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1 INTRODUCTION

1.1 Context: Vision of Small Air Transport System

Beside other drivers of the transportation systems (e.g. social needs, regulations, availability of fossil fuel), mobility studies show that the Gross Domestic Product (GPD) alone, leads to approximately 1-2 percent of motorized traffic growth[1] for each percent of GDP growth. If the long-term GDP increase continues in the future, then the coming decades will significantly increase the amount of the present European transportation system, and more particularly the surface and air transportation. Seeing however that *road transport and largest hub airports are already facing their limits of capacity, further traffic growth is expected to cause considerable congestions on the road as well as in the hub airports and busiest air routes*. For example for the volume of the European air transportation system is expected to double in the next decades[2].

Within these circumstances, a potential solution to ensure the future mobility includes capacity balancing with **advanced transportation using small aircraft at underutilized *airspace and infrastructures*, such as small / regional airports**. This is also reasonable from the point that the alternative transportation modes (especially high speed trains) are usually operated along highly populated corridors, and that the new EU member states are still facing with limited transportation infrastructures[3].

This new transport mode will enable fast travel in areas of Europe where high speed trains or traditional airline connections are unavailable and will alleviate road congestion problems in a customer - and environmentally friendly way. This vision is also in line with the related:

(i) reports of the Commission: "*general and business aviation complements regular air transport performed by commercial airlines and thus provides specific social and economic benefits such as increasing the mobility of citizens, the productivity of businesses and regional cohesion*" (European Parliament Resolution of 3 Feb 2009 on an Agenda for Sustainable Future in General and Business Aviation), and

(ii) the past or on-going national and EU projects such as EPATS, CESAR, PPlane, or ESPOSA.

The idea of Small Air Transport (SAT) focuses on the new more affordable, accessible, and energy effective component of the air transportation system in general. In the future, SAT is envisioned to provide a wide choice of transportation mode - and the wider use of small aircraft, served by small airports, to create access to more communities in less time.

The major objective of the SAT-Rdmp project is to **demonstrate and understand the role that small-size aircraft operating on scheduled or non-scheduled flights can play as a component of the Air Transport System to satisfy the needs of transportation in regions where transport networks are underdeveloped** and to satisfy:

- the need for low-intensity intercity air transport routes, which have been dependent so far on road transport;
- regions out of the central European "economic banana" with less developed infrastructures to stimulate the economic development;
- the needs of business people to travel door to door. Current business aviation is expensive and only for the happy few.

In this context, the project will (i) define a common vision of the European small aircraft transportation system, (ii) define relevant business cases being compliant with the user and SAT requirements, (iii) assess the current European capabilities, (iv) define a roadmap for SAT, (v) list the risks and benefits related to the concept of small aircraft transportation.

1.2 Delivery objective

In compliance with the Description of Work (DoW) related to the SAT-Rdmp Project (grant agreement number 265603), after the development of the common vision and more particularly based on the results of the demand model (as given in *D1.2: "Demand of small air transport aircraft analyses*") WP2 should:

- **define the most profitable business case**,
- define the economic, environmental and safety impact of different business models,
- define the major influential variables of the impact parameters of each business model.

In order to find the most profitable business case, one should first name the potential and relevant business cases, then define the basic impact parameters and construct a simulation model. These tasks were already performed under *D2.1. "Business case subscriptions with operational characteristics"*, and *D2.2."Impact parameters & simulation model; simulation of the model for each business case"*.

This deliverable *(D2.3. "Analysis of the impact of each business case on the technology roadmap") is fully based on the findings of related SAT-Rdmp deliverables (D2.1. "Business case subscription with operational characteristics", D2.2."Impact parameters & simulation model; simulation of the model for each business case"), and* ***aims to assess the effect of the major influential variables within the business cases, in order to find the most profitable, safe, sustainable and environmental friendly business case****.*
The work introduced here under this deliverable is fully compliant with Task 2.3: "Analysis of the impact of each business case on the technology roadmap".

To reach the objectives defined above, this deliverable is structured as introduced below. After a short introduction, the second chapter gives an insight of the estimated small aircraft demand, as given more in detail in D2.1.

Chapter 3 is the core part of the deliverable and summarizes the results of the simulations, in which for each business case, various alternative scenarios (with different factors for the major influential parameters) are considered.

By analyzing the results of the scenarios, chapter 4 gives the most profitable, sustainable and safe business model according to the assumptions made and the simulation. Please note that all results are based on simulations and realistic assumptions.

At the end of the deliverable, numerous appendixes are given, where the details of the simulation results are given.

2 ENVISIONED EUROPEAN DEMAND FOR SAT

The objective of this chapter is to present the estimated demand for various Small Aircraft Transport (SAT) operations between the member states of the European Union. In order to represent countries with different socio-economic factors, as well as new and old EU member states, the following 23 countries were considered: Austria (AT), Belgium (BE), Czech Republic (CZ), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (GR), Hungary (HU), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Norway (NO) Poland (PL), Portugal (PT), Romania (Ro), Slovenia (SI), Slovakia (SL), Spain (ES), Sweden (SE), Switzerland (CH), and United Kingdom (UK). These countries are chosen based on the following criteria:

- A reasonable amount of countries simulated in EPATS project should be chosen in SAT-Rdmp to make a reliable comparison
- Although the high accessibility due to the infrastructure available in Western Europe, they are chosen for comparison reasons
- The amount of countries to be simulated should fit the available computational power and project scope.

The simulation is fully based on the demand model and methodology defined in *D1.2. "Small air transport aircraft demand"*. Accordingly, the following aircraft categories are covered:

- Piston aircraft named EPATS1 aircraft
- Turboprop aircraft named EPATS2 aircraft
- Very Light Jet aircraft named EPATS3 aircraft

In order to make results comparable with the EPATS project, the simulation is based on the fares, prices and operating costs further specified in *EPATS D2.1 "Potential transfer of passenger demand to personal aviation by 2020"*and also in *EPATS D4.2"Operating cost analysis"* of the EPATS project. Accordingly, ***by 2035 a total of 112,21 million small aircraft passenger demand is estimated***. The passenger traffic would be split as follow between the three main small aircraft types:

- almost 99% of the passengers travelling with piston aircraft (EPATS1)
- about 1 % of the passengers travelling with turboprop aircraft (EPATS2)
- less than 1 % of the passengers travelling with jet aircraft (EPATS3)

For an operational description of the aircraft types the reader is referred to D2.1 chapter 4.3.1. The SAT Simulation model will limit the travel party size and consequentially the capacity to three as it represents approximately 97% of the market demand (D1.2).

Thus, the large majority of the flights would be made by piston aircraft that is followed by a minor turboprop and just a few jet movements. This, seeing the significant difference in the assumed fares between the pistons and turboprops or pistons and jets is reasonable, as the achievable time savings due to the higher flight speeds of the jets could not – in most of the case – compensated with its higher operating cost. In addition, the distribution of the flight distance in both EPATS and SAT-Rdmp predictions are to reflect that most of flights take place for short (see Figure 1. and 2.) distances, where the added value of higher flight speed is less attractive.

Seeing the load factors (average 68%) of all three aircraft categories, a total of 66,05 million small aircraft movements are predicted by 2030. In previous estimations made in the EPATS project, we already obtained an estimated a traffic of 45 million movements. This difference is certainly caused by the different time horizon, since in SAT-Rdmp the predictions are made for 2035, while in EPATS for 2020, although less countries were covered in SAT-Rdmp. Additionally differences are substantiated by the more detailed and accurate data available in SAT-Rdmp per city pair on a NUTS2 level making the demand more favorable. The reader is also referred to figure 2.4 in D2.1 (page 13).

Figure 1 illustrates the simulation results, as the geographical distribution of the piston small aircraft movements on a typical day in 2035. Seeing the Figure, it is found that the European small aircraft flights could be attractive across all European destinations with a center of gravity in North West Europe and Germany.

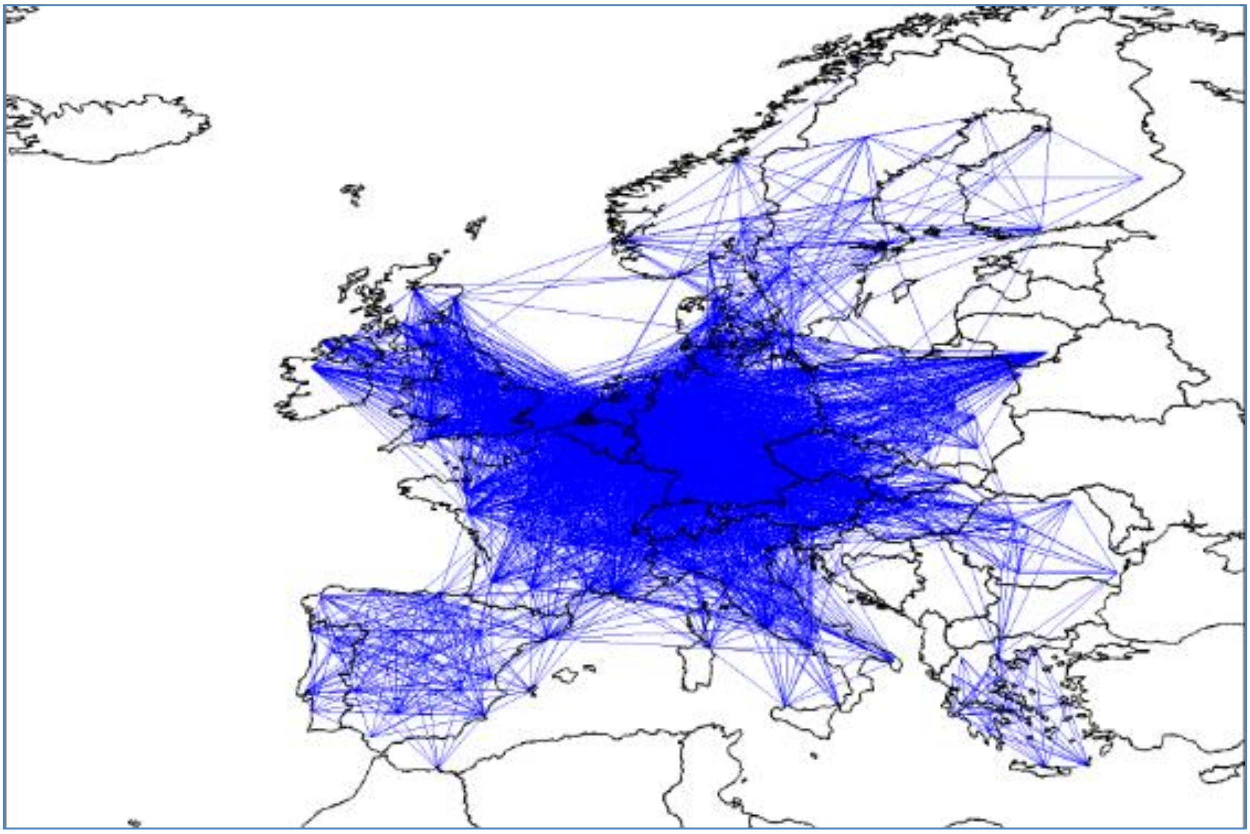

Figure 1: One typical day of EPATS1 flights in 2035

In order to locate where most of the flights take place, the Figure 2 shown in the next page, illustrates the simulation results in terms of the flight densities. Each line or city pairs are thus colored upon the envisioned number of movements a day. Green stands for 5-20, yellow for 20-50, orange for 50-100, while red for 100+ movements a day respectively.

