100	60.000
Q200	82.000
Q300	84.000
Q400	137.000
CRJ-100	35.000
CRJ-200	560.00
CRJ-700	137.000
CRJ-705	167.000
CRJ-900	171.000
CRJ-1000	217.000

Table 7. Current airplanes leasing prices (€/month)

Note that the fact of renting the aircraft, which means doing monthly payments for its possession, make this cost belonging to the Direct Costs of the company, which will be studied following.

Costs associated

Inside the costs associated to the exploitation of an airplane by an airliner it can be found [20]:

i. Direct costs, which directly depend on the airplane.
   a. Aircraft leasing cost.
   b. Fuel costs
   c. Maintenance costs
   d. Cabin crew and cockpit crew costs
   e. Airport and overflight fees
   f. Services to passengers
   g. Handling of the airplane
   h. Insurance, interests, depreciation and amortisation
ii. Indirect costs, which depend on the company.

During this part of the study, it will only be taken into account direct costs associated to the airplane operations (DOC's) of fuel, crew, maintenance and airport and on-route taxes because they will be the most decisive when selecting the most suitable airplane model. In addition, aircraft leasing cost was previously analysed in the section above. Rest of direct costs and indirect costs can be estimated as a percentage of the already known costs, and so will vary proportionally with them.

Costs depending on the number of block hours

Fuel, crew and maintenance costs are normally given in costs per block hour, so to be able to compare all the airplanes of the study it is necessary to analyse the total fuel, crew and maintenance costs. In this way, it will be necessary to calculate the block hours for every analysed airplane (see *Annex 3*).

In order to calculate the block hours, as this part is an initial study, it will be only necessary to find the block hours in one of the routes the company will cover (see *Annex 3*). In this manner, it will be obtained the costs on this route, which will be enough to have a first approach to know which airplane will suppose less fuel, crew and maintenance costs.

The route that will be chosen to find the number of block hours of each airplane will be the one from Barcelona-El Prat to London-Stansted or vice versa, which is a route of $1185\ km$ [13] [21]. Taking into account the cruise speed of every airplane, the following table shows the number of block hours corresponding to each one (see *Annex 3*).

Airplane model	**Block hours** $(\boldsymbol{h})$
AIRBUS Family	
Airbus A318	1,76
Airbus A319	1,76
Airbus A320	1,76
Airbus A321	1,76
BOEING Family	
Boeing 717	1,79
Boeing 737-300	1,85
Boeing 737-400	1,85
Boeing 737-500	1,85

Boeing 737-600	1,77
Boeing 737-700	1,77
Boeing 737-800	1,77
ATR Family	
ATR 72-200	2,63
ATR 72-210	2,63
ATR 42-500	2,47
ATR 72-500	2,66
ATR 42-600	2,47
ATR 72-600	2,66
EMBRAER Family	
ERJ 135	1,76
ERJ 140	1,76
ERJ 145	1,76
E 170	1,73
E 175	1,73
E 190	1,73
E 195	1,67
BOMBARDIER Family	
Q100	2,70
Q200	2,54
Q300	2,58
Q400	2,11
CRJ-100	1,84
CRJ-200	1,84
CRJ-700	1,76
CRJ-705	1,76
CRJ-900	1,73
CRJ-1000	1,77

Table 8. Block hours on the route BCN-STN of the current airplanes

Fuel costs

As fuel costs are given in price per block hour and as it have been already calculated each aircraft block hours, it lasts multiplying the fuel cost per block hour with the total block hours in order to find the total fuel costs:

$$[Total\ Fuel\ Cost] = \left[\frac{Fuel\ Cost}{Block\ hour} \cdot Block\ hours\right]\ [€]$$

Between the bibliography found about fuel costs, some of them were given in $\$/BH$, while others were given in $Imperial\ (UK)\ Gal/BH$ or lb/h and had to be converted to $€/BH$, to after calculate the total cost (see *Annex 4*).

In this way, total fuel costs will be the next ones:

Airplane model	Fuel cost ($€/BH$)	Block hours (h)	Total Fuel cost ($€$)
AIRBUS Family			
Airbus A318	1108	1,76	1.955
Airbus A319	1188	1,76	2.097
Airbus A320	1379	1,76	2.434
Airbus A321	1367	1,76	2.413
BOEING Family			
Boeing 717	1157	1,79	2.076
Boeing 737-300	1558	1,85	2.886
Boeing 737-400	1209	1,85	2.240
Boeing 737-500	1511	1,85	2.799
Boeing 737-600	1164	1,77	2.064
Boeing 737-700	1217	1,77	2.158
Boeing 737-800	1400	1,77	2.482
ATR Family			

ATR 72-200	333	2,63	877
ATR 72-210	351	2,63	922
ATR 42-500	375	2,47	924
ATR 72-500	352	2,66	936
ATR 42-600	375	2,47	924
ATR 72-600	352	2,66	936
EMBRAER Family			
ERJ 135	797	1,76	1.406
ERJ 140	766	1,76	1.351
ERJ 145	649	1,76	1.145
E 170	806	1,73	1.393
E 175	806	1,73	1.393
E 190	1205	1,73	2.081
E 195	1205	1,67	2.005
BOMBARDIER Family			
Q100	261	2,70	706
Q200	261	2,54	663
Q300	384	2,58	989
Q400	634	2,11	1.338
CRJ-100	668	1,84	1.230
CRJ-200	668	1,84	1.230
CRJ-700	730	1,76	1.287
CRJ-705	740	1,76	1.304
CRJ-900	740	1,73	1.278
CRJ-1000	730	1,77	1.290

* Fuel costs per block hour and total fuel costs have to be approximated to an integer which represents properly the values, due to there is not enough certainty of the decimal digits, and in addition, these costs will have to be added to another ones which there is even less certainty about.

Table 9. Total Fuel Cost of the current airplanes on the route BCN-STN

Maintenance costs

Similar to fuel costs, maintenance costs will be calculated with the next equation:

$$[Total\ Maintenance\ Cost] = \left[\frac{Maintenance\ Cost}{Block\ hour} \cdot Block\ hours\right]\ [€]$$

Next table shows then, maintenance costs of each current airplane:

Airplane model	**Maintenance cost** $(\$/BH)$	**Maintenance cost** $(€/BH)$
AIRBUS Family		
Airbus A318	271,02	255,64
Airbus A319	656,70	619,43
Airbus A320	705,13	665,12
Airbus A321	706,73	666,63
BOEING Family		
Boeing 717	710,00	669,71
Boeing 737-300	674,00	635,75
Boeing 737-400	792,00	747,06
Boeing 737-500	608,00	573,50
Boeing 737-600	628,51	592,84
Boeing 737-700	628,51	592,84
Boeing 737-800	628,51	592,84
ATR Family		
ATR 72-200	465,00	438,61
ATR 72-210	465,00	438,61
ATR 42-500	399,00	376,36
ATR 72-500	465,00	438,61
ATR 42-600	399,00	376,36
ATR 72-600	465,00	438,61
EMBRAER Family		

ERJ 135	400,25	377,54
ERJ 140	429,50	405,13
ERJ 145	402,00	379,19
E 170	368,00	347,12
E 175	367,33	346,49
E 190	510,75	481,77
E 195	500,30	471,91
BOMBARDIER Family		
Q100	400,00	377,30
Q200	400,00	377,30
Q300	530,00	499,92
Q400	554,00	522,56
CRJ-100	411,93	388,55
CRJ-200	411,93	388,55
CRJ-700	356,17	335,96
CRJ-705	350,17	330,30
CRJ-900	329,25	310,57
CRJ-1000	329,25	310,57

* Maintenance costs per block hour are an average between all the costs found in the consulted data.

* Fuel costs will be given in Euros instead of American dollars due to the study considers the incorporation of a European low cost company and the majority of the costs will be paid in Euros. Conversion rate applied: $1\$ = 0{,}943253848€$.

* Data of the maintenance costs per block hour of each airplane model consulted from [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32] and [33].

