SURVEY OF FLIGHT OPS ORGANIZATION AND EXISTING/FUTURE FLIGHT OPTIMIZATION TECHNIQUES USED BY BUSINESS JET OPERATORS

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Abstract

This report is written by OpenAirlines for the project Clean Sky BASE. This report is a deliverable for work packages 4.1 and 5.2: it is a survey of the flight practices of the business jet operators, their fueling strategies and their usages and adoptions of fuel saving best practices.

In order to write this report we have conducted an online survey among the business jet operators, and several interviews to complete this survey. We also used results from several studies published for the NBAA, EBAA and EUROCONTROL to give a broader insight on the business jet aviation organizations and techniques.

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TABLE OF CONTENTS

1 INTRODUCTION

The aim of this report is to survey the operations organizations and practices of the business jet operators, in order to understand their practices regarding noise and environment and the future evolution of those practices. For that purpose, we conducted an online survey that we have completed with interviews of several business jet operators and few published studies on business aviation.

1.1 SURVEY AND INTERVIEWS METHODOLOGY

In order to survey the business jet aircraft operators we have conducted an online survey and a series of interviews with people from the bizJet domain. The goal of the online survey was to reach a large amount of operators, whereas with the individual interviews we aimed at getting more details than we could have with an online survey.

1.1.1 ONLINE SURVEY

The online survey was co-written by SustainAvia and OpenAirlines. It was written in order to produce the necessary material for *work package 4 & 5* of project Clean Sky BASE. The survey was organized into 6 parts:

1. *Project presentation & survey presentation:* quick insight of the project BASE / contact and position in the airline
2. *Identification of the aircraft operator:* identification of the operator
3. *Operational organization:* how the aircraft operators organize their operations
4. *Environmental costs:* costs of environment in airline budget
5. *Flight ops optimization:* survey of techniques used and future techniques to optimize flight ops.

The survey was distributed through the business networks of SustainAvia, and got 164 participants. Among them, 100 finished the questionnaire (about 60%).

While the questionnaire was being completed by the operators, SustainAvia noticed that the answers rate was poor on the question about direct operating costs (DOC), therefore they added a 6th part with a simplified question on the DOC. Thanks to this last question they gathered 49 more answers on DOC for a total of 60 answers to this question.

On Figure 1 we reported the average amount of answers for each part of the survey. The questions on the airline identification (part 2) and on the operational organization (part 3) were answered by a large amount of participants (more than 120). We got fewer answers on costs (part 4) and flights ops (part 5) but the rate of answers for thoses two parts is close to 100 which still gives a good number of answers.

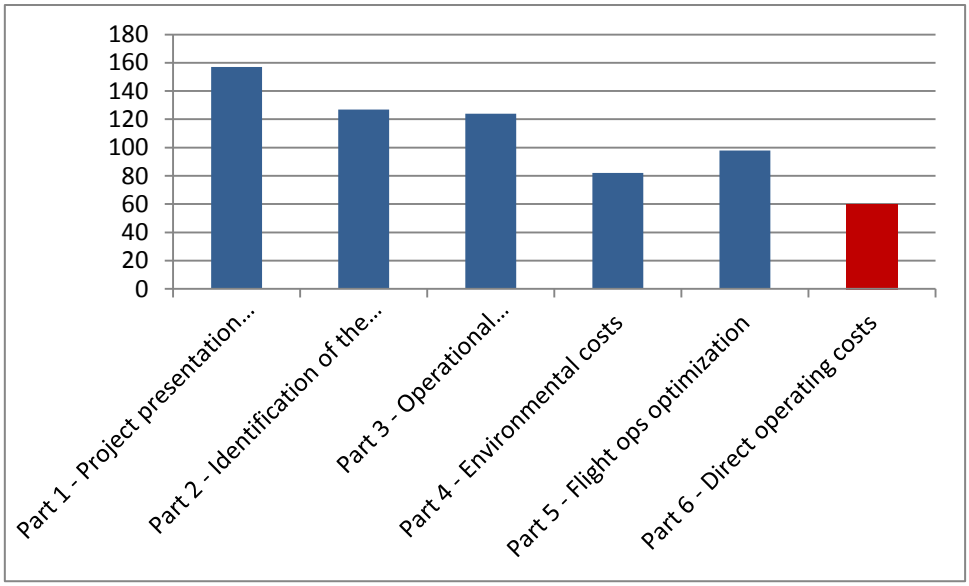

Figure 1 Average amount of answers by part. In red the additional part 6

The biz jets are classically operated under the following business model:

Private pilots – Non commercial business model, where the pilots own their aircraft and fly them for business or private purposes.

Corporate aviation – Non commercial business model where a professional crew flies the aircraft for a company

Air charter services – Commercial organization that performs charter flights (i.e. non regular) or on demand air taxi services.

Aircraft management – Commercial organization managing aircraft fleet for different clients (owners), i.e. the owner can outsource the management of the maintenance, the schedule, the administrative tasks, the crew, etc. to an Aircraft management company.

On Figure 2 we reported the answers of the operators we surveyed to the question *what is your business model/type of operations*. Most of the operators surveyed are *corporate aviation operators*. We also suspect that most of the pilots who answered private pilot are in fact part of corporate aviation because they also answered their flight department has few employees (hence they are not private pilot).

It is a weakness we identified for the BASE survey. For this reason we tried to interview mostly Air charter and aircraft management airlines. In this report we also used results from others published studies to consolidate the tendencies identified from our survey.