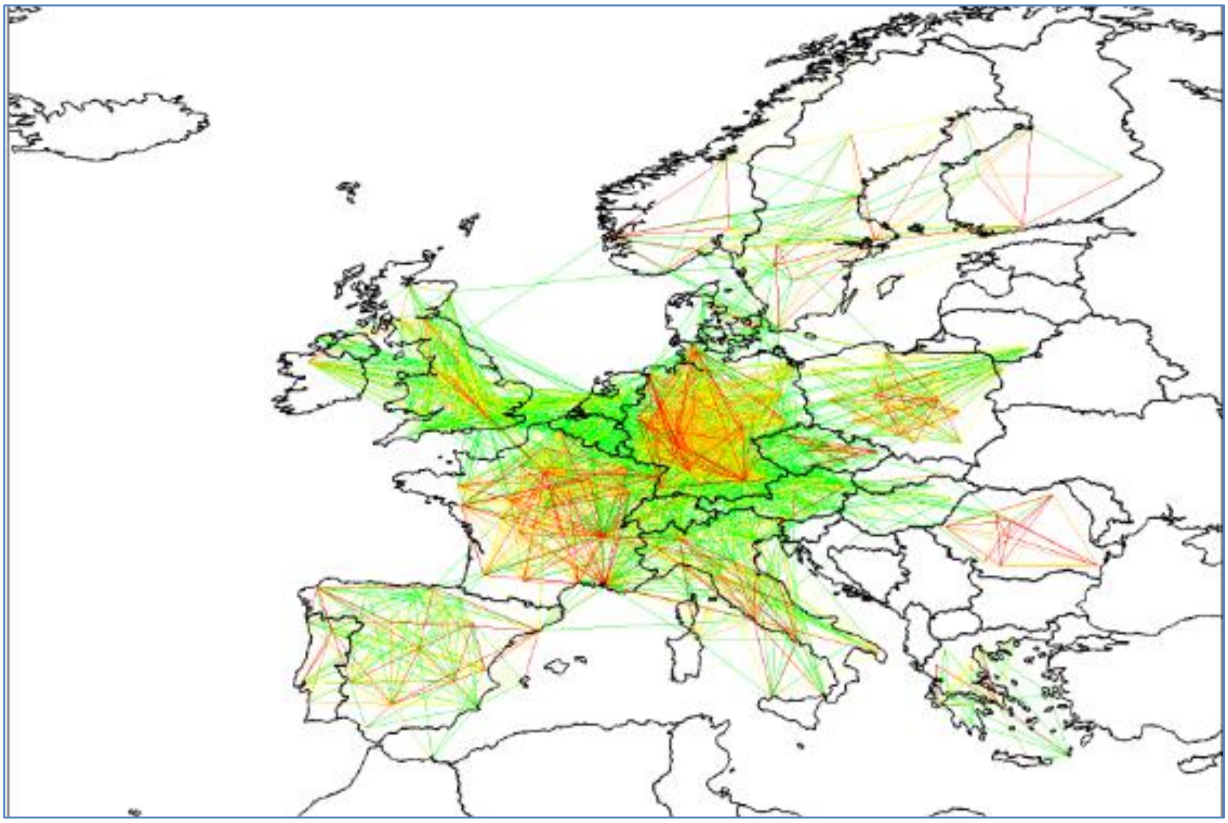

Figure 2: Small air transport flights routes in 2035, colored by number of daily flights
(Green stands for 5-20, yellow for 20-50, orange for 50-100, while red for 100+ movements a day respectively)

It is particularly interesting to note that the most developed countries have the most significant amount of SAT traffic. This is reasonable, as GDP is a key driver of the demand, and these countries are to offer the highest number of airports and airfields as well. If these countries are already to have a dense airport network and thus a significant small aircraft or general aviation demand in the present days, the attractive lower total operating cost of SAT should generate a demand at a higher extent. This is particularly the case for France, Germany and the UK.
Such distribution of the number of flights per country is also visible in the Figure 3 below. Accordingly, France, Germany, the United Kingdom, Spain and Norway are the most attractive departing countries of SAT transportation. These include domestic, as well as international flights.

The heaviest flights are domestic routes (e.g. France, Spain, Italy, and Germany); Small Air transport would hence help to answer to a large demand of direct flights between domestic cities which are not served by traditional or low-cost airlines.

The lower traffic amount in Benelux can however be explained by a good transport infrastructure and the lower population (in the analysis it was proved that the amount of SAT movements per inhabitant is on average 16 for these countries with a relative low spread, as well as by the short distances between the cities. The short distances and dense network of airfields (as a legacy of World War II) gives a higher spread of SAT demand.

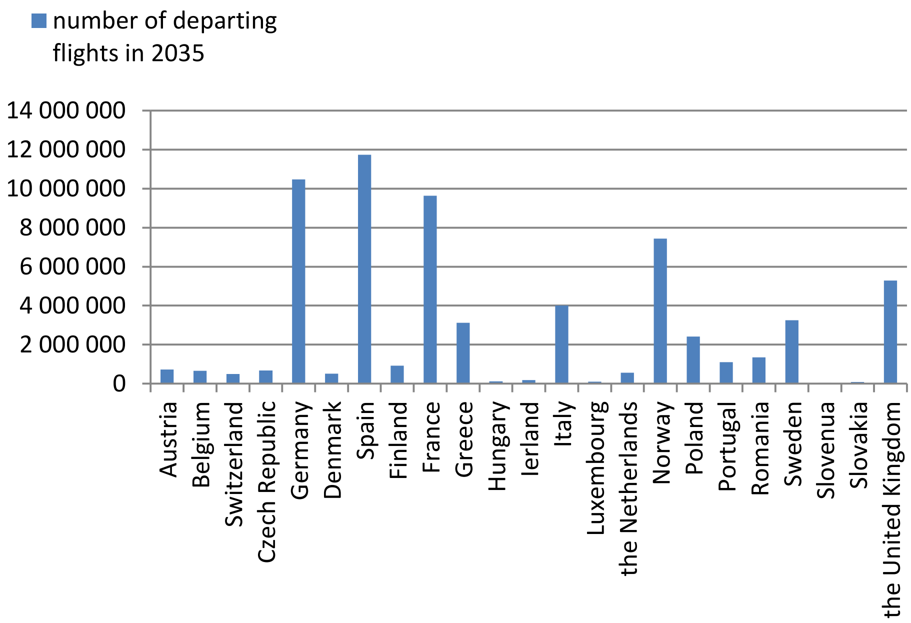

Figure 3: Number of departing flights per country in 2035

While the sensitivity of the demand model in general was already analyzed in *D1.2. "Small Air Transport Aircraft Demand"*, this section investigates how the predicted demand is influenced by the most important model variables, such as ticket price, range, and speed and payload limitations of the aircraft. As shown in the Figure 4, the demand grows significantly with lower ticket price. The slope and the non-linear relationship is also logical, and thus fully in line with the expectations, and results of related works. However, the assumed fares of SAT-Rdmp and the EPATS projects are different from those of the SAT resembling present air taxi companies. According to the Figure 5, showing the demand with the present air taxi fares and those of SAT-Rdmp, *a reduction of almost 50% would be required in the fares and accordingly the TOC* related to the present SAT competitive modes of air transportation to meet such demand as envisioned in the project.

The second most influential variable in this sensitivity analysis is found to be the payload. This sounds, as with higher payload, the total operating cost on a per seat basis gets lower, which leads to a higher demand. While higher speed is found to augment the demand, the slope of the curve is rather small. Therefore it is influencing the demand, but higher speed seems to be less capable to compensate its higher related costs. This behavior is behind the fact of predicting just a marginal jet SAT movements.
As for the range, Figure 4 shows that it is almost no effect on the demand. Seeing the average flight distance of SAT and the relatively small distance between the European cities, this is also found to be reasonable.

Not shown in the Figure 4, but interestingly, the High-Speed Rail network growth has almost no impact at all on the demand of SAT, after a sensitivity analysis done on the simulation based on the elaborated assumptions. This should be caused due to the relatively average low speed of the coming new networks, which compared to small aircraft transportation is less attractive to time-sensitive travelers. The International Union of Railways (2010)[5] (IUR) states that high-speed railway obtains a speed of 200km/h on upgraded tracks and 250km/h on new tracks. ETIS data

includes low and high-speed connections, so that the low-speed connections have to be filtered out as only the high-speed railway system is considered to be a transport alternative. This filter process over ETIS data shows that the current high speed railway networks hardly have higher average speeds then the IUR values. In addition, SAT is also focused on remote regions with underdeveloped infrastructures. Current network layout and future plans indicate that these areas would not be in focus of the High-Speed Rail developments, meaning SAT is not competitive to other surface modes, besides road transportation.

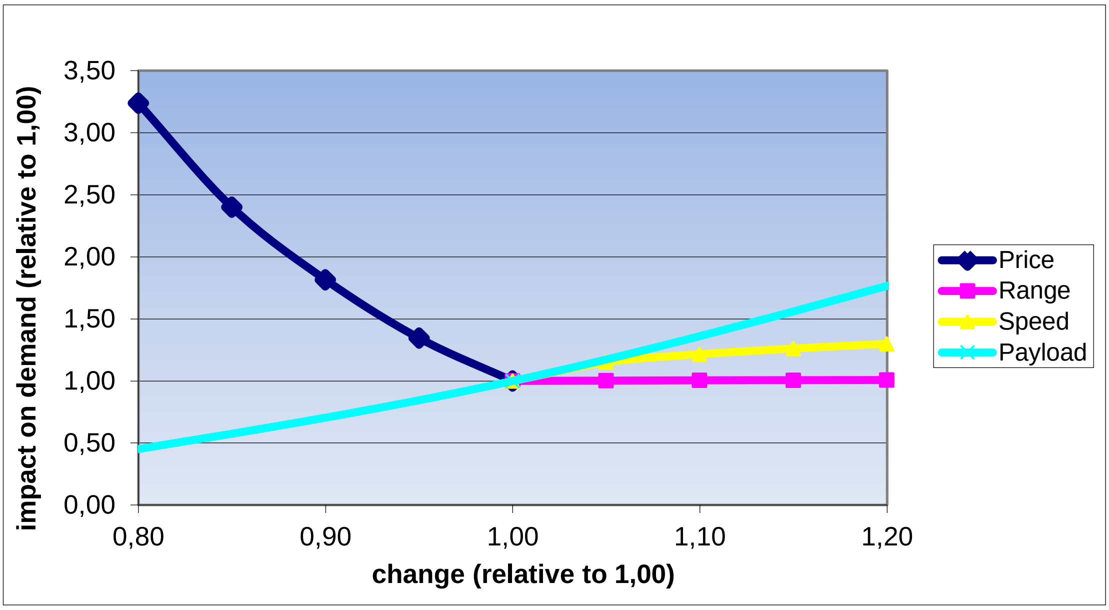

Figure 4: Sensitivity of passenger demand in 2035 (of piston aircraft)