Table 10. Maintenance Cost per block hour of the current airplanes on the route BCN-STN

Then, total maintenance costs will be the following:

Airplane model	Maintenance cost $(€/BH)$	Block hours (h)	Total Maintenance cost $(€)$
AIRBUS Family			
Airbus A318	256	1,76	451
Airbus A319	619	1,76	1.093
Airbus A320	665	1,76	1.174
Airbus A321	667	1,76	1.176
BOEING Family			
Boeing 717	670	1,79	1.202
Boeing 737-300	636	1,85	1.178
Boeing 737-400	747	1,85	1.384
Boeing 737-500	573	1,85	1.062
Boeing 737-600	593	1,77	1.051
Boeing 737-700	593	1,77	1.051
Boeing 737-800	593	1,77	1.051
ATR Family			
ATR 72-200	439	2,63	1.155
ATR 72-210	439	2,63	1.152
ATR 42-500	376	2,47	928
ATR 72-500	439	2,66	1.165
ATR 42-600	376	2,47	928
ATR 72-600	439	2,66	1.165
EMBRAER Family			
ERJ 135	378	1,76	666
ERJ 140	405	1,76	715
ERJ 145	379	1,76	669
E 170	347	1,73	600
E 175	346	1,73	599
E 190	482	1,73	832
E 195	472	1,67	786
BOMBARDIER Family			
Q100	377	2,70	1.020
Q200	377	2,54	958
Q300	500	2,58	1.289
Q400	523	2,11	1.103

CRJ-100	389	1,84	716
CRJ-200	389	1,84	716
CRJ-700	336	1,76	592
CRJ-705	330	1,76	582
CRJ-900	311	1,73	536
CRJ-1000	311	1,77	549

* Maintenance costs per block hour and total maintenance costs have to be approximated to an integer which represents properly the values, due to there is not enough certainty of the decimal digits, and in addition, these costs will have to be added to another ones which there is even less certainty about.

Table 11. Total Maintenance Costs of the current airplanes on the route BCN-STN

Aircrew costs

Considering that crew will be also leased, it will have to be studied as well in price per block hours, following the same equation that the one for fuel and maintenance costs:

$$[Total\ Crew\ Cost] = \left[\frac{Crew\ Cost}{Block\ hour} \cdot Block\ hours\right]\ [€]$$

Aircrew costs include cabin crew costs and cockpit crew costs, and these are an average between the maximum and minimum salary of a flight attendant (cabin crew) and a first officer and a captain (cockpit crew). In addition, these costs are given by the data consulted in cost per year, so it will be necessary to know how many hours crew usually flies per year, as well as the number of aircrew required by each aircraft, so as to find the cost of the crew per block hour (see *Annex 5*).

In this way, aircrew costs per block hour and total costs on the selected route will be:

Airplane model	Cabin crew Cost $(€/BH)$	Cockpit Crew Cost $(€/BH)$	Crew Cost $(€/BH)$
AIRBUS Family			
Airbus A318	83	164	247
Airbus A319	111	164	275
Airbus A320	111	164	275
Airbus A321	139	164	303
BOEING Family			
Boeing 717	83	171	254
Boeing 737-300	83	196	279
Boeing 737-400	111	196	307
Boeing 737-500	83	196	279
Boeing 737-600	83	207	290
Boeing 737-700	83	207	290
Boeing 737-800	111	207	318
ATR Family			
ATR 72-200	56	128	184
ATR 72-210	56	128	184
ATR 42-500	28	123	151
ATR 72-500	56	128	184
ATR 42-600	28	123	151
ATR 72-600	56	128	184
EMBRAER Family			
ERJ 135	28	130	158
ERJ 140	28	137	165
ERJ 145	28	137	165
E 170	56	154	210
E 175	56	154	210
E 190	83	162	245
E 195	83	162	245
BOMBARDIER Family			
Q100	28	119	147
Q200	28	119	147
Q300	56	119	175
Q400	56	138	194

CRJ-100	28	132	160
CRJ-200	28	132	160
CRJ-700	56	155	211
CRJ-705	56	155	211
CRJ-900	56	162	218
CRJ-1000	83	162	245

Table 12. Crew Costs per block hour of the current airplanes on the route BCN-STN

Finally, total crew costs will be the following:

Airplane model	**Crew Cost** $(€/BH)$	**Block hours** (h)	**Total Crew Costs** $(€)$
AIRBUS Family			
Airbus A318	247	1,76	436
Airbus A319	275	1,76	485
Airbus A320	275	1,76	485
Airbus A321	303	1,76	535
BOEING Family			
Boeing 717	254	1,79	456
Boeing 737-300	279	1,85	517
Boeing 737-400	307	1,85	569
Boeing 737-500	279	1,85	517
Boeing 737-600	290	1,77	514
Boeing 737-700	290	1,77	514
Boeing 737-800	318	1,77	564
ATR Family			
ATR 72-200	184	2,63	485
ATR 72-210	184	2,63	483
ATR 42-500	151	2,47	372
ATR 72-500	184	2,66	489
ATR 42-600	151	2,47	372
ATR 72-600	184	2,66	489
EMBRAER Family			
ERJ 135	158	1,76	279

ERJ 140	165	1,76	291
ERJ 145	165	1,76	291
E 170	210	1,73	363
E 175	210	1,73	363
E 190	245	1,73	423
E 195	245	1,67	408
BOMBARDIER Family			
Q100	147	2,70	397
Q200	147	2,54	373
Q300	175	2,58	451
Q400	194	2,11	409
CRJ-100	160	1,84	295
CRJ-200	160	1,84	295
CRJ-700	211	1,76	372
CRJ-705	211	1,76	372
CRJ-900	218	1,73	377
CRJ-1000	245	1,77	433

* Similar to crew costs per block hour, total crew costs have to be approximated to an integer which represents properly the values, due to there is not enough certainty of the decimal digits, and in addition, these costs will have to be added to another ones which there is even less certainty about.

Table 13. Total Crew Costs of the current airplanes on the route BCN-STN

Costs not depending on the number of block hours

Airport and on-route fees

Regarding airport taxes, every airport has its own charges for using their installations and infrastructure. Inside these taxes, the most important and so the most decisive at the time to study the DOC's of an airplane, are the following:

i. Taxes on taking off and landing.
ii. Taxes for parking the airplanes on their facilities.
iii. Charge for noise levels.

These taxes vary in a proportional way with the MTOW of the airplane and in order to have a first idea of which airplane will be the one that will suppose less costs, it will not be necessary to calculate these taxes, only taking a look on each airplane model MTOW (see *Airport taxes* section).

Overflight fees then, similar to the majority of airport taxes, strongly depend on the airplane MTOW too. Equally as airport taxes so, as this part of the study is only an initial one, it will not be necessary to carry out any calculations and find the exact on-route costs, due to it will be enough by having knowledge of each aircraft MTOW (see *On route fees* section).

MTOW of the different models of airplane

In this way, the MTOW's corresponding to each model of airplane are shown in the next table:

Airplane model	MTOW (kg)
AIRBUS Family	
Airbus A318	68.000
Airbus A319	75.500
Airbus A320	78.000
Airbus A321	93.500
BOEING Family	
Boeing 717	49.845
Boeing 737-300	61.235
Boeing 737-400	68.039
Boeing 737-500	60.555
Boeing 737-600	66.000
Boeing 737-700	70.080
Boeing 737-800	79.010
ATR Family	
ATR 72-200	21.500
ATR 72-210	21.500
ATR 42-500	18.600
ATR 72-500	22.800
ATR 42-600	18.600
ATR 72-600	23.000
EMBRAER Family	
ERJ 135	19.000
ERJ 140	21.000
ERJ 145	22.000
E 170	36.000
E 175	37.500
E 190	47.790

E 195	48.790
BOMBARDIER Family	
Q100	16.470
Q200	16.470
Q300	19.500
Q400	29.260
CRJ-100	24.041
CRJ-200	23.133
CRJ-700	33.000
CRJ-705	36.505
CRJ-900	36.505
CRJ-1000	40.084

* Data of the MTOW of each airplane model consulted from [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48] and [49].

Table 14. MTOW of the different analysed airplanes

Passengers facilities and invoicing

One facility passengers who decide flying in low cost companies value, is the quantity of cargo permitted during the flight. Many of the recent LCC allow passengers carrying for free what they call a hand luggage of a maximum of $10\ kg$ in the passenger cabin, and give the possibility of carrying a bigger suitcase of approximately $20kg$ in the cargo compartment, with an additional charge in the ticket price.