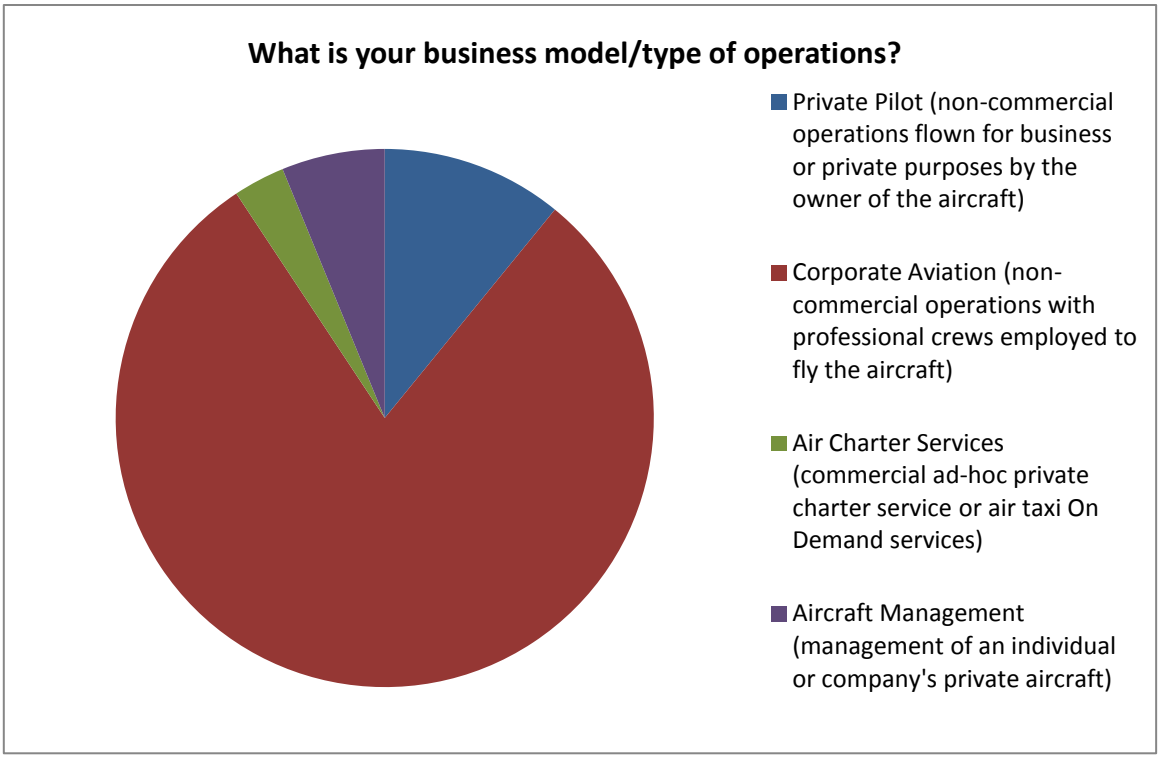

Figure 2 BASE Survey - What is your business model/type of operations?

According to Figure 3, another bias of the survey is that we successfully surveyed North American and few European ones; participations from other origins of the globe are marginal: participations from Africa, Middle East, Oceania, and Asia represents less than 25% of the participations to our survey.

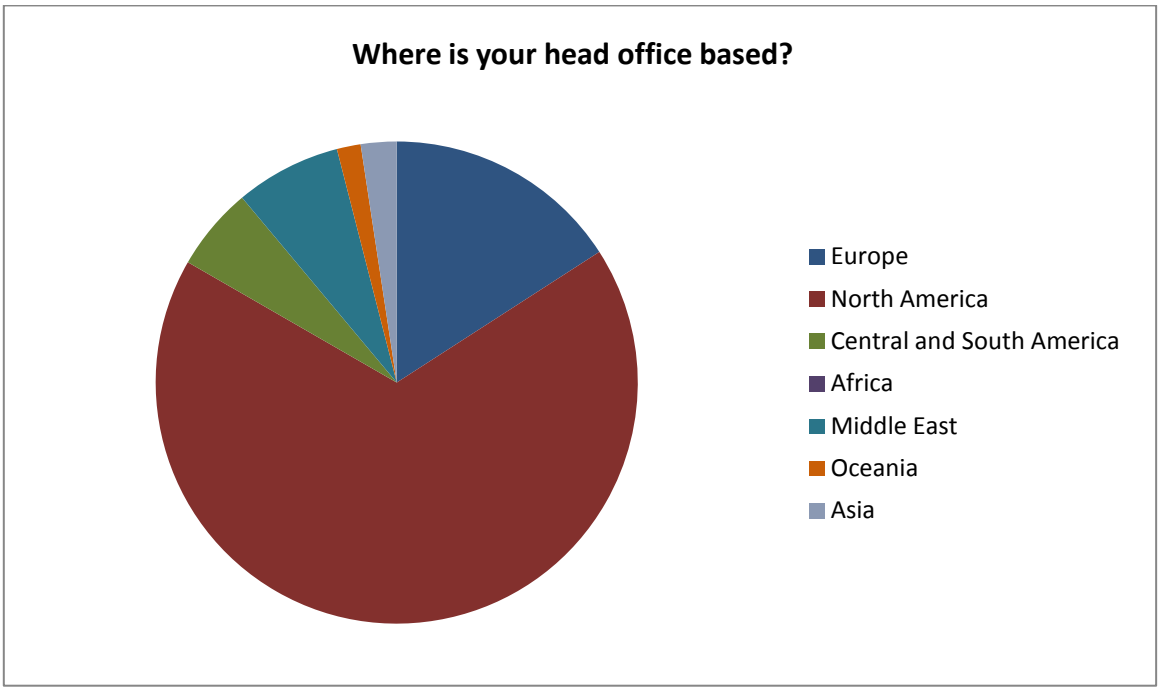

Figure 3 BASE Survey - Where is your head office based?

1.1.2 INTERVIEWS

In order to have more information about the biz jet costs and operations techniques, SustainAvia conducted interviews with several contacts working in the domain of the biz jet (airlines, constructors, etc.). Among those companies, SustainAvia interviewed:

- Dassault Falcon Service (Aircraft management and Air charter)
- ExecuJet (Aircraft management and Air charter)
- COMLUX Aviation (Aircraft management and Air charter)
- JetAviation (Aircraft management and Air charter)
- FTC Consulting (Aircraft management company / Air charter)
- A former member of EBAA and Dassault Aviation

In order to make those interviews happened, it was guaranteed the interview would be confidential, and the information gathered would only be used inside the report hence no minutes of those interviews are integrated within this report.

1.2 DOCUMENT ORGANIZATION

The document is organized this way:

Chapter 2 – *Organization of the operations* aims at describing the operations and the structure of the business jet operators. In a first time, we describe the service given by the business jet airlines: their size and structure, their clients and the reasons to fly with a business jet aircraft. Then we describe the operations (without the flight techniques): the destinations, the preparations and the debriefings of the flight, and the outsourced tasks. Lastly we describes from the interviewed we made the fueling strategies of the business jet airlines and how pilots apply those strategies.

Chapter 3 – *Flight optimization practices* describes the practices regarding the environment of the business jet operators. First we described their priorities for flight optimization. Then we synthesized their answers regarding noise issues and the impact on their operations of noise regulations. And lastly we reported the fuel best practices used within the operators and the tendencies on technology investment best practices.

Chapter 4 – *Conclusions* is the conclusions drawn from the survey on the practices of business jet operators.

2 ORGANIZATION OF THE OPERATIONS

This chapter describes the organization of the business jet operators. We tried to identified what was the service given by the business jet operators, why did the passenger use business jet, and who inside the business jet operators was performing the different tasks needed for the operations (operations limit studies, flight planning, aircraft rotations, etc.) and last we detail how fuel strategies can be applied within business jet operators and how pilots can use them in practice by using rule of the thumb.