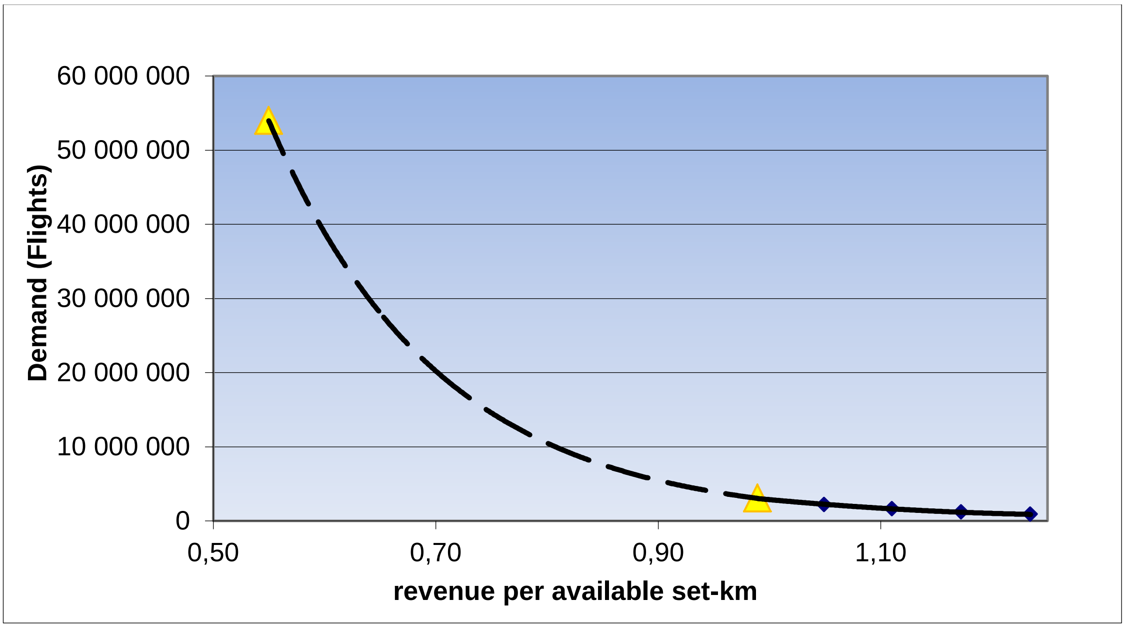

Figure 5: Fares should be considerably decreased to meet the envisioned demand: blue points show the present air taxi fares, while yellows the assumed fares in SAT-Rdmp and EPATS projects (based on EPATS1)

3 SIMULATION RESULTS

The following chapter projects the results from simulating the business models explained in D.2.1 by using the developed SAT model elaborated in D2.2. Extra background information by means of graphs (DOC, annual utilization rate, energy efficiency factor and profitability) for business models 1 to 5 is given in respectively in appendix A, B, C, D and E.
Operations are assumed in the countries of Europe (See chapter 2) without Czech Republic, Hungary, Ireland, Norway, Poland, Romania, Slovakia & Slovenia due to computational power restrictions. The other countries together represent 80% of the total general aviation traffic in Europe.

3.1 Business model 1

The research of this business model and the piston aircraft demonstrated that the main influential parameters for the piston modality are the fleet size, trips per day, region operated in, the number of airports in this region, flight altitude and the profit goal and additional services provided.

If the influence of input parameters is looked at an operation, economics & costs, emissions and safety level the parameters can be ranked as the list found here.

1. **Number of trips per day and fleet size**
The costs rise approximately linear with the fleet size and trips per day performed, e.g. doubling the fleet size for the same ratio of trips per day over fleet size will double costs too. Profit however increases faster than linear. For a ratio of trips per day over fleet size, altering the fleet size from 15to 30 to 100, the profit expressed as a percentage of costs is equal to 1.6%, 2.3% and3% respectively. Thus, profit rises faster than costs, for an increasing fleet size. The emissions have a linear relation with the amount of trips performed.

2. **Profit goal**
Besides the trips per day and fleet size, the profit goal is the main influential parameter. Costs and emissions are hardly affected by this parameter, yet profit can increase a numbers of times. An example of the profit goal of 10% compared to 5% can increase the operating profit by 3.1 times.

3. **Additional service**
Additional services can increase profit to 2.5 times, if seat comfort, flexibility and reliability are all implemented additionally. Different than editing the profit goal, costs do increase a lot as well, yet to a lesser extent (a factor 2). Even only implementing seat comfort increases profit by almost a factor 2, and costs only by almost a factor 1.5. Emissions are not affected by this factor.

4. **Operating region**
The operating region can have a significant effect on operations, as was observed. For the total operating profit, this can mean a decrease of 50% if a less optimal operating region is chosen (e.g. Austria, compared to the combination of Italy, Switzerland and Austria). Even though costs decrease by 75% as well, the sharp decrease in profit is not desired. On the other hand, a profit increase of 35%is observed is a more optimal operating region is selected (e.g. Germany, compared to the combination of Italy, Switzerland and Austria). Additionally, costs do not alter by operations in Germany, creating a double win situation. The emissions

in Austria decreased over 50%, whereas emissions in Germany slightly decreased (less than 5%).

5. Number of airports

Especially increasing the number of airports operated from has a negative influence on the operations, in a way that it can decrease profit up to 66% (observed for testing operations on 100 airports), and thereby even increase costs (yet only 8%). Selecting fewer airports can increase the profit (slightly, 13% higher when operating from 9 instead of 18 airports), while costs stay constant. However, a large downside is that it also affects the emissions, in the opposite way as the profit. Operating more airports is more efficient, and thus decreases emissions by slightly over 5% (while decreasing profit too). Operating fewer airports is less efficient as emissions rise (15%).
Even though the percentages of the effect of the emissions are smaller than the effect on profit, they should be taken into account.

6. Flight altitude

The final parameter discussed here is the flight altitude, which can increase profit by almost 50%, if own at 6000 feet. Costs rise to 20% extra too and a sacrifice is also made with regard to the emissions. However, the percentage increase of emissions is limited to only 5%, which is less than altering the number of airports, however noticeable.

As a final overview on the numbers before conclusions will be made on this business model, Table 3.1.1 displays a summary of results on utilization, load factor, direct operating costs, demand change vs. CASK, emissions and safety (based on 10 trips per day with 15 owned aircraft).

Parameter	Average value	Remarks
Utilization	Around 80%	Drops to values around 40% in case more airports are operated from
Load factor	Around 0.65 or 1	0.65 for on-demand and scheduled services, 1 for semi on-demand (as operations are only performed when at least two passenger want to fly, which is also the maximum TPS for piston aircraft)
DOC	Around 20.000.000 euro/year	Percentage differences are explained above in this section
CASK	Around 6 to 8	Around 5 for operations in Austria, 10 to 14 when implementing additional service
Emissions	Around 40kg fuel per flight on average	Lower when operating in Austria (19kg) or from more airports (38kg), high when operating less airports (47kg) or at lower altitude (45kg) (higher than expected, mainly due to longer average flight distance)
Safety	Safe	Around 0.0135 % chance on an accident per trip

Table 3.1.1: Summary table business model 1

Now, based on this analysis, the input parameters for the most profitable business model, while taking into account sustainability and safety are:

- Standard TPS (average TPS = 1.49)
- Piston fleet
- Fleet of 100 aircraft (or more?)
- 5 (to 10?)% profit on costs
- Leasing or buying does not have a significant influence (regarding profit, emissions and safety)
- Cruise altitude: 8000ft/2348m (or 6000ft/1829m in case emissions matter less)
- Scheduled service or semi on-demand (on-demand, when a higher profit goal is strived for)
- No additional service (yet additional service should be implemented when a higher profit goal is strived for)
- Operating region: Germany, France, Spain or a similar country/region
- Limit the number of airports to no more than 20, dependent on how ecological the business model is desired to be
- Limit the number of trips to 50 per day (or more, dependent on the fleet size, keeping a ratio of 50% between fleet size and number of trips per day)

The parameters above are selected in order to increase profit, decrease cost or limit emissions. The selection of these parameters has the following effects (with the means to reach the goal between parentheses):

- Decrease the number of subcontracted aircraft (large fleet size, less airports)
- Decrease the amount of empty leg flights (ratio of trips per day over owned fleet of approximately 0.5, less airports)
- Increase the fleet utilization (large fleet size, less airports)
- Increase the flights hours per year (large fleet size, less airports)
- Decrease the CASK (ratio of trips per day over owned fleet of approximately 0.5, less airports, no additional service)
- Increase the operating profit (large fleet size, size and demand region fit to aircraft operated)
- Increase sustainability (size and demand region fit to aircraft operated, operating at8000 feet, considering an increase in number of airports)

A conclusion which can be made is that a low cost business model will not result in the most profitable business model, when the interest in the demand service (i.e. on-demand is most profitable), additional service (e.g. seat comfort) and an increase in the profit goal (i.e. the large difference between 5 and 10%) with a reflection on the ticket price (and resulting profit) is observed, as these parameters increase profit and do not fit within a low cost business model. Yet, there is more demand to be answered with a fleet of 100 aircraft (not even 1% of the entire demand is answered), and operations are profitable, while taking into account the emissions of the operations and safety of the passenger. In order to decrease the emissions, operations should take place in smaller regions with more airports (conflicting with obtaining more profit), thus a trade-off needs will need to be made. Safety is approximately constant for all scenarios, and concluded to be safe and of less importance when selecting a business model.

3.2 Business model 2

The research of this business model and the very light jets demonstrated that the main influential parameters for the VLJ modality are the fleet size, trips per day, the flight altitude, the amount of airports operated from, the profit goal and additional service input. In addition, entering an estimate of the flight hours per year provides more accurate model output results. Especially for small fleet sizes (15 or 30 aircraft) where the amount of flight hours per year is rather low, this should be taken into account.

If the influence of parameters is looked at a level of profit, costs & emissions, the parameters can be ranked as follow.

1. **Number of trips per day and fleet size**
   The costs rise with the fleet size and trips per day performed, however less strong than linear as was observed for piston aircraft. And again, as observed for the piston aircraft too, the profit percentage on total costs rise as the fleet size increases. For a ratio of trips per day over fleet size, altering the fleet size from 15 to 30 to 100, the profit expressed as a percentage of costs is equal to 0.5%, 0.7% and 1.8% respectively. Thus, profit rises faster than costs, for an increasing fleet size. The emissions have a linear relation with the amount of trips performed.

2. **Profit goal**
   Besides the trips per day and fleet size, the profit goal is the main influential parameter. Costs and emissions are hardly affected by this parameter, yet profit can increase a numbers of times. An example of the profit goal of 10% compared to 5% can increase the operating profit by 2.7 times.

3. **Number of airports**
   Increasing or decreasing the number of airports operated from can have a very positive influence on profit, in a way that it can increase profit up to a factor 2.9 (observed for testing operations on 53 airports), and thereby increase costs only 7%. Selecting a lot more airports can increase the profit too, up to a factor1.7, while costs even decrease 8%. Emissions are not affected largely by decreasing the number of airports, however, decreasing the number of airports a lot (400 or 600airports) is the second most influential parameter on emissions (after altering the flight altitude), and can save 7% on emissions.

4. **Flight altitude**
   The flight altitude can increase profit by almost a factor 2.4, if flown at 43000 feet. Costs even drop 24%. This parameter is also the largest influence on the emissions, in a positive way, decreasing emissions by 17%.

5. **Additional services**
   Finally, additional service can increase profit to 2.2 times, if seat comfort, flexibility and reliability are all implemented additionally. Different than editing the profit goal, costs do increase a lot as well, in approximately the same order of magnitude (a factor 2.1). When only additional seat comfort is added, no profit benefits were obtained, while costs rose, making only implementing seat comfort not attractive. Emissions are not affected by this factor.

As a final overview on the numbers before conclusions will be made on this business model, Table3.2.1 displays a summary of results on utilization, load factor, direct operating costs, demand change vs. CASK, emissions and safety (based on 10 trips per day with 15 owned aircraft).