It will be also analysed the available weight that can be destined to invoicing. The word invoicing refers to all the cargo that must go on the hold cargo, and that will suppose an additional charge on the ticket price, and so, more earnings to the company. In this manner, as higher value of remaining weight destined to cargo, the more possibilities the company has more benefits.

In this manner, in this section it will be analysed the average weight of cargo permitted per passenger so as to know if the company could offer the same facilities of hand luggage to their clients as other companies, as well as, calculating the remaining available weight of cargo, in order to have knowledge of the possible earnings.

In order to give an average of the cargo allowed, it will be analysed the critical situation, which will be given when the airplane flies full, in other words, with the maximum number of passengers.

To obtain the average of cargo permitted per passenger it has to be followed the next equation:

$$Cargo\ permitted = \frac{Total\ Cargo}{Number\ of\ passengers}\quad [kg/pax]$$

So as to obtain the total cargo permitted by the airplane, it is necessary to have knowledge of the MPL of each airplane, and then subtracting to this value, the weight corresponding to passengers (see *Annex 6*):

$$Total\ Cargo = MPL - Passengers'\ Weight\quad [kg]$$

However, between the data consulted, it has been found the MPL of some of the current airplanes, while of others it has been found the MZFW and the OEW and it was necessary carrying out further operations (see *Annex 6*).

Final results of the maximum cargo permitted are shown in the next table:

Airplane model	Maximum Cargo permitted (kg/pax)
AIRBUS Family	
Airbus A318	36,6
Airbus A319	36,5
Airbus A320	33,6
Airbus A321	30,2
BOEING Family	
Boeing 717	25,7
Boeing 737-300	26,4
Boeing 737-400	28,2
Boeing 737-500	25,0
Boeing 737-600	40,9
Boeing 737-700	40,8
Boeing 737-800	35,8
ATR Family	
ATR 72-200	17,6
ATR 72-210	17,6
ATR 42-500	29,0
ATR 72-500	20,3
ATR 42-600	29,0
ATR 72-600	24,3
EMBRAER Family	
ERJ 135	36,5
ERJ 140	43,1
ERJ 145	38,7
E 170	39,7
E 175	37,5
E 190	37,7
E 195	33,1
BOMBARDIER Family	
Q100	31,1
Q200	42,2
Q300	32,3
Q400	23,8

CRJ-100	45,5
CRJ-200	41,9
CRJ-700	31,3
CRJ-705	43,0
CRJ-900	37,7
CRJ-1000	38,1

Table 15. Average cargo weight per passenger of the current airplanes

Analysing the results above, it is seen that all the studied airplanes will be able to provide to passengers the opportunity of carrying a hand luggage of $10\ kg$, while the company will also have an extra weight of cargo that could destine to invoicing.

The available weight to invoicing can be calculated with the following equation (see *Annex 6*):

$$Invoicing = Total\ Cargo - 10 \cdot Number\ of\ passengers \quad [kg]$$

In this sense, available cargo that can be used for invoicing is shown in the next table:

Airplane model	**Invoicing** $(\boldsymbol{kg})$
AIRBUS Family	
Airbus A318	3.516
Airbus A319	4.128
Airbus A320	4.240
Airbus A321	4.768
BOEING Family	
Boeing 717	2.798
Boeing 737-300	2.441
Boeing 737-400	3.438
Boeing 737-500	2.219

Boeing 737-600	4.074
Boeing 737-700	4.591
Boeing 737-800	4.876
ATR Family	
ATR 72-200	562
ATR 72-210	562
ATR 42-500	950
ATR 72-500	762
ATR 42-600	950
ATR 72-600	1062
EMBRAER Family	
ERJ 135	979
ERJ 140	1.456
ERJ 145	1.436
E 170	2.314
E 175	2.424
E 190	3.162
E 195	2.862
BOMBARDIER Family	
Q100	822
Q200	1.254
Q300	1.252
Q400	1.188
CRJ-100	1.774
CRJ-200	1.592
CRJ-700	1.741
CRJ-705	2.837
CRJ-900	2.489
CRJ-1000	2.927

Table 16. Cargo available for invoicing of the different airplanes

Flight duration

Flight duration is another fact that passengers usually take into mind. It will be better if the flight has a lower duration, due to passengers will arrive before to their destination and they will spent less time in an enclosed area as well as seated, and so will have less sense of discomfort.

In order to analyse the flight duration, typical cruise speed of each airplane will be taken into account, in the way that as higher the cruise speed is, the less time flying required to cover the same route.

In this manner, cruise speed of the different analysed airplanes is shown in the table below:

Airplane model	**Cruise speed (km/h)**
AIRBUS Family	
Airbus A318	828
Airbus A319	828
Airbus A320	828
Airbus A321	828
BOEING Family	
Boeing 717	811
Boeing 737-300	780
Boeing 737-400	780
Boeing 737-500	780
Boeing 737-600	823
Boeing 737-700	823
Boeing 737-800	823
ATR Family	
ATR 72-200	515
ATR 72-210	517
ATR 42-500	556

ATR 72-500	510
ATR 42-600	556
ATR 72-600	510
EMBRAER Family	
ERJ 135	828
ERJ 140	828
ERJ 145	828
E 170	850
E 175	850
E 190	850
E 195	890
BOMBARDIER Family	
Q100	500
Q200	537
Q300	528
Q400	667
CRJ-100	785
CRJ-200	785
CRJ-700	829
CRJ-705	829
CRJ-900	850
CRJ-1000	827

*Data of cruise speed values is already given in *Annex 3***.**

Table 17. Ranking of the current airplanes according to their cruise speed

Number of airplane existences on the selected area

Another aspect that could be taken into account at the time to determine which would be the most suitable airplane is the existent number of each airplane model in the area where the company will operate, especially for the following reasons:

i. It would be an advantage having a certain number of airplanes that could be available to fly in case of suddenly one of the company aircraft would not be able to do it, for instance, because of a breakdown.
ii. Having stored airplanes near the area the company will work is also important due to it will be more feasible to obtain some spare parts in pool.
iii. Last, flying with a previous used airplane will offer more guarantees to the company.

These three aspects can be analysed by having knowledge of the fleet of the European companies, due to the leasing, as well as the providing of spare parts, will be faster, as the airplane will be nearer to the airport where it is needed than if the company was, for example, American, and the airplane or spare part should came from there to the European airport where it is required.

In this way, many of the European companies' fleets will be analysed, and it will be taken into account, the number of airplanes they have in active service or in storage.

In order to select some European companies, it will be had a look on the companies that operate in the same airports as the new company, which were Barcelona (El Prat), Madrid (Adolfo Suárez-Barajas), London (Stansted), Paris (Orly) and Mallorca (Son Sant Joan) (see section *Geographical area of the study: Selection of the routes*).

Once these airlines are found, it will be made an analysis of their fleet so as to have knowledge of how many airplanes which are being studied each company has on its fleet (see *Annex 7)*:

Airplane model	Number of existences in Europe
AIRBUS Family	
Airbus A318	24
Airbus A319	450
Airbus A320	822
Airbus A321	214
BOEING Family	
Boeing 717	0
Boeing 737-300	117
Boeing 737-400	50
Boeing 737-500	63
Boeing 737-600	2
Boeing 737-700	33
Boeing 737-800	602
ATR Family	
ATR 72-200	0
ATR 72-210	2
ATR 42-500	7
ATR 72-500	9
ATR 42-600	11
ATR 72-600	5
EMBRAER Family	

ERJ 135	0
ERJ 140	0
ERJ 145	10
E 170	12
E 175	16
E 190	36
E 195	28
BOMBARDIER Family	
Q100	0
Q200	0
Q300	0
Q400	91
CRJ-100	15
CRJ-200	25
CRJ-700	0
CRJ-705	0
CRJ-900	18
CRJ-1000	10

Table 18. Number of existences of the current airplanes near the operating area

Airplane model obtaining: OWA

The Ordered Weighted Average (OWA) is the most commonly used method of decision taking because of its simplicity and robustness, and follows the next steps [50]:

i. Define the factors to consider in the method.
ii. Weight each of the defined factors by assigning a weight (W_i).
iii. Rate each of the factors (P_i).
iv. Calculate the relative weight by carrying out the next operation:

$$Relative\ Weight = P_i \cdot W_i$$

v. Add all weighted marks for each aspect and divide it by the sum of weights and the highest possible rating:

$$OWA = \frac{\sum_{i=1}^{n} P_i \cdot W_i}{P_{max} \cdot \sum_{i=1}^{n} W_i}$$

Once all these steps are made (see *Annex 8*), it will be obtained the OWA corresponding to each model of airplane and so the most suitable model of airplane, which will be the one with a highest OWA rate, in this case the Bombardier Q200.