2.1 THE BUSINESS AVIATION SERVICE

2.1.1 WHO ARE THE OPERATORS?

Two third of the operators which have participated to our online survey have a very small amount of employees in their flight ops department (most have less than 5 employees). The business jet operators generally don't fly a large number of hours. In our survey the corporate aviation declares a median value of 400 flight hours per year whereas air charter and aircraft management declares a median value of 700 flight hours per year.

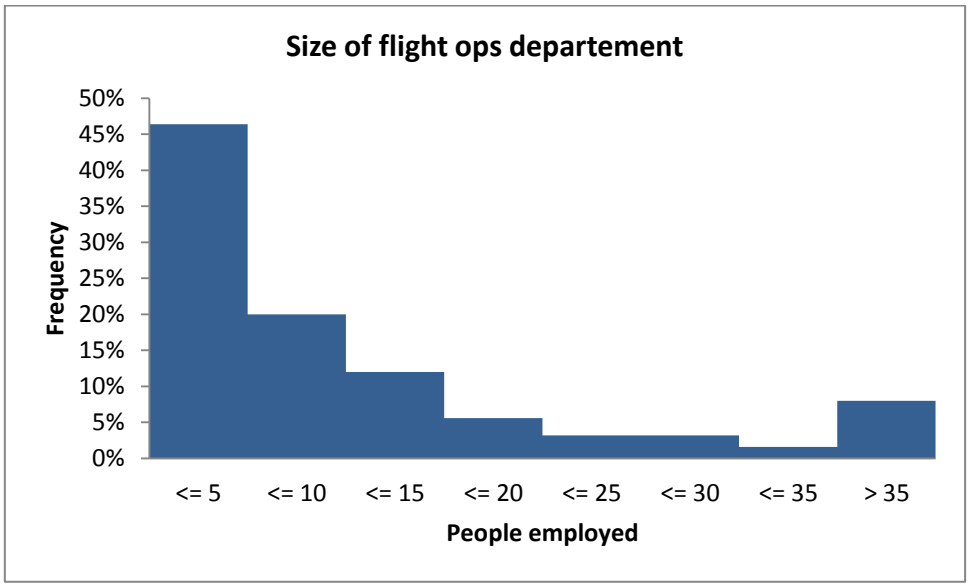

Figure 4 BASE Survey - Number of employees in flight ops department?

EUROCONTROL in *Getting to the point: Business Aviation in Europe* (May 2006, and May 2008) confirms most business operators are small operators or individuals. There is at least the same number of business jet operators than regular commercial airlines but the traffic is 10 times lower, which lead EUROCONTROL to conclude business jet operators market is dominated by "individual" and "small firms".

To complete these figures, the National Business Aviation Association (NBAA), which surveyed over 7000 business jet airlines during a study on business aviation in 1997, found out that 85% of the companies operating turbine-powered aircraft operate only one aircraft (see Figure 5). These numbers given by the NBAA are quite consistent with the figures of our survey, basically the business jet operators are small operators with a small amount of employees and only one aircraft.

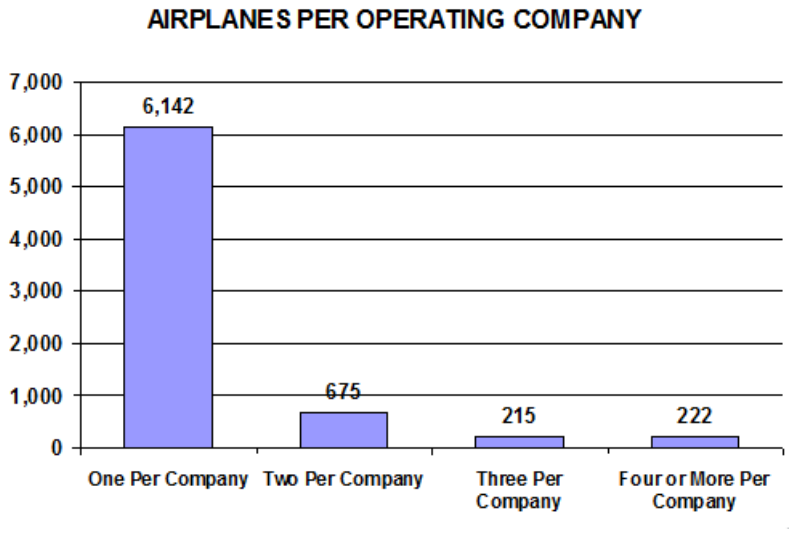

Figure 5 NBAA Survey (1997) - Size of the fleet

The operators have a small size with really few aircraft (often only 1) and they don't fly a large amount of hours. In order to understand how size impacted the flight hours we aggregated the average flight hours for flight department with less than 10 employees (small flight department) and with more than 10 employees. According to our survey small flight departments (less than 10 employees) have a median number of annual flight hours of 250 hours when larger flight departments declare to have median flight hours of 685 hours. In order to have an insight on these figures we checked the result with a study made by Harris interactive.

In 2009, Harris conducted a study for the NBAA and the General Aviation Manufacturers Association (GAMA) called *The Real World of Business Aviation: A Survey of Companies Using General Aviation Aircraft.* The survey was sent to operators and clients from business aviation in the United States. In this study (see Figure 6), Harris found the following figures (on a survey of US airlines):

- Airlines operating only one aircraft flew an average of 291 hours
- Airlines operating more than one aircraft flew an average of 431 hours