Parameter	Average value	Remarks
Utilization	Around 25 to 30%	Fleet utilization can increase sharply to 75%, when a larger fleet size is used (i.e. 100 aircraft)
Load factor	Around 0.75 or 0.5	0.75 for semi on-demand and scheduled services, 0.5 for on-demand (as a large portion of the traveling public travels alone)
DOC	Around 300.000.000 euro/year	Percentage differences are explained above in this section
CASK	Around 16 to 18	Around 12.6 for operations at 43000 feet, 22 to 34 when implementing additional service
Emissions	Around 924kg fuel per flight on average	Low when operating from more airports (890kg) or at higher altitude (795kg) (higher than expected due to longer average estimated travel distance)
Safety	Safe	Around 0.0025 % chance on an accident per trip

Table 3.2.1: Summary table business model 2

Now, based on this analysis, the input parameters for the most profitable business model while taking into account sustainability and safety are:

- Standard TPS (average TPS = 1.49)
- VLJ fleet
- Fleet of 100 aircraft (or more)
- 10% profit on costs
- Leasing or buying does not have a significant influence (regarding profit, emissions and safety)
- Cruise altitude: 43000ft/13106m
- On-demand service
- All additional service (seat comfort, flexibility and reliability) if higher profit desired, no additional service if higher operational efficiency and lower costs desired (less sub-contracted aircraft, less empty legs, higher fleet utilization, higher flight hours per year)
- Operating region: Europe
- Limit the number of airports to approximately 53, dependent on how ecological the business model is (by choosing 600 airports, less profitable, yet second best option, and more ecological)
- Limit the number of trips to 50 per day (or more, dependent on the fleet size, keeping a ratio of 50% between fleet size and number of trips per day, to fulfill the requested demand cq. an optimal operational combination within computational limits of the model).

The parameters above are selected in order to increase profit, decrease cost or limit emissions. The selection of these parameters has the following effects (with the means to reach the goal between parentheses):

- Decrease the number of subcontracted aircraft (large fleet size, less/a lot more airports, operating at higher altitude)

- Decrease the amount of empty leg flights (ratio of trips per day over owned fleet of approximately 0.5, less/a lot more airports, operating at higher altitude)
- Increase the fleet utilization (large fleet size, less/a lot more airports, operating at higher altitude)
- Increase the flights hours per year (large fleet size, less/a lot more airports, operating at higher altitude)
- Decrease the CASK (ratio of trips per day over owned fleet of approximately 0.5, operating at higher altitude)
- Increase the operating profit (large fleet size, higher profit goal percentage, less (a lot more, to a lesser extent) airports, include all additional services)
- Increase sustainability (operating at higher altitude)

A conclusion which can be made is that operating a VLJ fleet does not seem that profitable, as mentioned before in the economics and cost section (due to the small demand, the large region and high operating costs, especially due to the high number of subcontracted aircraft required, operating a VLJ fleet does not seems very attractive). Yet, as the ticket price can be chosen more freely in this business model, thus the profit goal increased to 10%, combined with more service towards the passenger implemented (seat comfort, flexibility and reliability), with operating at a higher cruise altitude (43000 fleet), the business model becomes more financially attractive to operate and at the same time more sustainable (especially due to operating at a higher altitude). As on-demand services deliver the highest profit, this fits within the business model and profit can further be increased. However, operating from only 53 airports is the most profitable way of operating in Europe, which is not a high amount of airports, especially in entire Europe, for on-demand services. 600 airports is second most profitable with respect to the number of airports operated from investigated (yet only half as profitable as operating from approximately 50 airports), which is also more sustainable and better fits the on-demand service and is therefore preferred over operating at 53 airports in Europe only. Safety is approximately constant for all scenarios, thus concluded to be of less importance when selecting a business model.

3.3 Business model 3

The research of this business model and the turboprop aircraft demonstrated that the main influential parameters for the turboprop modality are the fleet size, trips per day, region operated in, the number of airports in this region and the flight altitude. The profit goal and extra service implemented especially have an influence on the cost side and less on the operations.

If the influence of parameters is looked at based on operations, economics & costs, emissions and safety, the parameters can be ranked as follow

1. **Number of trips per day and fleet size**
   The costs rise approximately linear with the fleet size and trips per day performed, e.g. doubling the fleet size for the same ratio of trips per day over fleet size will double costs too. Profit however increases faster than linear. For a ratio of trips per day over fleet size, altering the fleet size from 15 to 30 to 75, the profit expressed as a percentage of costs is equal to 1.7%, 2.5% and 2.9% respectively. Thus, profit rises faster than costs, for an increasing fleet size. The emissions have a linear relation with the amount of trips performed.

2. Profit goal

Besides the trips per day and fleet size, the profit goal is the main influential parameter. Costs and emissions are hardly affected by this parameter, yet profit can increase a numbers of times. An example of the profit goal of 10% compared to 5% can increase the operating profit by 2.2 times.

3. Additional service

Additional services can increase profit to 2.3 times, if seat comfort, flexibility and reliability are all implemented additionally. In the contrary to changing parameter 2 (profit goal), costs will increase as well, in approximately the same order of magnitude (factor 2.1). When only additional seat comfort is added, no profit benefits were obtained, while costs rose, making only implementing seat comfort not attractive. Emissions are not affected by this factor.

4. Number of airports

Decreasing the number of airports operated from can have a very positive influence on profit, in a way that it can increase profit up to a factor 2.1 (observed for testing operations on 9 airports, in Italy, Switzerland and Austria), and thereby increase costs 30%. Selecting a lot more airports can increase profit too, yet to a much lower extent (or can even decrease profit if a less optimal number of airports is chosen, such as 36 when operating in Italy, Switzerland and Austria). A noticeable aspect is that the most effective way to decrease costs, out of all parameters, is by operating from a lot of airports (250), which decreases costs 16%. An effect on emissions is most clear by decreasing the number of airports to 9, increasing emissions by 9%.

5. Operating region

The operating region can have a significant effect on operations, as was observed. For the total operating profit, this can mean an increase of profit equal to a factor 2.1 when operations are chosen to be own over entire Europe. However, as observed very clear in the analysis in this chapter, costs rise out of proportion by a factor 8.3. Also emissions rise by a factor 2.4. Operations over the assumed countries in Europe (See chapter 2 without Czech Republic, Hungary, Ireland, Norway, Poland, Romania, Slovakia & Slovenia due to computational power restrictions. The other countries together represent 80% of the total general aviation traffic in Europe.) can clearly be classified as the least efficient way to operate turboprop aircraft, based on costs and emissions. The same trends can be observed for operations in a region slightly smaller, yet larger than the region of Italy, Switzerland and Austria, such as a combination of Belgium, the Netherlands, Luxembourg, France, Germany and Switzerland. A profit increase of 50% was observed, a cost increase by a factor 2.2 and emission increase of 1.2%, thus also less efficient to operate turboprop aircraft in.

6. Flight altitude

Finally, the flight altitude can increase profit by almost a factor 2, if operations are undertaken at 13000 feet in long range modus (or 1.7 if own at the standard cruise altitude of 25000 feet in high speed modus rather than long range). For both scenarios, costs increased approximately 34%. Yet, flying at 13000 feet in long range modus can save up to 16% emissions, while operating at 25000 feet in high speed modus increase emissions by 8%.

As a final overview on the numbers before conclusions will be made on this business model, Table 3.3.1 displays a summary of results on utilization, load factor, direct operating costs, demand change vs. CASK, emissions and safety (based on 10 trips per day with 15 owned aircraft).

Parameter	Average value	Remarks
Utilization	Around 65 to 80%	Fleet utilization is highest when operating at 13000 feet (82%), and as low as 22% when operating in larger regions (e.g. entire Europe or a combination of Belgium, the Netherlands, Luxembourg, France, Germany and Switzerland) or 49% when operating from a bad chosen value of airports to operate from (scenario 10)
Load factor	Around 0.75 or 0.5	0.75 for semi on-demand and scheduled services, 0.5 for on-demand (as a large portion of the traveling public travels alone)
DOC	Around 41.000.000 euro/year	Percentage differences are explained above in this section
CASK	Around 12.5 to 14	Around 15 for operations at 13000 feet in long range modus or operating from less airports (9), 17 to 18 in Europe, 16 to 26 when implementing additional service and only 11 when operating from a lot of airports (250)
Emissions	Around 464kg fuel per flight on average	Higher when operating from less airports (502kg), larger regions (1093kg for Europe, 571kg in Belgium, the Netherlands, Luxembourg, France, Germany and Switzerland), in high speed modus (at 25000 feet) (500kg) and lower when operating at lower altitude, namely 13000 feet (390kg) (lower than expected due to shorter average estimated travel distance)
Safety	Safe	Around 0.0055 % chance on an accident per trip

Table 3.3.1: Summary table business model 3

Now, based on this analysis, the input parameters for the most profitable business model while taking into account sustainability and safety are:

- Standard TPS (average TPS = 1.49)
- Turboprop fleet
- Fleet of 100 aircraft (or more?)
- (to 10?)% profit on costs
- Leasing or buying doesn't have a significant influence (regarding profit, emissions and safety)
- Cruise altitude: 13000ft/3962m, long range modus
- Scheduled service

No additional service (yet additional service should be implemented when a higher profit goal is strived for)

- Operating region: Germany or a combination of Italy, Austria and Switzerland, or a similar country/region (in between this area size)

- Limit the number of airports to no more than 20 (or even 10?), dependent on how ecological the business model is desired to be
- Limit the number of trips to 50 per day (or more, dependent on the fleet size, keeping a ratio of 50% between fleet size and number of trips per day)

The parameters above are selected in order to increase profit, decrease cost or limit emissions. The selection of these parameters has the following effects (with the means to reach the goal between parentheses):

- Decrease the number of subcontracted aircraft (large fleet size, less airports, size and demand region fit to aircraft operated, operating at lower altitude)
- Decrease the amount of empty leg flights (ratio of trips per day over owned fleet of between 0.5 and 0.6, less airports, operating at lower altitude, size and demand region fit to aircraft operated)
- Increase the fleet utilization (large fleet size, operating at lower altitude, not operating too many airports/too large region)
- Increase the flights hours per year (large fleet size, less airports, operating at lower altitude)
- Decrease the CASK (ratio of trips per day over owned fleet of around 0.5 to 0.6, not implementing extra service, flying in long range rather than high speed modus)
- Increase the operating profit (large fleet size, increase profit goal to more than 5%)
- Increase sustainability (operating at lower altitude, not operating too many airports/too large region)

A conclusion which can be made is that a low cost business model will not result in the most profitable business model (similar to business model 1), when additional service (e.g. seat comfort) and an increase in the profit goal (i.e. the large difference between 5 and 10%) with a reflection on the ticket price (and resulting profit) is observed, as these parameters increase profit and do not fit within a low cost business model. Yet, similar to business model 2, maximizing revenue and operations in Europe are not the ideal solution either, causing a large increase in costs (especially due to the number of extra subcontracted aircraft required) and inefficiency in operations (empty leg flights, fleet utilization etc.).

Choosing a region fit to the fleet, not operating too many airports while making a trade-off between profit and sustainability (the less airports, the more efficient for profit, the more airports, the more sustainable yet also less operationally efficient) and selecting a flight altitude fit to the operations can make a significant difference, as observed by the graphs and numbers in this business model (and the previous two). As demand is large enough for the turboprop aircraft as well, increasing the profit goal of the airline (thereby increasing the ticket price for the passenger), or implementing extra service, should be considered if the most profitable business model is projected. Safety is approximately constant for all scenarios, thus concluded to be of less importance when selecting a business model.

3.4 Business model 4

First of all, the expectations made when the business model was designed in D2.2 are very different compared to the results. This can be explained mainly due to the inefficiency of operating a VLJ fleet with respect to empty legs, fleet utilization and flight hours per year (especially when compared to the piston fleet, which are at least a factor two better on these

parameters). A low cost pricing strategy (due to a low profit goal and no service) is required for the VLJ aircraft (in order to not decrease demand too much), yet not most profitable. The piston aircraft do not experience the same effect, thus a higher ticket price can be set and additional service implemented to attain more profit. However, a possible operating region suited to both operations was found (Spain and Germany), with the piston aircraft used for domestic travel and VLJ for transportation between the countries.