Most suitable airplane	OWA
Q 200	0,7243

Table 19. Most suitable airplane model and its corresponding OWA

Airplane characteristics	Value
Aircraft leasing cost $(€/month)$	82.000
Fuel costs $(€/BH)$	261
Crew costs $(€/BH)$	147
Maintenance costs $(€/BH)$	377
MTOW (kg)	16.470
Cargo for invoicing (kg)	1.254
Cruise speed (km/h)	537
Number of existences	0

Table 20. Characteristics of the Q 200

Information of the Q 200

The Bombardier Q200, also known as De Havilland Canada Dash-8 200 is a twin-engine turboprop medium range introduced by De Havilland Canada, but now produced by Bombardier Aerospace, a Canadian company [51].

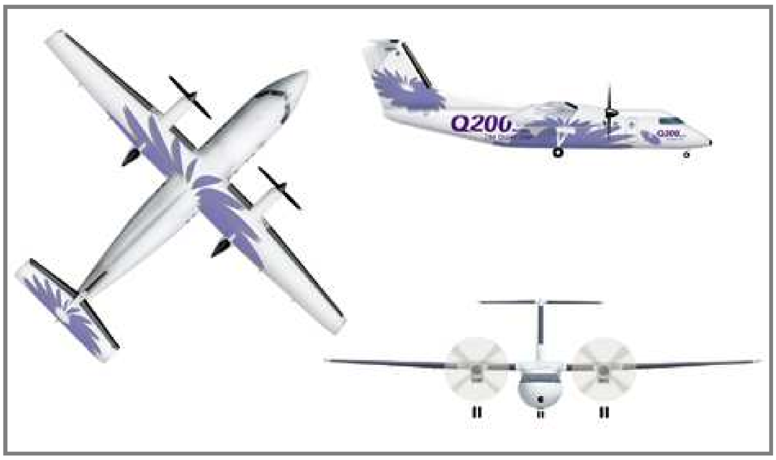

Figure 1. Q200 from [52]

Q 200 characteristics	
General characterisitics	
Seating (maximum)	39
Aircrew	1 x Flight attendant 1 x Captain 1 x First officer
Year of construction	1995-2010 (active service)
General dimensions	
Length (m)	22,2
Wing Span (m)	25,9
Height (m)	7,5
Wing area (m^2)	54,4
Cabin dimensions	
Cabin width (m)	2,51
Cabin height (m)	1,95
Aisle width (m)	0,40
Seat width (m)	0,44
Performance	
Range (km)	1.700
Cruise speed (km/h)	537
Service ceiling (m)	7.600
Take-off field length required (m)	1.000
Landing field length required (m)	780
Weights	
MTOW (kg)	16.470
MLW (kg)	15.600
MPL (kg)	4.647
MZFW (kg)	14.700
Engines	
2 x Pratt and Whitney Canada PW123C/D (38,83 kN thrust each)	

*Data consulted from [53] and [54].

Table 21. Q 200 characteristics

2.3 Development of the solution

2.3.1 Number of airplanes required

Once the model of airplane has been selected, next step is to determine the initial number of airplanes that will be the optimum for the company by carrying out a fleet feasibility study of the possible demand of passengers the new company can have.

In this way the feasibility study will follow the next steps:

i. Analysing the current low cost companies that typically cover the routes selected by the company in order to obtain the following information:
    a. Number of daily and weekly flights in the selected routes.
    b. Typical fares of these current companies on the destinations.
    c. Number of passengers carried per week by the companies and in total.

ii. Establishing a target of passengers and ticket prices for the new company in order to know the required weekly and daily flights and so the necessary number of airplanes.

On the route Barcelona-Madrid and Madrid-Barcelona, it will have to take into account in addition, the AVE *(Alta Velocidad Española)* services connecting these two cities.

Analysis of the current companies: low cost airlines and AVE.

The companies that will be analysed so as to carry out the fleet feasibility will be the ones shown on the table below:

Company	Route
Airline	
easyJet	Barcelona-London / London-Barcelona Barcelona-Paris / Paris-Barcelona
Iberia	Barcelona-Madrid / Madrid-Barcelona
Ryanair	Barcelona-London / London-Barcelona Barcelona-Paris / Paris-Barcelona Barcelona-Mallorca / Mallorca-Barcelona
Transavia	Barcelona-Paris / Paris-Barcelona
Vueling	Barcelona-Madrid / Madrid-Barcelona Barcelona-London / London-Barcelona Barcelona-Paris / Paris-Barcelona Barcelona-Mallorca / Mallorca-Barcelona
AVE	Barcelona-Madrid / Madrid-Barcelona

Table 22. Current low cost airlines and AVE in the selected routes

Analysis of the number of passengers carried on the selected routes

The number of passengers carried on the selected routes will be obtained by knowing the number of passengers each company carries and the number of trips/flights per week it does (see annexes *9, 10* and *11*).

As there is no data of the exact number of passengers carried by each company, it will be necessary to make a few hypotheses in order to obtain these values:

i. The number of passengers of each company will be obtained by having knowledge of the model of airplane (and train, in the case of AVE) used in each route.

ii. It will be supposed that all the flights carry at least a 95% of their seats occupied because if it was not in this way, the flight would be eliminated from the company offer. It is important planes fly almost full in order to give benefits to the company.

iii. Assuming that at least a 95% of the airplane must be occupied, the number of passengers will be supposed taking into account the prices of each company (see *Annex 11*).

iv. With regards to Iberia, the airplanes of this company have a two-class configuration (business and tourist). It will be only taken into account the number of seats destined to the low cost class, as the new company will be a low cost as well, and it does not have interest to compete with the other type of flight classes.

v. In relation to the company AVE, it will be supposed at least a 95% of the tourist class seats occupied. AVE, similarly to Iberia, counts with different wagons with different passenger classes, so it will be only taken into account the number of seats destined to the class with the lowest fare.

Following the suppositions above it is obtained the number of passengers each company carries per week, as well as the total number of passengers carried per week in each route and the % of the total demand corresponding to each company (See *Annex 11*).

Number of passengers carried per week on the selected routes

Route Barcelona-Madrid		
Company	Passengers/week	Corresponding market %
AVE	48.000	69
Iberia	11.069	16
Vueling	10.203	15
Total number of passengers (Barcelona-Madrid)		69.272

Route Madrid-Barcelona		
Company	Passengers/week	Corresponding market %
AVE	48.000	69
Iberia	11.858	17
Vueling	10.203	14
Total number of passengers (Madrid-Barcelona)		70.061

Route Barcelona-London		
Company	Passengers/week	Corresponding market %
easyJet	8.890	48
Ryanair	5.264	28
Vueling	4.576	24
Total number of passengers (Barcelona-London)		18.730

Route London-Barcelona		
Company	Passengers/week	Corresponding market %
easyJet	8.722	47
Ryanair	5.264	29
Vueling	4.446	24
Total number of passengers (London-Barcelona)		18.432

Route Barcelona-Paris		
Company	Passengers/week	Corresponding market %
easyJet	3.507	15
Ryanair	2.632	11
Transavia	2.730	12
Vueling	14.432	62

Total number of passengers (Barcelona-Paris)		23.301
Route Paris-Barcelona		
Company	Passengers/week	Corresponding market %
easyJet	3.283	14
Ryanair	2.632	12
Transavia	2.700	12
Vueling	14.022	62
Total number of passengers (Paris-Barcelona)		22.637
Route Barcelona-Mallorca		
Company	Passengers/week	Corresponding market %
Ryanair	3.948	28
Vueling	10.324	72
Total number of passengers (Barcelona-Mallorca)		14.272
Route Mallorca-Barcelona		
Company	Passengers/week	Corresponding market %
Ryanair	3.948	28
Vueling	10.150	72
Total number of passengers (Mallorca-Barcelona)		14.098

Table 23. Number of passengers carried per week by each company and in total

Selection of the number of airplanes required

In order to find the number of airplanes that will compose the new company's fleet, it will be necessary to follow the next steps (see *Annex 12)*:

i. Establishing a target in terms of passengers and ticket prices according to the competence fares and demand. The target of passengers will be given in a % of the market. The target established will be seen as a % of passengers the company takes from the other companies. Demand on the routes is supposed to be the same at least during the first year of the company incorporation to the market, so it will not provide a higher demand on the routes than the already existent.
ii. Calculating the number of passengers per week corresponding to the established percentage of the demand targeted.
iii. Calculating the number of flights per week required to be able to carry the marked objective of passengers.
iv. Calculating the number of flights per day required to carry the desired demand.
v. Supposing a number of flights per day on the different routes a single airplane can cover.