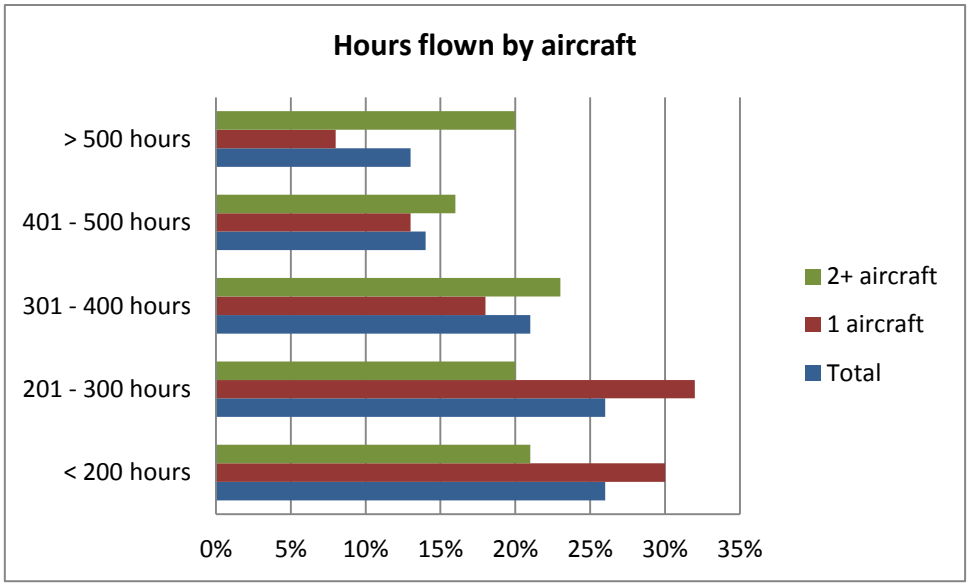

Figure 6 Harris Survey - Hours flown by aircraft in 2008

Their figures are a little bit different than ours[1], however it shows the same tendency of having a small amount of flight hours per year per aircraft. It is paramount important to understand that a large amount of the business jet operators don't fly much a year. One of the effects of this is that operators that fly a small number of hours per year are less sensible to technology improvement based on return on investment that usually depends on the amount of flight hours.

Thanks to our survey we noticed that size of the flight department is somehow correlated (see Figure 7) with the number of annual flown hours i.e. it is correlated to the activity of the flight department.

[1] The questions were slightly different too: we asked the approximate total, they asked the logged flight hours by aircraft.

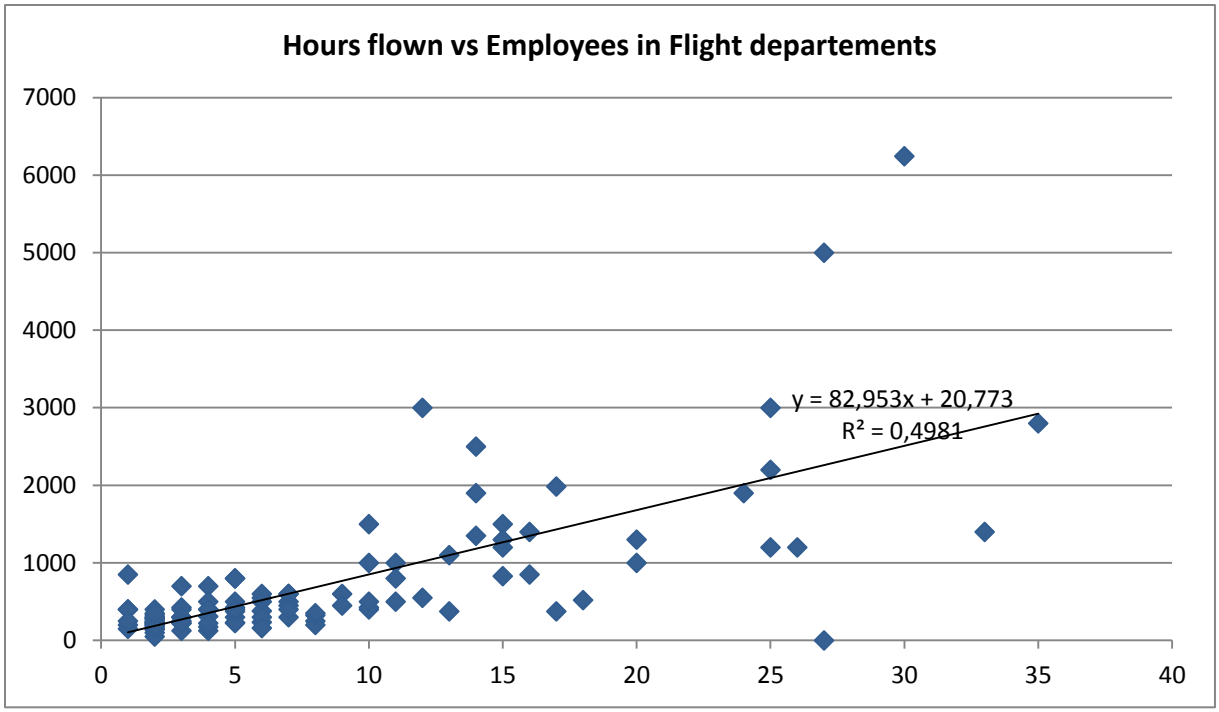

Figure 7 BASE Survey - Total annual hours flown vs. Employees in the flight departements

However those studies and surveys fail to depict entirely the service given by the Air Charters and Aircraft management airlines because of the very large number of private pilots and corporate flight departments. The structures of those airlines are bigger than flight departments from corporate aviation. In their employees organization we will find more similitude (flight dispatcher, flight attendant/purser, etc.) with commercial airline, the additional cost of having a cabin crew is generally passed to the client. However from the answer of the interviews we did understand that they don't fly a large number of hours per aircraft (figures often given is an approximate 500 hours per aircraft).

2.1.2 WHO ARE THE USERS?

In 1997, the NBAA made a survey on the reasons why people uses business jet (see Figure 8). It appeared the main reasons were *to keep efficient schedule* and then *to reach remote location*. Basically, business aviation is used as an efficient way to travel and:

- Avoid delays at maximum: EUROCONTROL showed in 2007 that biz jet flights were proportionally delayed less often by en route control than commercial jet. However when they were delayed the delay was greater.
- Fly to destination harder to reach with commercial jet: Eurocontrol showed that 2/3 of the flights of made with business aircraft in 2007 were connecting cities not serviced by daily scheduled commercial flights.

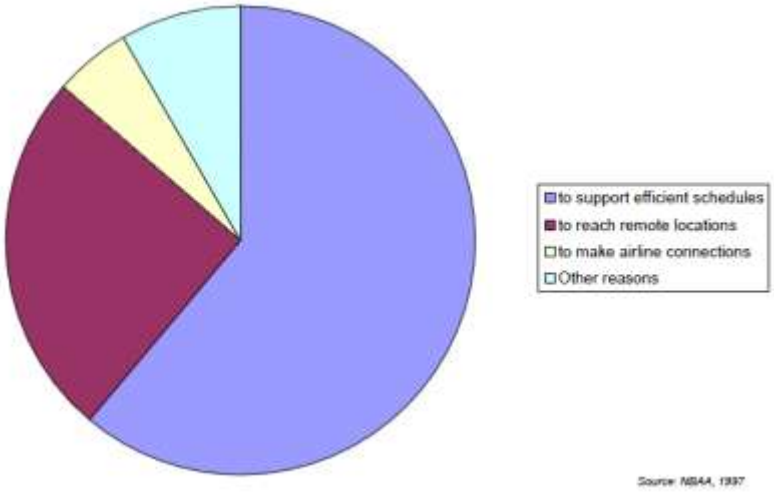

Figure 8 NBAA Survey (1997): Reasons to use Business Aircraft

To keep efficient schedule, business aviation is generally operated on business airports or regional airports with an affair terminal, it is faster for the client to go through the check points and it means flying from (respectively to) a less congested airport, i.e. less chance to be delayed for takeoff or put on a holding stack during the approach. These tendencies were confirmed in the 2009 Harris Survey with the following results:

- 64% support schedules not met with scheduled airlines
- 19% reach locations scheduled airlines do not serve
- 6% industrial or personal security reasons (privacy)
- 1 % make connections with scheduled airline flights
- 9% other reasons

One of the reason some passengers answered industrial or personal security reasons is that CEOs or important personalities may need to keep their movements secret in order to sign very important contract.