A region fit to combine a piston and VLJ fleet was found, suited to the operations. However, conflicts on the economical and cost level were observed, especially with regard to develop the most profitable business model (i.e. the negative effects on operations, costs and demand of a higher profit goal and additional service for the VLJ fleet). Yet, a very important factor in this business model is the sustainability. A VLJ is approximately a factor 20 less fuel efficient on an average trip compared to the piston aircraft. In addition, the demand is far lower for the VLJ (a factor 100 over entire Europe), which was elaborately explained by Geudens (2011)[4], making it hard to justify the usage of a VLJ for future operations with the fuel consumption observed.

3.5 Business model 5

A conclusion in line with the previous business model can be made. The chosen strategy in D2.2 is not a strategy which can uniformly be used over this business model in order to attain the highest profit and stay sustainable as well, especially with respect to combining a piston, turboprop and VLJ fleet. The same concept as in business model 4 was used as this was found to be most appropriate, thus to add the turboprop aircraft to the same kind of operations as the piston aircraft to come to business model 5 (next to the VLJ fleet used for operating between the countries). The operations can be summarized as using piston and turboprop aircraft to operate within Spain and Germany, operating approximately 20 to 25 aircraft per country, striving for a profit goal around 10%, an on-demand service, in which all additional service is added. The VLJ aircraft operate between Spain and Germany, from the same airports, yet attaining a lower profit goal (around 5%), with on-demand services as well, without additional service added.

Although a region fit to combine a piston, turboprop and VLJ fleet was found, suited to the operations, conflicts on the economical and cost level were observed, especially with regard to develop the most profitable business model (i.e. the negative effects on operations, cost and demand of a higher profit goal and additional service for the VLJ fleet). Next to the fact that operations for VLJ are (especially operationally, yet also on a cost basis) far less efficient and demand is a lot lower, operational (and cost) efficiency for turboprop aircraft is lower too, and demand is still also a factor 10 lower (and operations most efficient in approximately the same regions for the same number of airports).

However, a very important factor in this business model is sustainability. A VLJ is approximately a factor 20 less fuel efficient on an average trip compared to the piston aircraft, as the turboprop aircraft is. In addition, the demand is far lower for the VLJ (a factor 100 over entire Europe) and turboprop aircraft (a factor 10 over entire Europe), which was explained by Geudens (2011)[4], making it hard to justify the usage of a VLJ or turboprop aircraft for future operations with the fuel consumption observed.

4 THE MOST PROFITABLE, SUSTAINABLE AND SAFE BUSINESS MODEL

The objective of this chapter is to assess, which of the business models – and how their major influential parameters (such as fleet size, operational region or flight altitude) should be set to – provide the most profitable, sustainable, environmental friendly and safe small aircraft operations. To reach this goal, various scenarios were defined for each business case, in which different factors for the major influential parameters were assumed. By running the model (with the input parameters defined in the scenarios), the analysis of the results, such as fuel consumption, travel time, or load factor, permitted to select the scenario that is the most profitable, environmental friendly and safe.

4.1 Business models summary

This chapter gives an analysis of the 5 business models created in Chapter 3. Based on the sensitivity analyses per fleet type, the most influential parameters are the amount of trips per day, the fleet size, profit goal, additional service, operating region, number of airports and flight altitude. An overview of the output per fleet type can be observed in Table 4.1.1, for a fleet size of 15 aircraft, performing 10 flights per day (for more detail, the reader is referred to the business model analysis in this chapter). OD, SCH and SOD respectively stand for on-demand, scheduled and semi on-demand.

Parameter	Piston	VLJ	Turboprop
Utilization	Around 80%	25 - 30%	65 - 80%
Load factor	0.65(OD,SCH) or 1(SOD)	0.75(SOD,SCH) or 0.5(OD)	0.75(SOD,SCH) or 0.5(OD)
DOC	20.000.000 euro/year	300.000.000 euro/year	41.000.000 euro/year
CASK	6 - 8	16 - 18	12.5 - 14
Emissions	40kg fuel/flight	924kg fuel/flight	464kg fuel/flight

Table 4.1.1: Summary table business model output dependent on fleet type

4.2 Methodology

While the first idea on the most profitable, safe and sustainable business model could be already made from the analysis of the simulation results discussed under chapter 3, in this chapter an additional sensitivity analysis was performed. This consisted on the definition of 15 alternative scenarios, within various factors for the most influential parameters were assumed, as discussed below:

- Scenario 1: As for all business models, a standard travel party size is selected, for the piston fleet, performing 50 trips per day with 100 aircraft (an optimal operational combination, within computational limits of the model). A slightly yet still realistic profit of 10% is purposed, to increase profit (and since demand is large enough). The choice whether to buy or lease does not have a large influence, thus even though the choice to lease is selected, it is not of large influence to the output. The flight altitude of8000 feet proved to be optimal from previous simulations. Operations are on-demand, including all service (seat comfort, flexibility and reliability), an optimal recipe too. The amount of airports operated on is selected as 20, an optimal number as well. Other input parameters not mentioned are the estimate of flight hours per year and the maintenance bases used,
- Scenario 2: Operations are altered to Spain, a similar region to Germany with highest demand in Europe,

- Scenario 3: Operations are altered to France, a similar region to Germany with second highest demand in Europe,
- Scenario 4: The number of airports are decreased to 15, to see the effect of the number of airports in the best of the three regions tested,
- Scenario 5: The number of airports are increased to 25, to see the effect of the number of airports in the best of the three regions tested,
- Scenario 6: The number of airports are increased to 600, to see the effect of the number of airports in the best of the three regions tested (which is a number of airports from which operations for VLJ become more optimal to operations again),
- Scenario 7: The profit goal is decreased to 8%, to see the effect in the best of three regions tested, with the optimal amount of airports,
- Scenario 8: The profit goal is increased to 12%, to see the effect in the best of three regions tested, with the optimal amount of airports,
- Scenario 9: The additional service is decreased to only seat comfort, to see the effect in the best of three regions tested, with the optimal amount of airports and profit goal,
- Scenario 10: The additional service is decreased to only seat comfort and reliability, to see the effect in the best of three regions tested, with the optimal amount of airports and profit goal,
- Scenario 11: The amount of trips per day is decreased to 45, to see the effect in the best of three regions tested, with the optimal amount of airports, profit goal and amount of service.
- Scenario 12: The amount of trips per day is increased to 55, to see the effect in the best of three regions tested, with the optimal amount of airports, profit goal and amount of service,
- Scenario 13: The influence of semi on-demand services is simulated, to see the effect in the best of three regions tested, with the optimal amount of airports, trips per day, profit goal and amount of service,
- Scenario 14: The influence of scheduled services is simulated, to see the effect in the best of three regions tested, with the optimal amount of airports, trips per day, profit goal and amount of service,
- Scenario 15: The influence of flight altitude simulated at 6000 feet, to see the effect in the best of three regions tested, with the optimal amount of airports, trips per day, profit goal, amount of service and demand service.

#	TPS	Fleet	Fleetsize	Profit (%)	Leasing/buying	Altitude (ft)	Scheduled vs. (S)OD	WTPS	Region	Airport limit	Trip limit
1	Standard	Piston	100	10	Leasing	8000ft	On-demand	All comfort	Germany	20 airports	50/day
2	Standard	Piston	100	10	Leasing	8000ft	On-demand	All comfort	Spain	20 airports	50/day
3	Standard	Piston	100	10	Leasing	8000ft	On-demand	All comfort	France	20 airports	50/day
4	Standard	Piston	100	10	Leasing	8000ft	On-demand	All comfort	BEST OF 3	15 airports	50/day
5	Standard	Piston	100	10	Leasing	8000ft	On-demand	All comfort	BEST OF 3	25 airports	50/day
6	Standard	Piston	100	10	Leasing	8000ft	On-demand	All comfort	BEST OF 3	600 airports	50/day
7	Standard	Piston	100	8	Leasing	8000ft	On-demand	All comfort	BEST OF 3	BEST OF 4	50/day
8	Standard	Piston	100	12	Leasing	8000ft	On-demand	All comfort	BEST OF 3	BEST OF 4	50/day
9	Standard	Piston	100	BEST OF 3	Leasing	8000ft	On-demand	Seat comfort	BEST OF 3	BEST OF 4	50/day
10	Standard	Piston	100	BEST OF 3	Leasing	8000ft	On-demand	Seat + Reliability	BEST OF 3	BEST OF 4	50/day
11	Standard	Piston	100	BEST OF 3	Leasing	8000ft	On-demand	BEST OF 3	BEST OF 3	BEST OF 4	45/day
12	Standard	Piston	100	BEST OF 3	Leasing	8000ft	On-demand	BEST OF 3	BEST OF 3	BEST OF 4	55/day
13	Standard	Piston	100	BEST OF 3	Leasing	8000ft	Semi on-demand	BEST OF 3	BEST OF 3	BEST OF 4	BEST OF 3
14	Standard	Piston	100	BEST OF 3	Leasing	8000ft	Schedueld	BEST OF 3	BEST OF 3	BEST OF 4	BEST OF 3
15	Standard	Piston	100	BEST OF 3	Leasing	6000ft	BEST OF 3	BEST OF 3	BEST OF 3	BEST OF 4	BEST OF 3

Table 4.2.1.: An overview of the considered scenarios to find the most profitable, sustainable and safe business case.

By running a simulation for each scenario, the analysis of the results permits to locate, which set-up of the influential parameters lead to the most profitable, sustainable and safe SAT operation.

4.3 Results

Based on the previous analysis in business model 1 to 5, a piston fleet is selected as the base for the most profitable, sustainable and safe business model. The input parameters are chosen based on the conclusions made in business model 1 (scenario 1 in chapter 3). The most influential parameters on the operations of the business model were investigated. Selecting a single communal piston aircraft fleet seems to be the main influential parameter. The estimated SAT demand found in chapter 2 confirms the favour towards a piston fleet.

Besides the fleet selection, (i) the amount of aircraft, (ii) the trips performed per day, (iii) the profit goal, and (iv) the additional service are also main influential parameters. All of these can increase operating profit by at least a factor two by applying changes. The other influential parameters were investigated in this chapter too and are the operating region, number of airports operated from and flight altitude. The effect of on-demand vs. semi on-demand vs. scheduled services is simulated too for completeness.

Scenario	Δ *Profit*	Δ *Costs*	Δ *Emissions*
1. Germany	-34	-28	-18
2. Spain	-23	-12	-8
3. France	-38	-29	-6
Operations in Spain selected			
4. 15 airports	**100**	**100**	**100**
5. 25 airports	-35	-15	-7
6. 600 airports	-41	-9	-14
Operations over 15 airports selected			
7. 8% Profit goal	-34		
8. 12% Profit goal	+18		
Operations for 10% profit goal selected			
9. Seat comfort	-38	-37	
10. Seat comfort + Reliability	-29	-25	
Operations with all comfort selected			
11. 45 Trips/day	-17	-13	
12. 55 Trips/day	-5	+9	
Operations for 50 trips/day selected			
13. Semi on-demand	-16	-5	
14. Scheduled	(-3)	(-2)	
Operations for on-demand service selected			
15. 6000 feet	(-4)	(-2)	(+4)
Operations at 8000 feet selected			
The Most profitable, sustainable & safe business model			

Table 4.3.1.: Parameter influence percentages compared to the most profitable, sustainable & safe business model (scenario 4)

For more detail on the influence of these parameters, the reader is referred to the conclusion on business model 1 (Section 3.1). However, Table 4.3.1 with an overview of the sensitivity analysis on the most influential parameters with respect to obtaining the most profitable, sustainable and safe business model is provided above. Spaces are left white in case it does not contribute to the table, to have a better overview, e.g. a 1% difference in emissions is simply not displayed. In case less influential output was observed and considered important to mention in the table, it is put between parentheses. The table compares total costs, total profit and total emissions differences with the final chosen business model scenario operations (which is scenario 4, see chapter 4.2), marked in bold in the table, and the selection of a parameter after every main parameter sensitivity analysis written down in the table.