The total number of airplanes required will have to accomplish with some aspects, if not, an iteration process will be needed so as to reach them. These aspects are mentioned in the following lines:

i. The objective is to reach an exact or nearly exact number of occupied airplanes, due to it is the most profitable result. If one route, for instance, gives that 4,3 airplanes are needed, it means that the company will have to lease/buy 5 airplanes, and that one of them will fly almost empty, fact that it is not profitable for the company. This supposition is made as it is an initial study and it will be supposed that the new company will not share flights with other companies, so as to facilitate the study.

i. It will be taken into account that the number of airplanes required in routes from Barcelona to a specific destination, will be the same required in the inverse route. Number of airplanes required to fly from Barcelona to London, for instance, must be the same as the required to fly from London to Barcelona, as it is supposed the company, and so its airplanes, follow a star-type network with Barcelona-El Prat as the hub airport and that all airplanes will return to Barcelona at the end of the day.

ii. Number of airplanes obtained should be a feasible number, which means that the company has to be able to afford them in terms of price. It will be very difficult for a new company, for example, affording an initial number of 20 airplanes.

Regarding the iteration process that could be needed so as to reach the aspects above, it will consist on playing with the parameters of target of passengers and ticket prices, increasing or decreasing the number of days of the week when the route is covered, increasing or decreasing the number of flights a same airplane can do in a day or considering the idea of eliminating any of the offered routes.

In this way, after some iteration, next table shows the optimum number of airplanes required by the company to cover the four established routes.

Route	Days/week	Flights/day	Daily flights per airplane	Number of airplanes
BCN-MAD	7	15,22	4	3,81 → 4
MAD-BCN	7	15,40	4	3,85 → 4
BCN-STN	3	8	2	4
STN-BCN	3	7,87	2	3,94 → 4
BCN-ORY	4	11,95	3	3,98 → 4
ORY-BCN	4	11,60	3	3,87 → 4
BCN-PMI	7	4,70	5	0,94 → 1
PMI-BCN	7	4,64	5	0,93 → 1
Total number of airplanes required				**13**

Table 24. Number of airplanes required by the company to cover each route

As it is seen in table above, the study gives that the new company would need 13 airplanes to cover the selected routes with the given prices and target of passengers. However, this result has to be economically feasible for an initiating company, and 13 airplanes are an elevated number of airplanes to start.

In this way, it will have to consider the option of refusing one of the routes in order to decrease the initial number of airplanes. Analysing the results obtained:

i. Flights between Barcelona and London and Barcelona and Paris, will be maintained due to according to the results (4 and 3,94 at the London route and 3,98 and 3,87 at Paris route) the 4 airplanes needed will be well used as they will fly nearly full and this fact is very profitable for the company. In addition, as the London route will be covered 3 days a week and the Paris route, 4 days a week, there is no need of 8 airplanes to cover both routes, as a single airplane can place the two different routes amongst the 7 days of the week.

ii. According to flights between Barcelona-Madrid and Barcelona-Mallorca, as it is observed in *Table 24,* go and back route of Mallorca would take more profit of the airplane as the route of Madrid. In addition, choosing the route of Mallorca, the company will need a minor number of airplanes (5 in total against 9 with the route of Madrid), and so more possibilities to afford the initial leasing costs. Moreover, the route of Madrid, as it has been seen, is a route with a lot of competitors (AVE and the Shuttle service) and it would be more difficult to the company to deal with it. Due to this high competence, for instance, the company would not have great margin of timetables, while departures in the Mallorca route could have between them enough margin of time to try to avoid delays.

In this manner, the optimum number of airplanes of the new company will be 5, and they will cover the routes of London, Paris and Mallorca.

Initial number of airplanes and covered routes of the new LCC

Route	Number of airplanes
Barcelona-Paris / Paris-Barcelona Barcelona-London / London-Barcelona	4
Barcelona-Mallorca / Mallorca-Barcelona	1
Total number of airplanes required	**5**

Table 25. Initial number of airplanes and covered routes

The fact of needing 5 airplanes operating per day on the routes of London and Paris in order to be able to carry the established target of passengers, gives to the company the possibility of offering a wide flexibility of departing times, thing that is very useful to business travellers.

2.3.2 Flight schedule

When the required number of airplanes and the routes they have to cover have been found, next step is to elaborate an initial flight schedule for these airplanes.

In order to establish the different timetables of the airplanes on their routes, it will be followed the next hypotheses:

i. It will be necessary to have knowledge of the competence schedule. In this way, departing times of the new company airplanes should try to fill in the periods when the other companies do not offer flights. This will increase the possibilities to passengers to extend the range of hours to go to their desired destination and so to choose the new company. If flights were at the same time, there would not be certain that clients chose the company. In addition, it will be more difficult to be able to depart at the same time as another airplane with the same destination, due to they would follow the same route and there would not be enough free fields.

ii. It will be tried to fly in the typical range of hours. As mentioned in *Range of more demanded service hours* section, this range will be from 06:00h to 00:01h.

iii. Finally, it will be tried to establish timetables in which there is a certain margin between the arrival and departing time, so as to avoid as much as possible the possibility of having delays.

Remembering that four of the five airplanes combine their flights between London and Paris with the different days of the week, and that the fifth airplane is destined to the route of Mallorca, the company's fleet will follow the next flight schedules:

Airplane 1

Route Barcelona-Paris / Paris-Barcelona								
Departure → Arrival	Days of the week							Route
06:00 → 07:58	-	-	Tu	-	-	-	Sa	BCN-ORY
08:00 → 09:58	Su	-	-	-	Th	-	-	BCN-ORY
08:50 → 10:43	-	-	Tu	-	-	-	Sa	ORY-BCN
11:05 → 12:58	Su	-	-	-	Th	-	-	ORY-BCN
11:30 → 13:28	-	-	Tu	-	-	-	Sa	BCN-ORY
14:00 → 15:58	Su	-	-	-	Th	-	-	BCN-ORY
14:15 → 16:08	-	-	Tu	-	-	-	Sa	ORY-BCN
16:50 → 18:43	Su	-	-	-	Th	-	-	ORY-BCN
17:00 → 18:58	-	-	Tu	-	-	-	Sa	BCN-ORY
19:40 → 21:38	Su	-	-	-	Th	-	-	BCN-ORY
20:15 → 22:08	-	-	Tu	-	-	-	Sa	ORY-BCN
22:20 → 00:13^{+1}	Su	-	-	-	Th	-	-	ORY-BCN

Route Barcelona-London / London-Barcelona								
Departure → Arrival	Days of the week							Route
06:00 → 08:41	-	Mo	-	We	-	Fr	-	BCN-STN
09:30 → 12:06	-	Mo	-	We	-	Fr	-	STN-BCN
13:00 → 15:41	-	Mo	-	We	-	Fr	-	BCN-STN
17:00 → 19:36	-	Mo	-	We	-	Fr	-	STN-BCN

Table 26. Timetable of airplane 1

Airplane 2

Route Barcelona-Paris / Paris-Barcelona								
Departure → Arrival	Days of the week							Route
06:15 → 08:13	Su	-	Tu	-	Th	-	Sa	BCN-ORY
09:00 → 10:53	Su	-	-	-	Th	-	-	ORY-BCN
09:10 → 11:03	-	-	Tu	-	-	-	Sa	ORY-BCN
11:50 → 13:48	Su	-	-	-	Th	-	-	BCN-ORY
12:00 → 13:58	-	-	Tu	-	-	-	Sa	BCN-ORY
14:30 → 16:23	Su	-	-	-	Th	-	-	ORY-BCN
15:00 → 16:53	-	-	Tu	-	-	-	Sa	ORY-BCN
17:10 → 19:08	Su	-	-	-	Th	-	-	BCN-ORY