Interviewed operators explained that they were generally waiting for the client to arrive with the aircraft ready, i.e. the aircraft is almost ready for takeoff when the passenger boards. For some operators it means they have more hours of APU than flight. It is an “always ready” policy.

In the Harris survey we have learnt that most people using the business aviation are managers, i.e. 72% of the answers distributed in 22% of top managers and 50% of managers (see Figure 9).

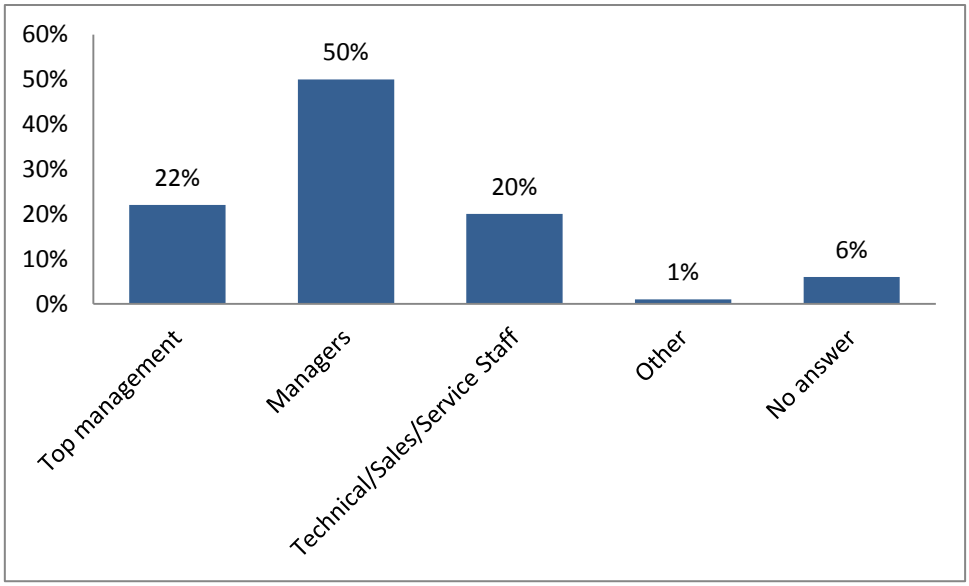

Figure 9 Harris Survey – Passenger title in their organizations (in 2009)

The users of business aviation are generally head of companies' top managers or managers. According to Harris Survey they declare to be able to accomplish work tasks more easily while flying on a business aircraft instead of a commercial airliner. 46% (respectively 10% on commercial airliner) of them also declare to use the internet access available on-board often or really often, whereas only 21% (respectively 52% for commercial airliner) declare to never use it.

2.1.3 CONCLUSIONS

- Business jet operators are generally small structures, they have few employees (45% of the answers declare less than 5 employees) and a very small fleet, i.e. generally 1 aircraft
- Business jet operators don't fly a large amount of hours with their aircraft (average of 358 hours per aircraft per year)
- Users of business jet aircraft are managers and technical people, and generally use their time to work during their travel in business jet.
- They use business jet aircraft to keep efficient schedule and to reach remote location that wouldn't be easily reached with commercial schedule airlines. Time is important; they want to fly close to their final destination.

2.2 OPERATIONS

2.2.1 WHERE DO BUSINESS JETS FLY?

EUROCONTROL in "More to the point: business aviation in Europe in 2007" stated that the 500 busiest routes flown by business aviation (see Figure 10) carried a total of 28% of the business aviation flights in 2007.

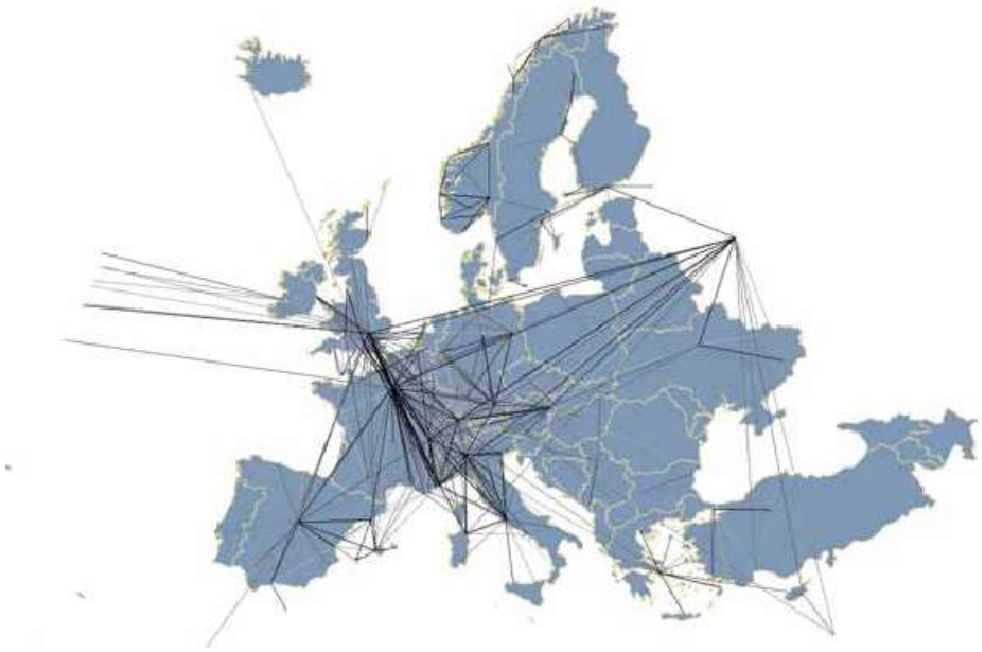

Figure 10 EUROCONTROL - 500 busiest routes flown by business aviation

The figures of EUROCONTROL show the non repetitiveness of the flights and the diversity of the routes flown by business aviation. It means that most business routes are not flown a large amount of time each year, which is not surprising because business aviation is generally on demand (charter or non regular).