Finally, the most profitable, sustainable and safe business model can be defined as the one described in scenario 4, using the following input in the list of 12 items below. A maximum profit was strived for when designing the business model, while at the same time trying to maximize the operational efficiency, sustainability and safety. As operating turboprop and VLJ aircraft, emissions per average trip lay approximately a factor 20 higher, and operations far less efficient (see business model 4 and 5), these aircraft types were disregarded. Within the piston fleet, a trade-off needed to be made on whether to increase profit or decrease emissions. An example that was observed is the number of airports operated from. Fewer airports led to a higher profit but also more emissions, while more airports led to decreased emissions while sacrificing on profit. A final overview on these numbers is provided in Table 4.3.2.

Parameter	Average value	Remarks
Utilization	84%	While operating 1010 flight hours per year (average trip duration of 129 minutes, over 440 km), and only 4.9% empty leg flights
Load factor	0.65	Translatable to 1.3 passenger per flight, who fly at a cost of 5.5 euro per passenger per kilometer
DOC	Around 204.000.000 euro/year	With an actual profit of 8% on these costs (not equal to the 10% profit goal, which can partly be explained by the need for 22 subcontracted aircraft, equal to 11% of total costs). Translated to 2030, these DOC would be -77% (Geudens, 2011), thus equal to approximately 47.000.000 euro/year
CASK	Around 12.7	A higher value as observed for business model 1, which can mostly be explained due to the implementation of additional service (see previous chapter for more detail)
Emissions	Around 47kg fuel per flight on average	Equal to 60 liter per flight. Traveling by car (for the same target group, namely business passenger) consumes approximately 55 liter per trip of 440km (Geudens, 2011), thus approximately as fuel efficient as traveling by car
Safety	Safe	Around 0.0158% chance on an accident per trip

Table 4.3.2: Summary table: Most profitable, sustainable and safe business model

- Standard TPS (average TPS = 1.49)
- Piston fleet
- Fleet of 100 aircraft (or more?)
- 10% profit on costs
- Leasing (or buying, does not have a significant influence regarding operations, profit, costs, emissions and safety)
- Cruise altitude: 8000ft/2348m
- On-demand service (yet the specific service type does not have a significant influence regarding operations, profit, costs, emissions and safety)
- All additional service (seat comfort, reliability, flexibility)
- Operating region: Spain
- Limit the number of airports to 15
- Limit the number of trips to 50 per day (or more, dependent on the fleet size, keeping a ratio of 50% between fleet size and number of trips per day)
- (Flying approximately 1000 flight hours per year)

5 CONCLUSION

The objective of this deliverable was to assess the effect of the major influential variables within the business cases, in order to find the most profitable, safe, sustainable and environmental friendly business case.
Based on the business cases (as defined in *D2.1."Business case subscriptions with operational characteristics"*) and the impact parameters (as given in *D2.2. "Impact parameters & simulation model"*), at first, the simulation results of the alternative scenarios for each business cases are discussed. This was made by assuming various different factors for the most influential parameters of the business cases.
Regarding the business model 1, it was found that a low cost business model will not result in the most profitable business model, when the interest in the demand service, and an increase in the profit goal with a reflection on the ticket price is observed, as these parameters increase profit and do not fit within a low cost business model.
At the business model 2, it was concluded that operating a VLJ fleet does not seem that profitable, due to higher operating costs, being less attractive for the price sensitive demand, observed in D1.2.
Similarly to model 1, business model 3, as a low cost model isn't expected to be the most profitable business model. Business model 4 is also less attractive, as low cost pricing strategy (due to low profit goal and no service) which does not lead to the most profitable operations.
The selected strategy behind the business model 5 cannot be used to attain the highest profit and stay sustainable as well, especially by knowing that the fuel efficiency of a VLJ is far lower compared to a piston aircraft.

Finally, it was found, that the most profitable, sustainable and safe business model is reached with the following parameters:

- On-demand service (yet the specific service type does not have a significant influence regarding operations, profit, costs, emissions and safety)
- Standard TPS (average TPS = 1.49)
- Piston fleet
- Fleet of 100 aircraft (or more?)
- 10% profit on costs
- Cruise altitude: 8000ft/2348m
- All additional service (seat comfort, reliability, flexibility)
- Operating region: Spain
- Limit the number of airports to 15
- Limit the number of trips to 50 per day (or more, dependent on the fleet size, keeping
a ratio of 50% between fleet size and number of trips per day)
- Flying approximately 1000 flight hours per year
- Leasing (or buying, does not have a significant influence regarding operations, profit, costs, emissions and safety)

Further research is recommended in what the most profitable business models are in the new member states and Scandinavia region, which are characterized by relatively lower GDPs and poor alternatives due to underdeveloped infrastructure.

Additionally it is also recommended to research in the future how the implementation of the most profitable business model will enable passengers to achieve the FlightPath 2050 objective: "90% of travelers within Europe are able to complete their journey, door-to-door within 4 hours."

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APPENDIX A: BUSINESS MODEL 1 RESULTS

#	TPS	Fleet	Fleetsize	Profit (%)	Leasing/buying	Altitude (ft)	Scheduled vs. (S)OD	WTPS	Region	Airport limit	Trip limit
3	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	-50%	5/day
4	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	-50%	10/day
5	Standard	Piston	15	10	Leasing	8000ft	Semi on-demand	No	12	-50%	10/day
6	Standard	Piston	15	20	Leasing	8000ft	Semi on-demand	No	12	-50%	10/day
7	Standard	Piston	15	50	Leasing	8000ft	Semi on-demand	No	12	-50%	10/day
8	Standard	Piston	5+5+5	5	Buying	8000ft	Semi on-demand	No	12	-50%	10/day
9	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	-75%	10/day
10	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	No	10/day
11	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	100 airports	10/day
12	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	250 airports	10/day
13	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	-50% (2 maintenance bases)	10/day
14	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	12	-50% (18 maintenance bases)	10/day
15	Standard	Piston	15	5	Leasing	8000ft	On demand	No	12	-50%	10/day
16	Standard	Piston	15	5	Buying	8000ft	Semi on-demand	No	12	-50%	10/day
17	Standard	Piston	15	5	Leasing	8000ft	Scheduled	No	12	-50%	10/day
18	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	2	-50%	10/day
19	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	No	3	-50%	10/day
20	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	Seat comfort	12	50%	10/day
21	Standard	Piston	15	5	Leasing	8000ft	Semi on-demand	All	12	50%	10/day
22	Standard	Piston	15	5	Leasing	3000ft	Semi on-demand	No	12	50%	10/day
23	Standard	Piston	15	5	Leasing	6000ft	Semi on-demand	No	12	50%	10/day
24	Standard	Piston	30	5	Leasing	8000ft	Semi on-demand	No	12	-50%	10/day
25	Standard	Piston	30	5	Leasing	8000ft	Semi on-demand	No	12	-50%	15/day
26	Standard	Piston	30	5	Leasing	8000ft	Semi on-demand	No	12	-50%	20/day
27	Standard	Piston	30	5	Leasing	8000ft	Semi on-demand	No	12	-50%	25/day
28	Standard	Piston	100	5	Leasing	8000ft	Semi on-demand	No	12	-50%	25/day
29	Standard	Piston	100	5	Leasing	8000ft	Semi on-demand	No	12	-50%	50/day
30	Standard	Piston	100	5	Leasing	8000ft	Semi on-demand	No	12	-50%	65/day

TableA.1: Scenario Overview

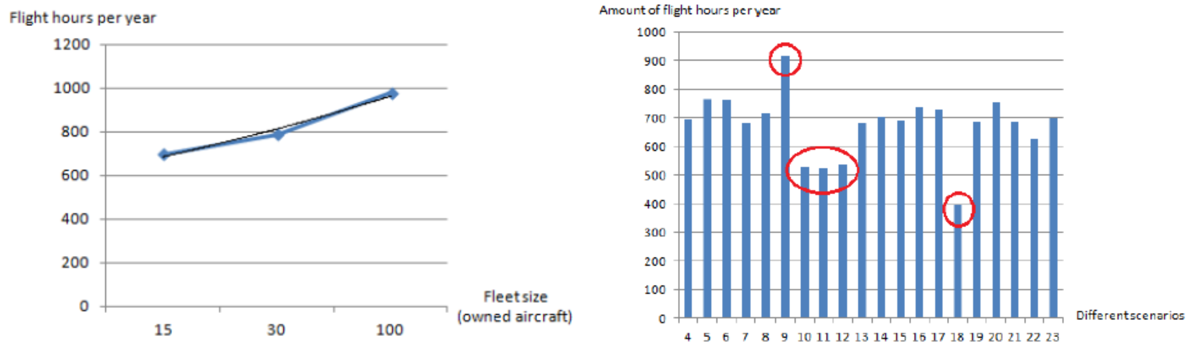


Table A.2: Flight hours per year, dependent on fleet size (with a two third ratio for trips/day over owned fleet size)

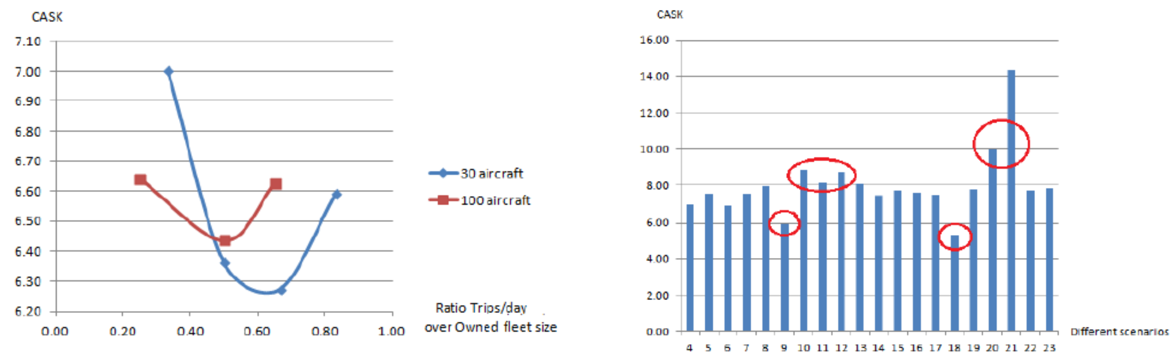


Table A.3: Cost per Available Seat Kilometre (CASK), dependent on the ratio for trips/day over owned fleet size, for an owned fleet size of 30 and 100 aircraft