18:00 → 19:58	-	-	Tu	-	-	-	Sa	BCN-ORY
20:55 → 22:48	Su	-	Tu	-	Th	-	Sa	ORY-BCN
Route Barcelona-London / London-Barcelona								
Departure → Arrival	Days of the week							Route
07:00 → 09:41	-	Mo	-	We	-	Fr	-	BCN-STN
10:30 → 13:06	-	Mo	-	We	-	Fr	-	STN-BCN
15:00 → 17:41	-	Mo	-	We	-	Fr	-	BCN-STN
18:30 → 21:06	-	Mo	-	We	-	Fr	-	STN-BCN

Table 27. Timetable of airplane 2

Airplane 3								
Route Barcelona-Paris / Paris-Barcelona								
Departure → Arrival	Days of the week							Route
07:45 → 09:43	Su	-	Tu	-	Th	-	-	BCN-ORY
08:00 → 09:58	-	-	-	-	-	-	Sa	BCN-ORY
10:30 → 12:23	Su	-	Tu	-	Th	-	-	ORY-BCN
10:50 → 12:43	-	-	-	-	-	-	Sa	ORY-BCN
13:30 → 15:28	Su	-	Tu	-	Th	-	Sa	BCN-ORY
16:25 → 18:18	Su	-	Tu	-	Th	-	Sa	ORY-BCN
19:00 → 20:58	Su	-	Tu	-	Th	-	Sa	BCN-ORY
22:00 → 23:53	Su	-	Tu	-	Th	-	Sa	ORY-BCN
Route Barcelona-London / London-Barcelona								
Departure → Arrival	Days of the week							Route
08:00 → 10:41	-	Mo	-	We	-	Fr	-	BCN-STN
11:30 → 14:06	-	Mo	-	We	-	Fr	-	STN-BCN
16:00 → 18:41	-	Mo	-	We	-	Fr	-	BCN-STN
19:30 → 22:06	-	Mo	-	We	-	Fr	-	STN-BCN

Table 28. Timetable of airplane 3

Airplane 4

Route Barcelona-Paris / Paris-Barcelona								
Departure → Arrival	Days of the week							Route
08:30 → 10:28	-	-	-	-	-	-	Sa	BCN-ORY
08:45 → 10:43	Su	-	Tu	-	Th	-	-	BCN-ORY
11:30 → 13:23	Su	-	Tu	-	Th	-	Sa	ORY-BCN
14:20 → 16:18	Su	-	-	-	-	-	Sa	BCN-ORY
14:35 → 16:33	-	-	Tu	-	Th	-	-	BCN-ORY
17:00 → 18:53	-	-	-	-	-	-	Sa	ORY-BCN
17:15 → 19:08	Su	-	Tu	-	Th	-	-	ORY-BCN
19:45 → 21:43	-	-	-	-	-	-	Sa	BCN-ORY
20:20 → 22:18	Su	-	Tu	-	Th	-	-	BCN-ORY
22:30 → $00:23^{+1}$	-	-	-	-	-	-	Sa	ORY-BCN
23:00 → $00:53^{+1}$	Su	-	Tu	-	Th	-	-	ORY-BCN
Route Barcelona-London / London-Barcelona								
Departure → Arrival	Days of the week							Route
09:00 → 11:41	-	Mo	-	We	-	Fr	-	BCN-STN
14:00 → 16:36	-	Mo	-	We	-	Fr	-	STN-BCN
17:30 → 20:11	-	Mo	-	We	-	Fr	-	BCN-STN
21:05 → $00:11^{+1}$	-	Mo	-	We	-	Fr	-	STN-BCN

Table 29. Timetable of airplane 4

Airplane 5

Departure → Arrival	Days of the week							Route
06:30 → 07:13	-	-	Tu	We	-	-	-	BCN-PMI
07:30 → 08:13	Su	-	-	-	Th	Fr	Sa	BCN-PMI
08:00 → 08:44	-	-	Tu	We	-	-	-	PMI-BCN
08:30 → 09:13	-	Mo	-	-	-	-	-	BCN-PMI
09:00 → 09:44	Su	-	-	-	Th	Fr	Sa	PMI-BCN
09:30 → 10:13	-	-	Tu	We	-	-	-	BCN-PMI
10:00 → 10:44	-	Mo	-	-	-	-	-	PMI-BCN
10:30 → 11:13	Su	-	-	-	Th	Fr	Sa	BCN-PMI
12:00 → 12:44	Su	-	Tu	We	Th	Fr	Sa	PMI-BCN
12:30 → 13:13	-	Mo	-	-	-	-	-	BCN-PMI

13:30 → 14:13	Su	-	Tu	We	Th	Fr	Sa	BCN-PMI
14:00 → 14:44	-	Mo	-	-	-	-	-	PMI-BCN
15:00 → 15:44	Su	-	Tu	We	Th	Fr	Sa	PMI-BCN
15:30 → 16:13	-	Mo	-	-	-	-	-	BCN-PMI
16:30 → 17:13	Su	-	Tu	We	Th	Fr	Sa	BCN-PMI
17:00 → 17:44	-	Mo	-	-	-	-	-	PMI-BCN
18:00 → 18:44	Su	-	Tu	We	Th	-	Sa	PMI-BCN
19:00 → 19:43	-	Mo	-	-	-	-	-	BCN-PMI
19:00 → 19:44	-	-	-	-	-	Fr	-	PMI-BCN
19:30 → 20:13	Su	-	Tu	We	Th	-	Sa	BCN-PMI
20:30 → 21:13	-	-	-	-	-	Fr	-	BCN-PMI
20:30 → 21:14	-	Mo	-	-	-	-	-	PMI-BCN
21:30 → 22:14	Su	-	Tu	We	Th	-	Sa	PMI-BCN
22:20 → 23:03	-	Mo	-	-	-	-	-	BCN-PMI
22:30 → 23:14	-	-	-	-	-	Fr	-	BCN-PMI
23:50 → 00:34^{+1}	-	Mo	-	-	-	-	-	PMI-BCN

Table 30. Timetable of airplane 5

3. Summary of results

3.1 Economical feasibility study

Viability of the project is studied by taking into account some feasibility parameters as cash flow, payback time, breakeven point, net present value and internal rate of return during the first 10 years of the existence of the new company (see annexes *13* and *16*).

The economical feasibility results show that the company has to eliminate the routes of London and Paris if it wants to have profits, and so be economically feasible (see *Annex 13*).

In this way, it is estimated that operating on the route of Mallorca with a fleet of 1 Bombardier Q200, an initial inversion of 1.527.015 € (see *Budget*) and a discount rate of a 10%, inversion will be recovered before the 6th year of the existence of the company and will give benefits of 575.891 €. Moreover, the company has a margin of 581 passengers between its breakeven point and its maximum occupation of the airplane, and the Internal Rate of Return reaches a percentage of a 18% (see *Annex 16*).

Feasibility study results		
Initial investment (€)	1.527.015	
Discount rate (%)	Risks (%)	Investor benefit (%)
	2	8
Payback time (years)	5,98	
NPV (€)	575.891	
IRR (%)	18	

Table 31. Feasibility study results

The fact that the routes of London and Paris are not economical feasible routes for the company, while there is certainty that they are profitable routes due to many low cost airlines fly them, could be owned to the time flight required by the Q200 to cover these routes is significantly higher than the one of the airplanes from the competence. This, in addition to the already existent timetables of flights of the current companies in these routes, would limit the number of daily flights of the new company to these routes in a number below the one that make the route feasible. Other companies, however, can carry out the desired number of flights to obtain benefits.

In addition, due to the elevated flight time required to cover these two routes (because of the low cruise speed of the airplane) the costs per block hour calculated during the study are considerably increased and the income cannot counteract with these expenses.

Finally, the Q200 is an airplane that carries a maximum of 39 passengers, while current airplanes in these routes can carry at least 130 passengers (A318). This means that for carrying the same target of passengers the new company needs to do a greater number of flights per week, and so it needs a higher number of airplanes, fact that increases the direct costs (leasing costs mainly) and so makes impossible to the company having benefits.