To get a closer insight, Harris asked the users about their destination and they classified the answers according to whether the user was flying to:

- A large commercial airport
- A secondary airport
- Infrequent or not scheduled airline service airport

The result was that only few were flying to large commercial airport (18% on 1 aircraft airline – 23 % on others), and that most, around 47%, were even flying to infrequent destination (Figure 11)

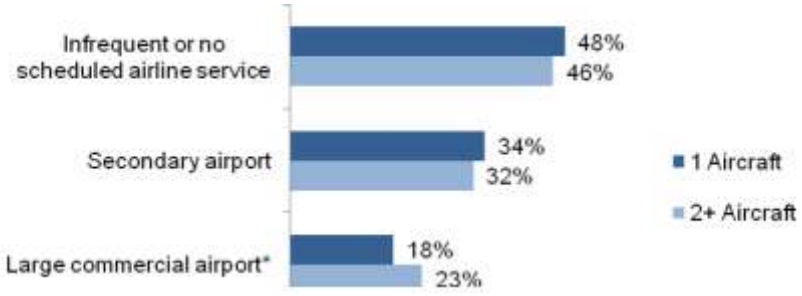

Figure 11 Harris Survey - Destinations

Those results confirm that business aviation is used to reach locations that are the final destination of the client (not only the biggest airport of the region).

2.2.2 PREPARATION AND DEBRIEF

Most flights of business jet aviation are charter flights, i.e. the flights are not on a regular scheduled, they are programmed "on demand of the client". According to our survey, a flight is scheduled:

- Typically 1 week to a month (~ 68%) before the flight.
- It can be shorter notice such as few hours or days before the flight (~ 21%).
- Few also answered flights were planned up to several months before the flight (~11%).

As business jet operators are small structures, most of them don't hire ground staff to only do flight preparation such as generating the flight plans. According to our survey, within 83% of the operators surveyed pilots[2] prepare the flight plan. Among the 13% of companies that answered *other* a majority of them declared to outsource partly or entirely the creation of their flight plan.

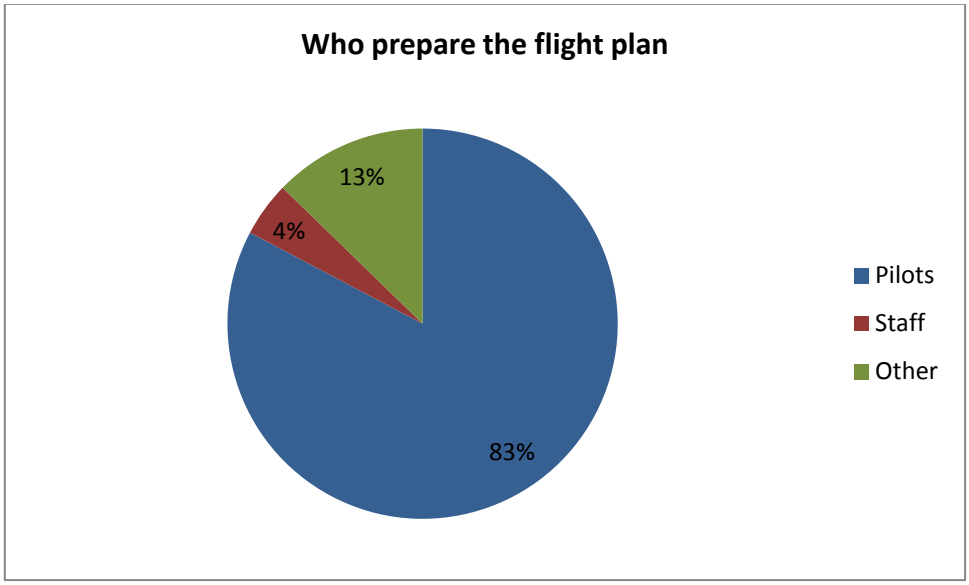

Figure 12 BASE Survey - Who prepares the flight plan?

In the same way, and for the same reason our survey shows that flight procedures, the administrative tasks (such as filing flight plan to ATC), or even the study of new routes and airports are mostly completed by pilots (on average around 80%). Figure 13 shows the result of our survey to the question *Who writes the procedure?*. We can find almost the same results for *Who study the airport limitations, aircraft limitations?*. We have to remember that a lot of business jet are operated by individuals or are very small operators (65% with less than 10 employees) for this reason, being a business jet pilot is a completely different work as being a traditional commercial airliner pilot: inside small structures, the pilot does almost everything from the paper work for the authorities to taking the luggage of the client and giving them advice about the hotel and taxi.

[2] It is almost always the pilot on flight: less than 5% answered another pilot.

When the administrative tasks related to operation and flight preparation are not done by the pilots, they are either: outsourced, done by a flight ops engineer (or a dispatcher), or done by the director[3] of the airline. This last answer stresses again how small business jet operators' structures are. Even if you are the director, you do the paper work for the flight preparation, the limitations study, the procedure, etc.

In corporate aviation, managing the flight department is generally only one of the tasks of a flight department manager.

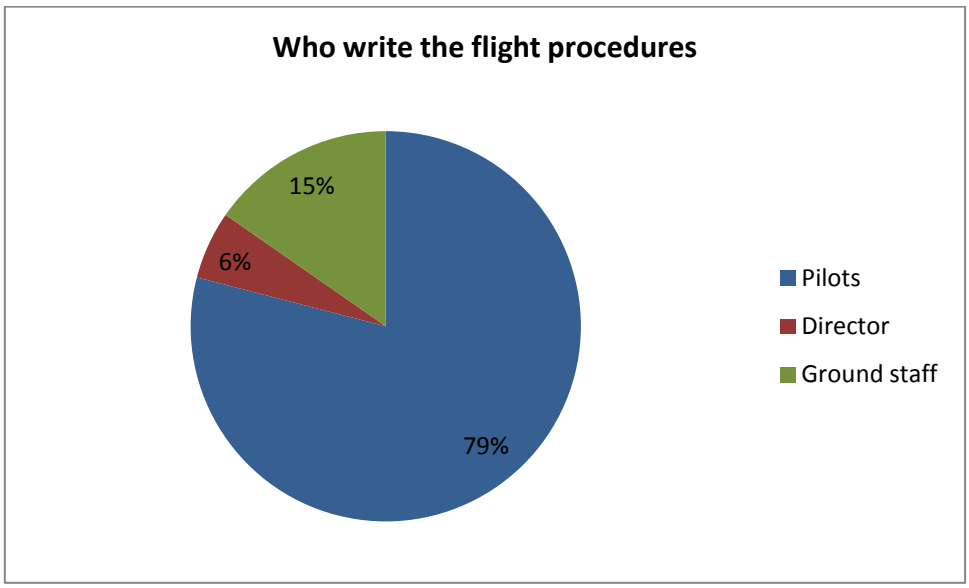

Figure 13 BASE Survey - Who writes the procedure

2.2.3 IN HOUSE TASKS

As we saw in the previous subsection, some business jet operators do not hesitate to outsource some parts of their ground tasks. In this part we study more accurately which services business jet airlines are likely to outsource.