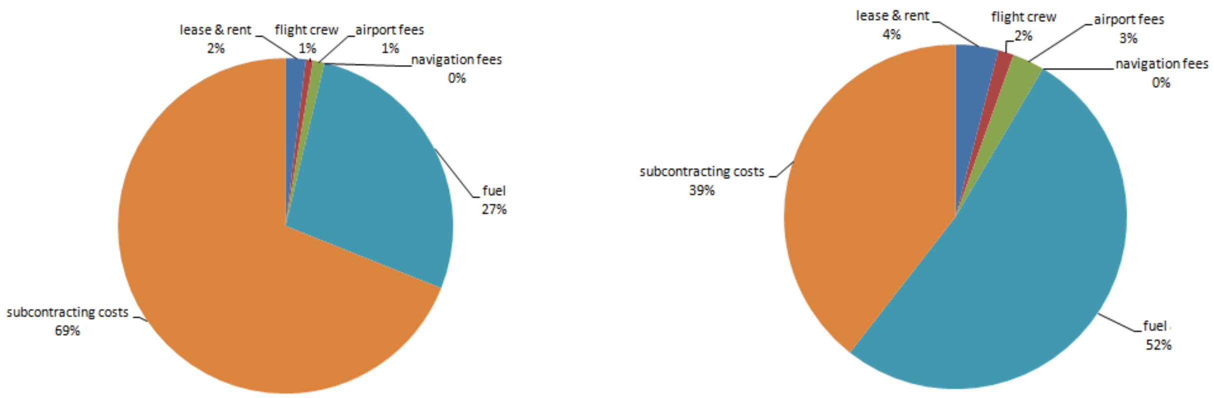
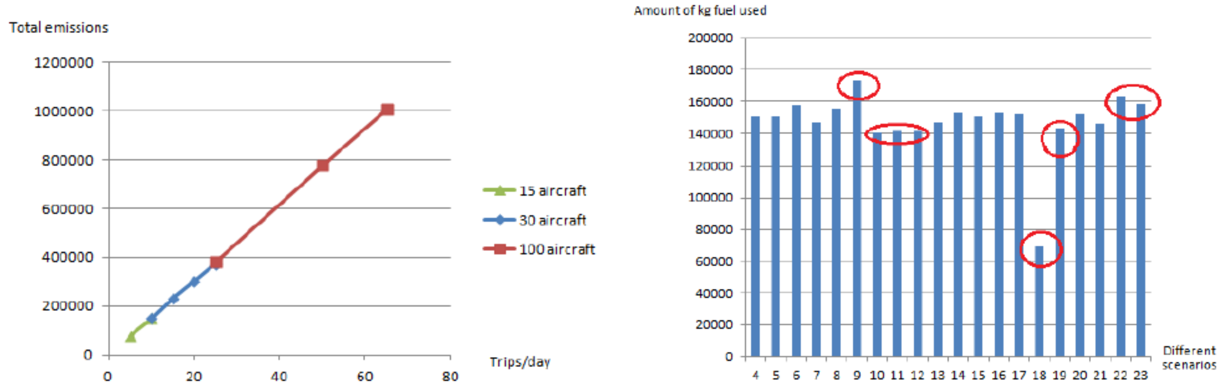


Table A.4: Cost breakdown for scenario 4 and 12
(subcontracting costs are cost related to neither non-owned nor leased aircraft, e.g. brokered aircraft)



TableA.5: Total emissions (kg fuel)

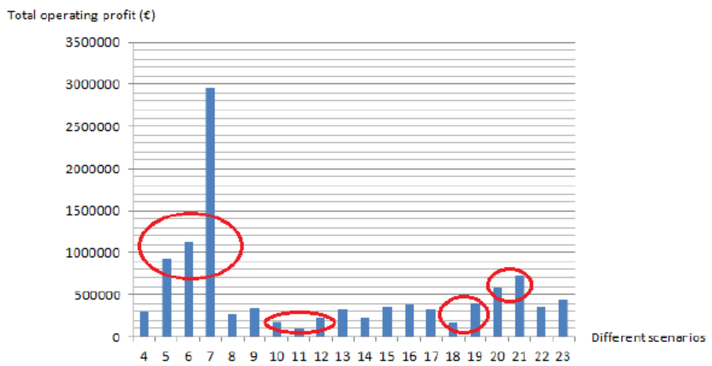
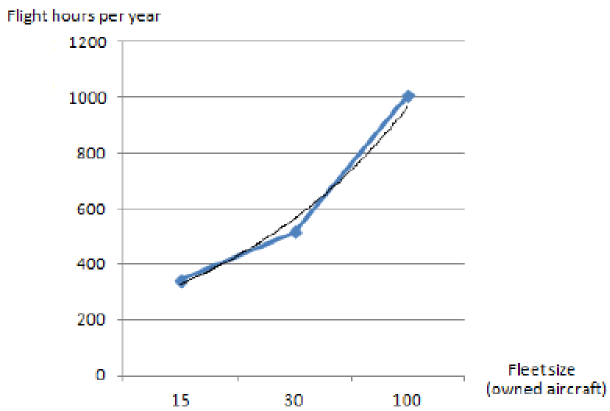


Table A.6: Total operating profit

APPENDIX B: BUSINESS MODEL 2 RESULTS

#	TPS	Fleet	Fleetsize	Profit (%)	Leasing/buying	Altitude (ft)	Scheduled vs. (S)OD	WTPS	Region	Airport limit	Trip limit
3	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	-50%	5/day
4	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	-50%	10/day
5	Standard	VLJ	15	10	Leasing	37000ft	Semi on-demand	No	12	-50%	10/day
6	Standard	VLJ	15	20	Leasing	37000ft	Semi on-demand	No	12	-50%	10/day
7	Standard	VLJ	15	50	Leasing	37000ft	Semi on-demand	No	12	-50%	10/day
8	Standard	VLJ	5+5+5	5	Buying	37000ft	Semi on-demand	No	12	-50%	10/day
9	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	-75%	10/day
10	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	No	10/day
11	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	400 airports	10/day
12	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	600 airports	10/day
13	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	-50% (2 maintenance bases)	10/day
14	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	-50% (18 maintenance bases)	10/day
15	Standard	VLJ	15	5	Leasing	37000ft	On demand	No	12	-50%	10/day
16	Standard	VLJ	15	5	Buying	37000ft	Semi on-demand	No	12	-50%	10/day
17	Standard	VLJ	15	5	Leasing	37000ft	Scheduled	No	12	-50%	10/day
20	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	Seat comfort	12	50%	10/day
21	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	All	12	50%	10/day
23	Standard	VLJ	15	5	Leasing	43000ft	Semi on-demand	No	12	50%	10/day
24	Standard	VLJ	30	5	Leasing	37000ft	Semi on-demand	No	12	-50%	10/day
25	Standard	VLJ	30	5	Leasing	37000ft	Semi on-demand	No	12	-50%	15/day
26	Standard	VLJ	30	5	Leasing	37000ft	Semi on-demand	No	12	-50%	20/day
27	Standard	VLJ	30	5	Leasing	37000ft	Semi on-demand	No	12	-50%	25/day
28	Standard	VLJ	100	5	Leasing	37000ft	Semi on-demand	No	12	-50%	25/day
29	Standard	VLJ	100	5	Leasing	37000ft	Semi on-demand	No	12	-50%	50/day
30	Standard	VLJ	100	5	Leasing	37000ft	Semi on-demand	No	12	-50%	65/day
31	Standard	VLJ	15	5	Leasing	37000ft	Semi on-demand	No	12	-50%	10/day

TableB.1: Scenario Overview



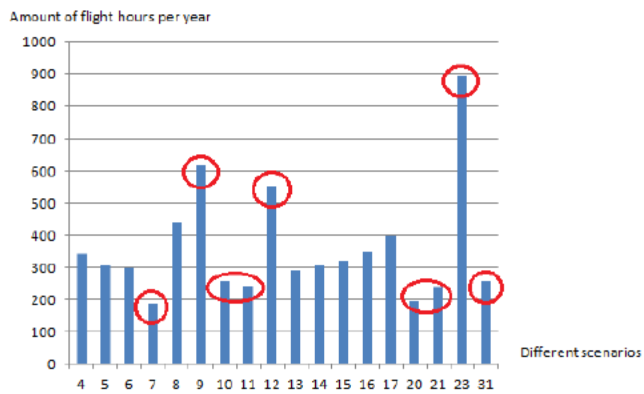
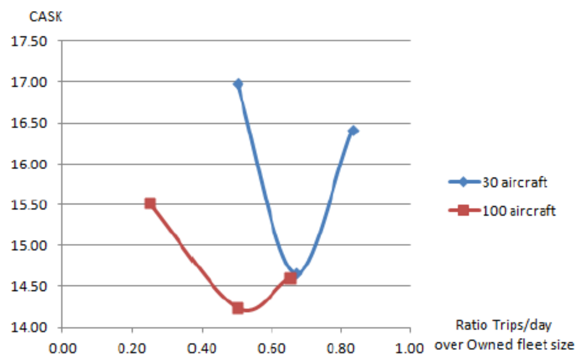


Table B.2: Flight hours per year, dependent on fleet size (with a two third ratio for trips/day over owned fleet size)



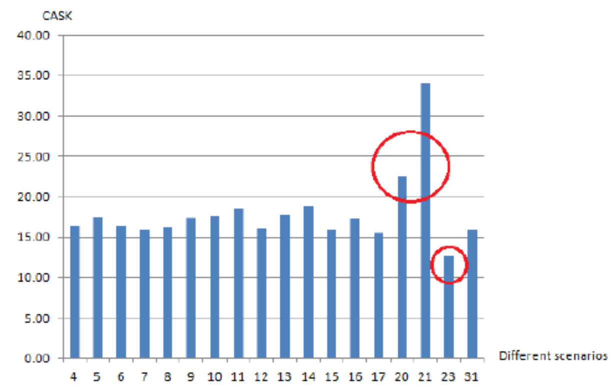


Table B.3: Cost per Available Seat Kilometre (CASK), dependent on the ratio for trips/day over owned fleet size, for an owned fleet size of 30 and 100 aircraft

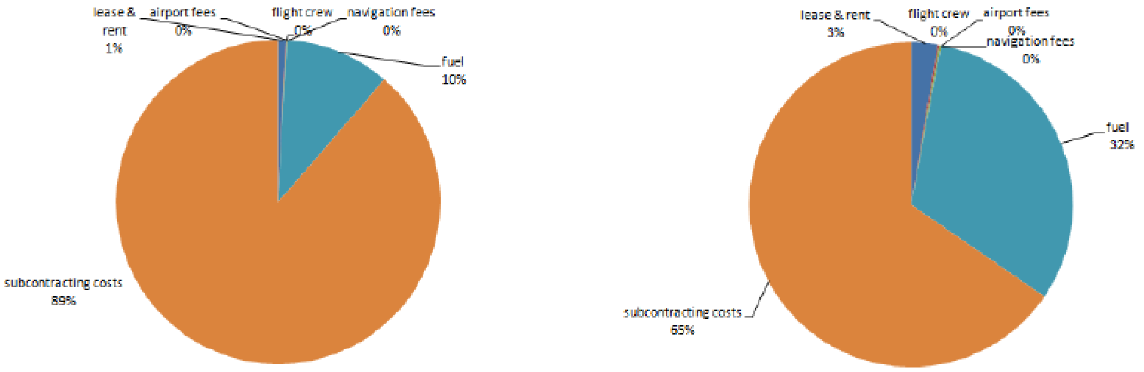


Table B.4: Cost breakdown for scenario 4 and 30

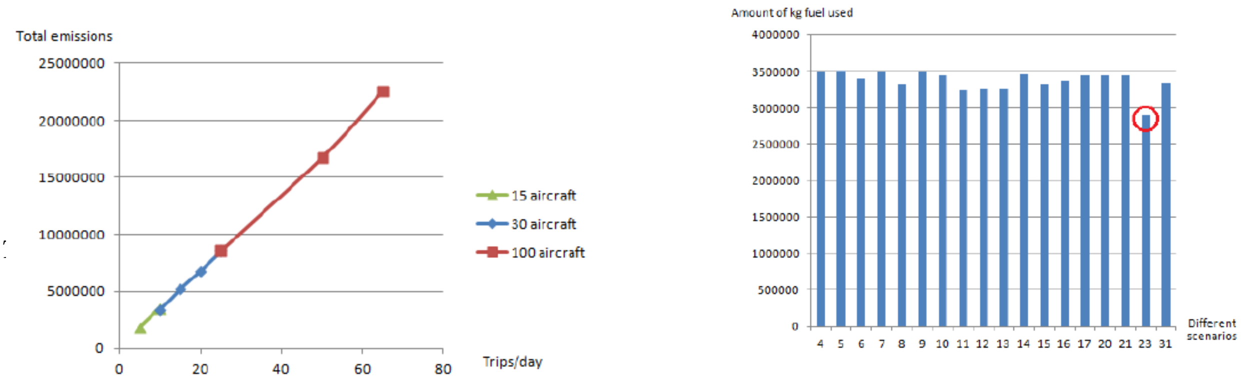


Table B.5: Total emissions (kg fuel)