3.2 New LCC characteristics

The carried out study, after having done the economical feasibility study of the company, has finally determined that the optimum fleet for the new company will be formed by 1 Bombardier Q200 aircrafts, operating on the routes of Mallorca from its hub airport, located at Barcelona-El Prat.

The company will offer the following flight schedules and ticket prices on the different routes:

Route Barcelona-Mallorca									
Ticket price (€)		32							
Departure → Arrival	Airplane	Days of the week							Route
06:30 → 07:13	Airplane 5	-	-	Tu	We	-	-	-	BCN-PMI
07:30 → 08:13	Airplane 5	Su	-	-	-	Th	Fr	Sa	BCN-PMI
08:30 → 09:13	Airplane 5	-	Mo	-	-	-	-	-	BCN-PMI
09:30 → 10:13	Airplane 5	-	-	Tu	We	-	-	-	BCN-PMI
10:30 → 11:13	Airplane 5	Su	-	-	-	Th	Fr	Sa	BCN-PMI
12:30 → 13:13	Airplane 5	-	Mo	-	-	-	-	-	BCN-PMI
13:30 → 14:13	Airplane 5	Su	-	Tu	We	Th	Fr	Sa	BCN-PMI
15:30 → 16:13	Airplane 5	-	Mo	-	-	-	-	-	BCN-PMI
16:30 → 17:13	Airplane 5	Su	-	Tu	We	Th	Fr	Sa	BCN-PMI
19:00 → 18:43	Airplane 5	-	Mo	-	-	-	-	-	BCN-PMI
19:30 → 20:13	Airplane 5	Su	-	Tu	We	Th	-	Sa	BCN-PMI
20:30 → 21:13	Airplane 5	-	-	-	-	-	Fr	-	BCN-PMI
22:20 → 23:03	Airplane 5	-	Mo	-	-	-	-	-	BCN-PMI
22:30 → 23:14	Airplane 5	-	-	-	-	-	Fr	-	BCN-PMI

Table 32. Flight timetable offered on the route Barcelona-Mallorca

Route Mallorca-Barcelona									
Ticket price (€)		30							
Departure → Arrival	Airplane	Days of the week							Route
08:00 → 08:44	Airplane 5	-	-	Tu	We	-	-	-	PMI-BCN
09:00 → 09:44	Airplane 5	Su	-	-	-	Th	Fr	Sa	PMI-BCN
10:00 → 10:44	Airplane 5	-	Mo	-	-	-	-	-	PMI-BCN
12:00 → 12:44	Airplane 5	Su	-	Tu	We	Th	Fr	Sa	PMI-BCN
14:00 → 14:44	Airplane 5	-	Mo	-	-	-	-	-	PMI-BCN
15:00 → 15:44	Airplane 5	Su	-	Tu	We	Th	Fr	Sa	PMI-BCN
17:00 → 17:44	Airplane 5	-	Mo	-	-	-	-	-	PMI-BCN
18:00 → 18:44	Airplane 5	Su	-	Tu	We	Th	-	Sa	PMI-BCN
19:00 → 18:44	Airplane 5	-	-	-	-	-	Fr	-	PMI-BCN
20:30 → 21:14	Airplane 5	-	Mo	-	-	-	-	-	PMI-BCN
21:30 → 22:14	Airplane 5	Su	-	Tu	We	Th	-	Sa	PMI-BCN
23:50 → 00:34^{+1}	Airplane 5	-	Mo	-	-	-	-	-	PMI-BCN

Table 33. Flight timetable offered on the route Mallorca-Barcelona

3.3 Environmental study

In this section it will be analysed the impact on the environment the chosen airplane has, compare it first to its flying direct competitors and then to any other public transport that covers the selected routes, in other words, the airplanes and other public transport on the route of Mallorca.

3.3.1 Analysis of the current airplane competitors

In order to study the environmental impact of the Q200 and the rest of airplanes that cover the same routes, it will be taken into account the air pollution produced by the engine emissions and the noise pollution produced by the different airplanes.

Aircraft engine emissions

According to *Annex 17*, where emissions of hydrocarbon, oxides of nitrogen and carbon monoxide of each airplane engine have been analysed, it can be stated:

i. NOx emissions are a bit lower than the majority of the airplanes that cover the same routes.

ii. Considering the emission of hydrocarbon, the Q200 presents a value 10^5 times lower than its direct competitors, probably due to its turboprop engine.

iii. Emissions of CO of Q200, however, are 0,5 points higher than the competitor with the highest index, and nearly 4 points higher than the competitor with the lowest index of this kind of emission.

Aircraft noise pollution

Evaluating the noise pollution produced by the Q200 and its direct competitors (see *Annex 17*), it can be observed that Q200 noise levels are generally lower than the ones of the rest of airplanes, making the Q200 the less noisy airplane of the group.

Recycling-After life

Being able to recycle aircraft parts offers numerous benefits to the environment, including less water, soil and air pollution, as well as landfills [55]. Nowadays nearly all aircraft manufacturers are part of a project or association involving aircraft recycling so as to be able to recycle between 85-95% of the whole aircraft in the next future, due to at present, the normal percentage of recyclability of an aircraft stays around a 60% [56].

In this way, it can be supposed that new generations of airplanes will have higher rates of recyclability and so more beneficial to the environment. As the model Q200 is an old model, it can be said that its recyclability index is below the actual airplanes one and it will have to pay more attention to the components after the cycle life of them.

3.3.2 Analysis of the current ships competitors

Finally, comparing the environmental impact of an airplane in front of a ferry that covers the route Barcelona-Mallorca, according to a study published on *The Guardian*, it is revealed that carbon dioxide emissions of ships are the double than airplanes [57]. In this way, it can be said that Q200 will be less dangerous for the environment than travelling by a maritime transport.

3.4 Security considerations

Security is an important aspect the company has to guarantee to its clients and employees. In this way, so as to assure a safe flight, the company will follow the required airport security measures and its leased (or bought, in a future) Bombardier Q200 airplanes must accomplish as well with all the requirements of *EU-OPS Subpart D-Design and construction*.

Airport security measures

Inside airport security measures that must be followed, it is found:

i. At any airport, passengers may be screened by security scanners, either as the primary method of screening or as an additional method to resolve the cause of any alarms [58].
ii. Regarding hand luggage and hold luggage, they must accomplish with the established code, which gives restrictions of liquids, as well as sharp objects, explosive or inflammable items transportation; prohibits any kind of weapons on board; and limits the size, weight and quantity of the carried luggage [58].

Airplane safety measures

According to *EU-OPS Subpart D-Design and construction* [59]:

i. Each seat, berth, safety belt and harnesses must be approved.
ii. Every seat and so every passenger will count, in addition to a safety belt, with a certified life vest and oxygen mask in case there was any situation of emergency.
iii. Before the start of any flight, cabin crew members will have to give a security briefing to passengers so as to inform them about the utilisation of any security equipment. In addition, there will be a security information leaflet in each passenger's seat.
iv. Every airplane will count with one *Type II* and one *Type III* emergency exits for each side of the fuselage.
v. Every airplane will have a luminous way which shows the emergency exit around the passengers' cabin floor and it will have to be also clearly identified in the darkness.
vi. Every airplane will count with three fire extinguishers: one located at the cockpit crew and two at the cabin crew. In addition, one of the fire extinguishers of the cabin crew must contain Hallon 1211.

Moreover, all the airplanes of the company will follow with all the necessary maintenance inspections so as to verify the airplane structure and equipment are in conditions of flying.

3.5 Planning and programming

According to the results obtained in this work, further studies will have the objective to continue evaluating the optimum fleet for the new low cost carrier, analysing the options of keeping with the same airplane, changing the model of airplane or having two different models of airplanes to cover routes with different ranges.

Brief tasks description

1. **Redefining the requirements of the company**. Reading the requirements of the last study and thinking about changing them, always according to the typical characteristics of a low-cost company.

2. **Selection of the geographical area of the study.**

   2.1 **Establishment of the central base airport**. Central base airport will be maintained.

   2.2 **Establishment of the aerial routes**. Searching for information, deciding the strategies at the time of selecting the flight routes and making the final decision of these routes. It will have to be searched routes of very short/short range and routes of medium/large range and choose at least one of each.