In Figure 14 we show the different services and the ratio of airlines which perform those services in-house.

[3] The director might be a pilot; however the participants to the survey felt the need to specify director in their answer.

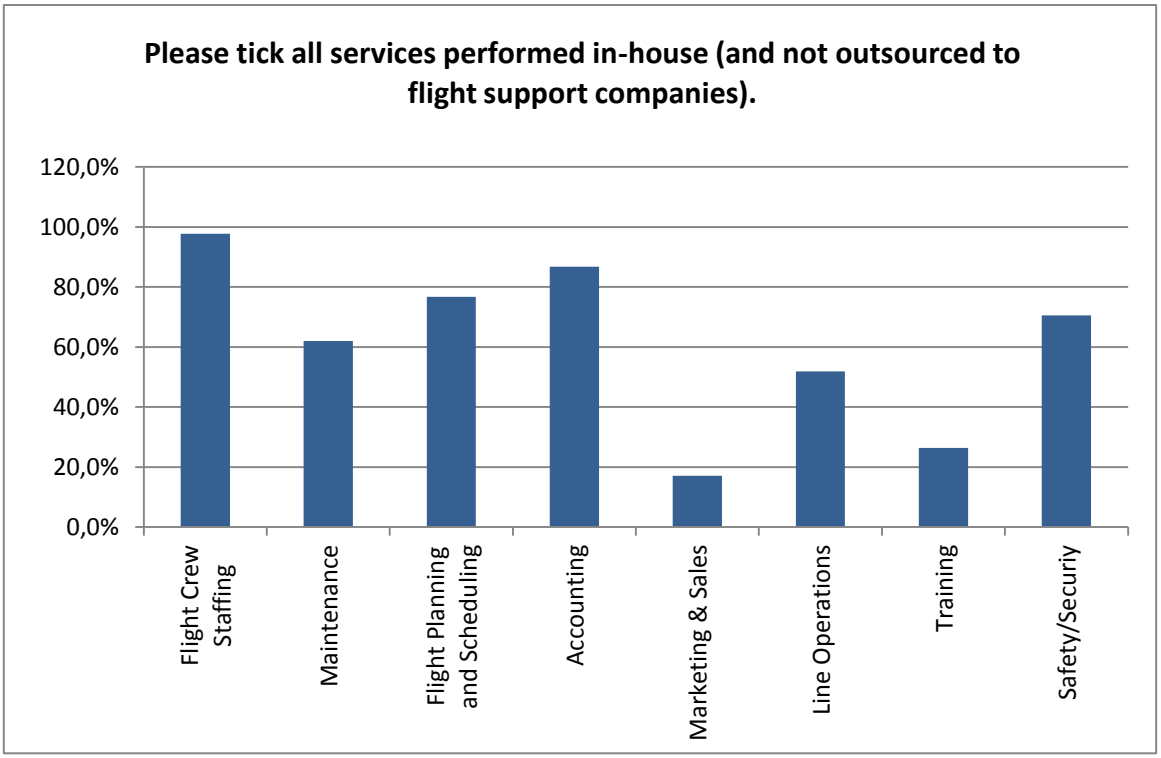

Figure 14 BASE Survey - Services performed in-house

Most of the participants performed in house the *flight crew staffing* (98%), their *accounting* (87%), their *flight planning and scheduling* (77%), their *safety/security* (70%). More than half of the participants answered they were performing in-house the *maintenance* (62%) and the *line operations* (52%).

Most airlines surveyed answered they were not performing in house their *training* (26% in house) and the *Marketing & sales* (17% in house). This last service is not relevant for corporate business operartors because they are not in a commercial business model. When we filter only the answers from Air charter and aircraft management airlines we found the same tendencies (see Figure 15).

Half of the 24% of airlines that answered that the flight planning and scheduling was not performed in house answered that the flight plan was prepared by the pilot on flight which indicates that they only outsource a part of this service i.e. either only the scheduling and the rotations are outsourced either pilots are helped by a service company to do to those tasks.

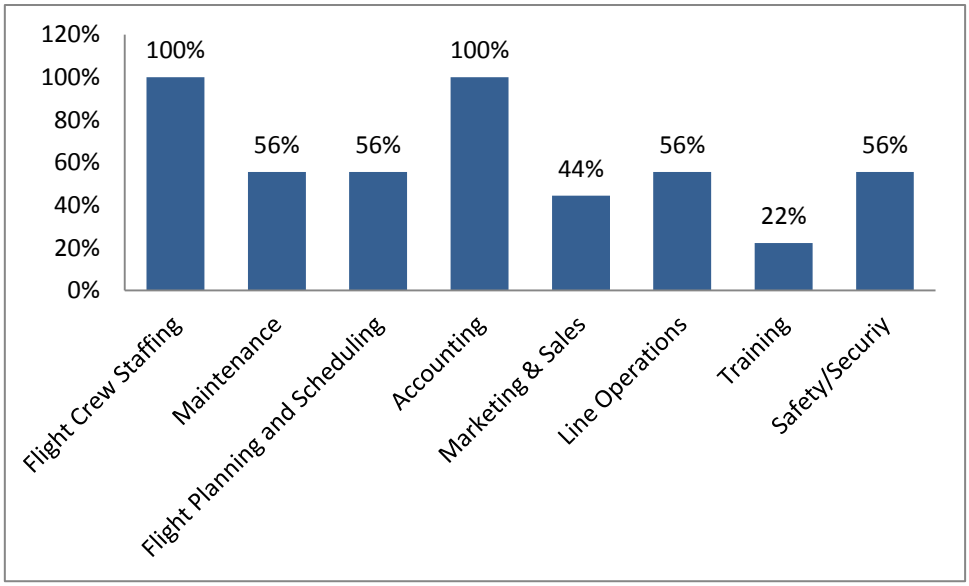

Figure 15 BASE Survey - Services preformed in-house of Air charter and aircraft management

2.2.4 CONCLUSIONS

- Most business jet aircraft are operated by small operators, pilots have a key role in the organization, they do lots of tasks that a commercial pilot wouldn't do: from building the aircraft rotation sequences, organize dispatch, or do the tasks of a flight attendant.
- Business jet operators also outsource tasks when they are not needed to be performed in-house: according to our survey training and marketing and sales are the most outsourced tasks.