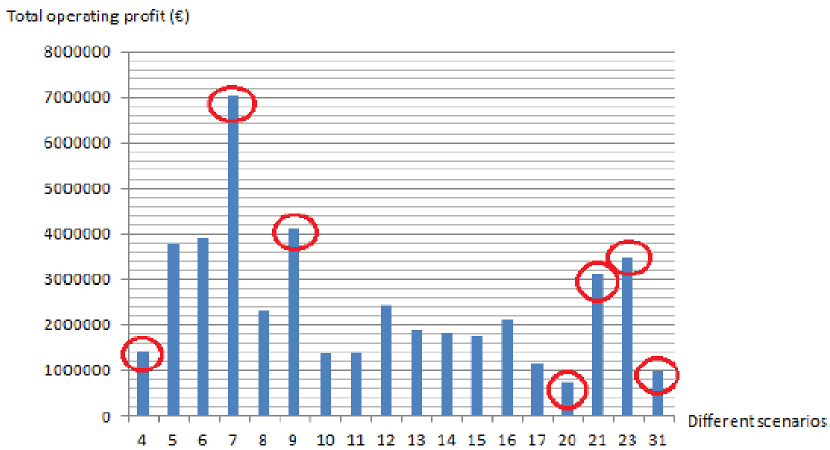


Table B.6: Total operating profit

APPENDIX C: BUSINESS MODEL 3 RESULTS

#	TPS	Fleet	Fleetsize	Profit (%)	Leasing/buying	Altitude (ft)	Scheduled vs. (S)OD	WTPS	Region	Airport limit	Trip limit
3	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	5/day
4	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	10/day
5	Standard	Turboprop	15	10	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	10/day
6	Standard	Turboprop	15	20	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	10/day
7	Standard	Turboprop	15	50	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	10/day
8	Standard	Turboprop	5+5+5	5	Buying	25000ft, LR	Semi on-demand	No	12	-50%	10/day
9	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	-75%	10/day
10	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	No	10/day
11	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	100 airports	10/day
12	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	250 airports	10/day
13	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50% (2 maintenance bases)	10/day
14	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50% (18 maintenance bases)	10/day
15	Standard	Turboprop	15	5	Leasing	25000ft, LR	On demand	No	12	-50%	10/day
16	Standard	Turboprop	15	5	Buying	25000ft, LR	Semi on-demand	No	12	-50%	10/day
17	Standard	Turboprop	15	5	Leasing	25000ft, LR	Scheduled	No	12	-50%	10/day
18	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	3	-50%	10/day
19	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	1	-50%	10/day
20	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	Seat comfort	12	50%	10/day
21	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	All	12	50%	10/day
22	Standard	Turboprop	15	5	Leasing	13000ft, LR	Semi on-demand	No	12	50%	10/day
23	Standard	Turboprop	15	5	Leasing	25000ft, HS	Semi on-demand	No	12	50%	10/day
24	Standard	Turboprop	30	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	10/day
25	Standard	Turboprop	30	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	15/day
26	Standard	Turboprop	30	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	20/day
27	Standard	Turboprop	30	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	25/day
28	Standard	Turboprop	100	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	25/day
29	Standard	Turboprop	100	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	50/day
31	Standard	Turboprop	75	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	25
32	Standard	Turboprop	75	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	38
33	Standard	Turboprop	75	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	50
34	Standard	Turboprop	15	5	Leasing	13000ft, HS	Semi on-demand	No	12	-50%	10/day
35	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	12	-50%	10/day
36	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	1	No	10/day
37	Standard	Turboprop	15	5	Leasing	25000ft, LR	Semi on-demand	No	13	-50%	10/day

Table C.1: Scenario Overview

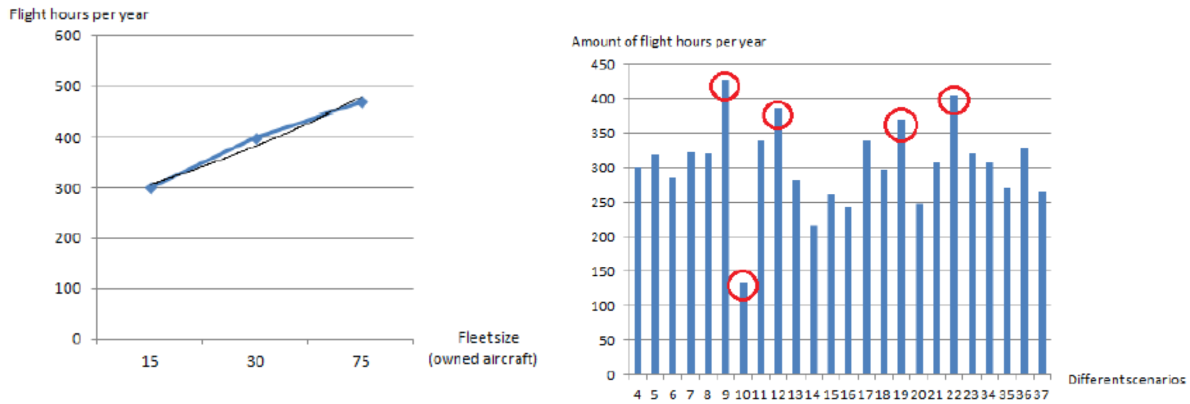


Table C.2: Flight hours per year, dependent on fleet size (with a two third ratio for trips/day over owned fleet size)

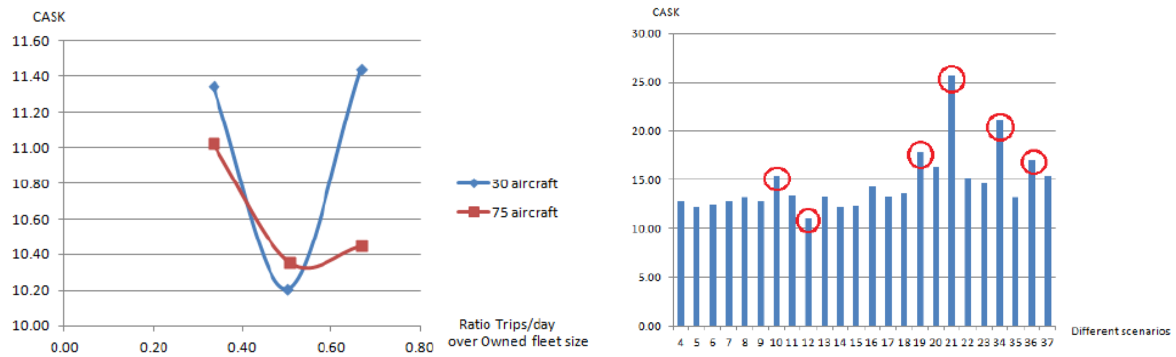


Table C.3: Cost per Available Seat Kilometre (CASK), dependent on the ratio for trips/day over owned fleet size, for an owned fleet size of 30 and 100 aircraft

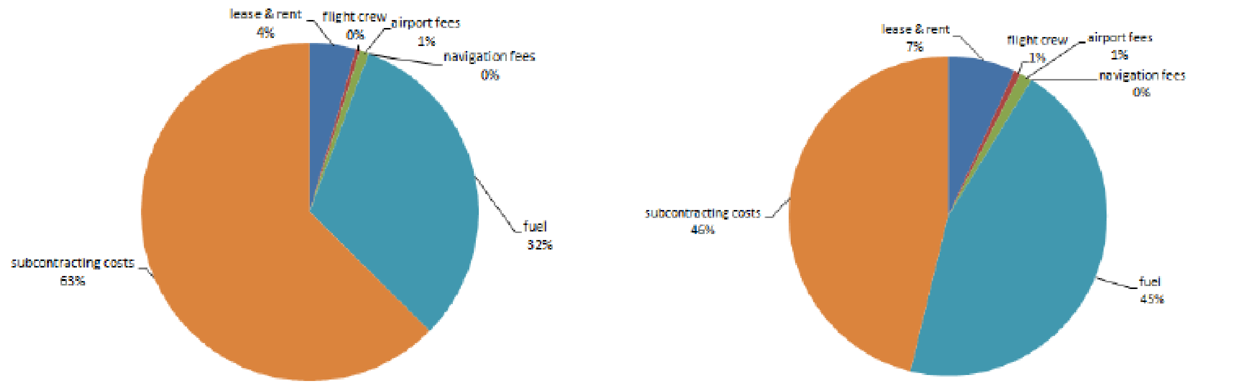
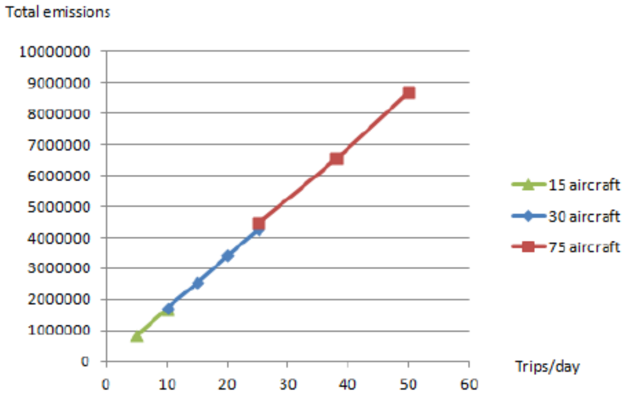


Table C.4: Cost breakdown for scenario 4 and 33



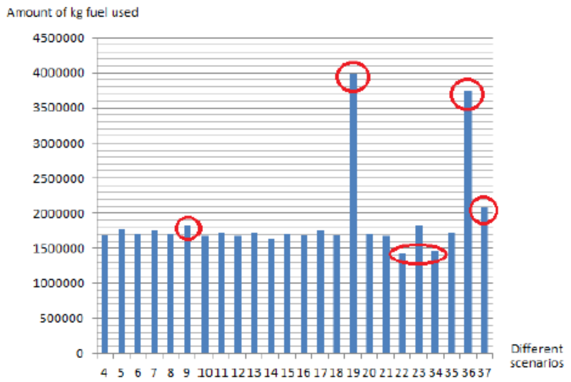


Table C.5: Total emissions (kg fuel)

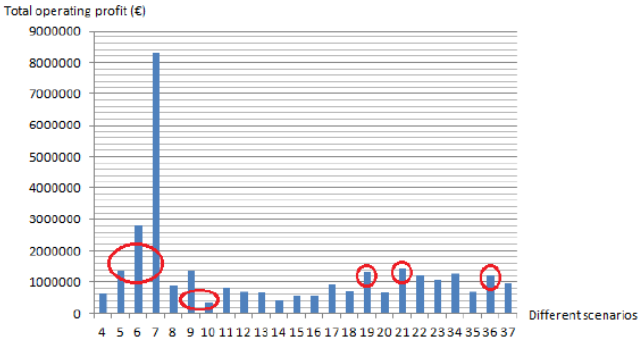


Table C.6: Total operating profit