3. **Decision of the optimums airplanes.** Selection of the optimum models of the different existing airplanes for the company to cover the two different types of routes.

   3.1 **Selection of the optimum model of airplane destined to short haul**. The model of airplane destined to short range operations will be the already obtained in the last study.

3.2 Selection of the optimum model of airplane destined to medium/long haul. Carrying out the OWA method between the models of airplane of more than 100 seats (so as to be able to compete with the existent airlines in these routes and because from last study it has been obtained that small airplanes are not feasible) giving the desired weights to each required aspects (same as last study).

4. **Selection of the optimum number of airplanes.** Determination of the optimum number of airplanes for the company.

4.1 Fleet feasibility study. Carrying out a study in order to choose the optimum number of airplanes of the two models obtained (following same procedure as in last work).

4.1.1 Establishing a target in terms of passengers. Estimate the number of passengers in each flight.

4.1.2 Establishing a target in terms of the ticket prices. Estimate the flight price in order to accomplish the established target of passengers.

4.1.3 Decision of the number of airplanes. Obtaining of the optimum number of airplanes required by carrying out analysing the fleet feasibility.

4.2 Iteration process. Recalculation of the optimum number of airplanes by changing some parameters on the feasibility study.

4.2.1 Redefinition of the flight routes. Adding or taking out routes from the initial decision in order to obtain a feasible fleet (if necessary).

4.2.2 Reestablishing a target in terms of passengers and tickets price. Redefinition of the number of passengers per flight and flight ticket's cost (if necessary).

4.2.3 Recalculation of the optimum number of airplanes. Carrying out the feasibility study with the modified parameters in order to obtain the optimum number of airplanes (if necessary).

5. **Definition of an initial flight schedule.** Once having decided the fleet of the company, determining the flight plan for each airplane and day of the week.

6. **Economical feasibility study.** Carrying out an economical feasibility study of the company, taking into account the three possible fleet configurations: only the Q200 model, only the medium/long haul model and the two models together; and see which configuration gives more benefits to the company.

7. **Study of the company growth.** Carrying out a study of the company evolution on selling and on number of airplanes in the following years.
   - **7.1 Establishing a target on evolution of passengers.** Defining the evolution on number of passengers of the company per year.
   - **7.2 Establishing a target on ticket prices.** Establishing a target in terms of ticket price so as to assure the expected evolution of passengers.
   - **7.3 Selection of the optimum number of airplanes.** Determining the required number of airplanes so as to cover the demand.
   - **7.4 Flight schedule.** Estimating the timetable and the aerial routes of the required airplanes.
   - **7.5 Economical feasibility study.** Carrying out an economical feasibility study in order to assure the company's profitability.
   - **7.6 Iteration process.** Carrying out the required iterations in terms of routes, evolution of passengers, ticket prices, number of airplanes and flight schedules so as to assure the company's economical feasibility.

Temporal programming

Temporal programming of the further study can be approximated by having knowledge of the real time destined to each task of the last study.

Task code	Task identification	Hours	Preceding task(s)
1	**Redefining the requirements of the company**	**10**	
2	**Selection of the geographical area of the study**	**20**	1
2.1	Establishment of the central base airport	-	
2.2	Establishment of the aerial routes	20	2.1
3	**Decision of the optimum airplanes**	**80**	2
3.1	Selection of the optimum model of airplane destined to short haul	-	
3.2	Selection of the optimum model of airplane destined to medium/long haul	80	
4	**Selection of the optimum number of airplanes**	**100**	3
4.1	Fleet feasibility study	50	
4.1.1	*Establishing a target in terms of passengers*	*(4)*	
4.1.2	*Establishing a target in terms of the ticket prices*	*(4)*	
4.1.3	*Decision of the number of airplanes*	*(42)*	*4.1.1; 4.1.2*
4.2	Iteration process	50	4.1
4.2.1	*Redefinition of the flight routes*	*(22)*	
4.2.2	*Reestablishing a target in terms of passengers and tickets price*	*(8)*	

4.2.3	*Recalculation of the optimum number of airplanes*	*(20)*	*4.2.1; 4.2.2*
5	**Definition of an initial flight schedule**	**30**	2; 3; 4
6	**Economical feasibility study**	**80**	2; 3; 4; 5
7	**Study of the company growth**	**210**	2; 3; 4; 5; 6
7.1	Establishing a target on evolution of passengers	4	
7.2	Establishing a target on ticket prices	4	
7.3	Selection of the optimum number of airplanes	42	7.1; 7.2
7.4	Flight schedule	30	7.3
7.5	Economical feasibility study	80	7.4
7.6	Iteration process	50	7.5
	Total number of hours	**530**	

* Note that the tasks of this further study are not exactly the same as the study before. These tasks are planned supposing all the search of information of the previous study can be maintained, and in addition, report's contribution has not been taken into account. In this way, total number of hours required are given as a help, but more hours will be needed.

Table 34. Approximated temporal programming of further studies

4. Conclusions and recommendations

At the time of setting up a new airline, it is important to carry out some studies of the best way to enter into the market, in terms of what type of market will be destined to, which routes will be covered, which will be the most suitable model of airplane and which will be the optimum number of airplanes required. In addition, it will be necessary to carry out an economical feasibility study in order to assure the previous aspects are profitable to the company or it should be made a reselection of some of them.

During this study, all the aspects mentioned above have been carried out giving the result that new low cost carrier will start operations with a fleet of one Bombardier Q200 airplane on the route from and to Barcelona and Mallorca.

This result was obtained after having to eliminate the routes of London and Paris, which were previously to the economical feasibility study selected by the new company. According to the economical feasibility study, they were not profitable routes and make the company have losses and so not being feasible, aspect that is vital.

The fact that routes of Paris and London were not profitable to the company, when there is certainty these routes provide good economical results because there are other low cost companies that cover these routes due to they have benefits with it, leads to think that the Q200 is a too small airplane to compete on medium and long range routes where exist airplanes with more than 130 passengers. Bombardier Q200, although according the OWA method was determined as the most suitable model of airplane, mainly because its low operational costs, has result in not being a proper model of airplane to cover long routes. The explanation can lay on a combination of three possible causes:

i. The low capacity on number of passengers of this model makes the company need a major number of airplanes in order to carry the same demand as the competence. This fact increases the direct costs (especially leasing costs) and the result is that the incomes generated in each flight are not enough to compete with these high costs.
ii. Due to its low cruise speed, the flight time is significantly increased, and in addition to the already existent timetable of flights on the analysed routes, makes the airplane to cannot carry out the minimum number of daily flights so as to generate the enough income to be economically feasible.
iii. Due to its low cruise speed another time, all the costs that were given in cost per block hour significantly increase with the range of the route, and so they end being too high to be counteracted by the income.

Bombardier Q200 so, is a great candidate to cover short haul routes but results in not being feasible when routes increase their range. In this way, if the company decides to keep on trusting the Q200 model, it will have to offer short range routes, possibly, regional routes.

The company has to think now, whether if maintaining the Q200 model and sacrifice the routes with high demand to other important European cities, or considering the possibility of changing its fleet configuration by adding a competitive airplane in the last mentioned routes and so counting with two different models of airplane in the fleet, or eliminating the Q200 of its fleet and keeping the other model of airplane.

On this further study it can be supposed the company has already had earnings with the initial fleet configuration (1 Bombardier Q200 and route of Mallorca) and so it can consider the possibility of using these benefits to buy an airplane instead of leasing it, relieving in this way, the direct costs of the company. Moreover, as the company has been profitable it is possible the initial investor decides to reinvest, and so it will be possible to buy more airplanes or improve any other aspect of the company.

In addition, the new company could think as well on the possibility of sharing an airplane in a flight with another company. In this way, if required number of airplanes after carrying out the study does not give a high occupation of any of them, it can be supposed this airplane can be shared with another airline and so the company will not have to lease/buy it on its own and costs will be reduced, while it will maintain the incomes.

The new low cost company so, will start operations with the Bombardier Q200 on the route of Mallorca, but it will keep studying how to improve its configuration, so as to not close itself into a single route, which is more risky than covering more routes. Depending on a single route does not give margin of unpredictable problems that affect to the demand on this route, which could result on losses on the company.

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