2.3 FUELING STRATEGIES

In this part of the document, we present the different fuel strategies business operator may use, while fueling their aircraft for a flight. The fuel strategy is the policy used by a company to evaluate the quantity of fuel to fill in the tank above the mandatory fuel which is determined by regulation for the safety of the flight. The additional fuel (above what is mandatory) can be added in order to buy fuel where it is cheaper (tinkering) or in order to be reasonably sure the flight will not have to divert to an alternate airport to refuel for example.

2.3.1 MANDATORY FUEL

To understand fuel strategies one needs to know the quantity of fuel that is put in the tanks as mandatory fuel, i.e. the minimum imposed by the regulator. In this section we give the detail of the regulation in the US. The European regulations on mandatory fuel are quite similar even though they may differ by some details.

In the US, business jet are operated either on JAR part 93 or JAR part 135 certificates.

For example Under JAR part 93 (or part 135) mandatory fuel to operate a VFR flight is the sum of:

- Trip fuel (fuel required to reach the destination with the forecast condition)
- Fuel for 30 minutes (45 minutes if flying at night) of additional flight

Under JAR part 93 mandatory fuel to operate an IFR flight is the sum of:

- Trip fuel
- Fuel to fly from the arrival airport to the selected alternate (doesn't apply if weather forecast indicates that between 1h before and 1h after the estimated time of arrival the ceiling is above 2000ft)
- 45 minutes of flight at cruising speed

The mandatory fuel to take on board for a flight depends on the regulation the airlines have to comply but it generally accounts for:

- Trip
- En route delay
- Approach hold
- Diversion to an alternate airport

All those fuel quantity added on board are computed to allow the safe operation of the aircraft, i.e. with the mandatory fuel your aircraft should be able to land safely either at scheduled airport or at an alternate airport. However, when using a business jet, the client (or the owner) wants to ensure he will get to his destination and not be diverted to an alternate airport or only if it's impossible to land at the chosen destination.

2.3.2 OPTIMAL FUEL

The only degree of freedom while choosing the fuel on board for an airline (or a pilot) is to set the additional fuel. When an operator has to choose the quantity of additional fuel to put in the tanks of an aircraft, they may evaluate also the cost of being forced to land not at destination in order to refuel. One of the interviewed airlines explained us they were:

- Accounting the inconvenience of not reaching the wanted destination (marginal cost for comfort on Figure 16)

- Accounting the excess fuel costs to transport excessive fuel

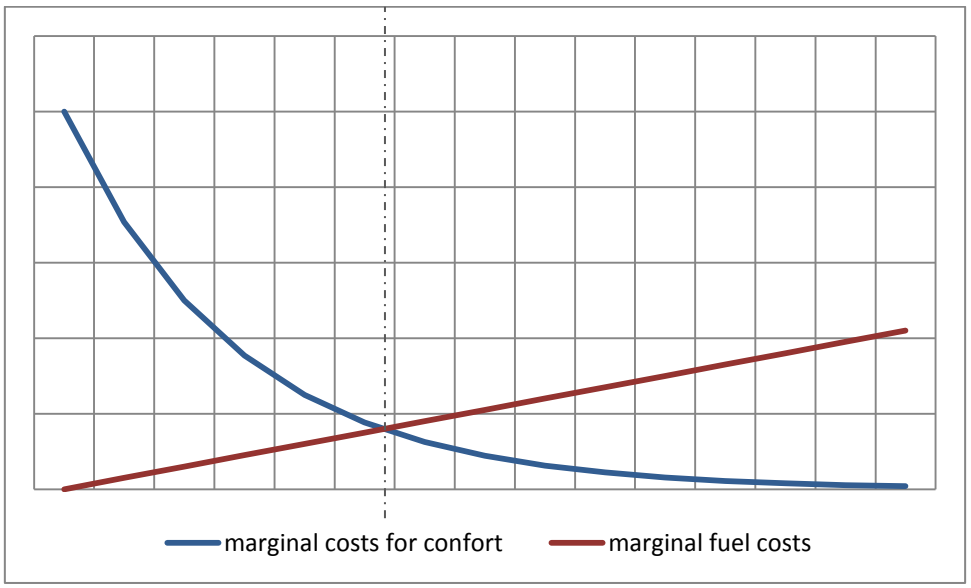

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Figure 16 Costs taken into account for optimal fuel by business jet operators vs the quantity of additional fuel taken on board

The marginal cost for refueling before the arrival station is at its maximum value when the additional fuel is null, and decrease as quantity of additional fuel increase. The variations of the cost is higher for low value of additional cost, i.e. a small quantity of additional fuel will decrease the risk of not landing to the chosen destination more than for the same amount of fuel added when the tanks have already a high quantity of additional fuel (the blue line on the figure is a like a negative exponential function).

The cost of additional fuel is generally considered has being linear with the quantity of additional fuel in the tanks, i.e. it increase linearly the quantity of fuel burnt during the fuel.

The operator we interviewed explained us that commercial airlines are generally on the left part of the part of the Figure 16 and that business jet operators are on the right part. It means commercial airlines try to keep fuel costs as low as possible when business jet operators care more about the satisfaction of the clients.

The interviewed personal also explained us that generally business aviation use to have excess fuel greater than the value of the equilibrium whereas the general commercial aviation airlines had lower values of excess fuel. Pilots of commercial airliners may have to explain their additional fuel, and the recent trends in term of fuel savings for commercial airlines is to limit as maximum the use of additional or excess fuel.

2.3.3 TANKERING

From the interviews we learnt that lots of the operators do over fuel their aircraft in order to:

- Buy fuel where it is cheaper

- Have faster rotation if needed: as the tanks have already the fuel for the return leg, the rotation can be shorter, no need to put fuel in the tanks again.
- Have fuel in tanks at some airports (especially in Africa) where it might be difficult to buy fuel.

Decision to do fuel tankering is a decision guided by both saving money and having a better quality of service as explained by interviewed operators.

Formally, with the basic hypothesis that fuel price is linear to quantity, cost of a quantity q of fuel is different at location A than B because unit cost at A c_{fuel_A} differs from unit cost at B. The saving due to price difference is equal to $|c_{fuel_A} - c_{fuel_B}| \times q$. However it has to be adjusted with the cost of transporting the fuel from A to B. We note T_{AB} the cost (in kg of fuel) of transport 1kg of fuel from A to B.

With the hypothesis of lower cost at A, the saving is then $saving = (c_{fuel_B} - c_{fuel_A}) \times q - T_{AB} \times q$. In order to have an interesting tankering in term of price:

$$c_{fuel_B} \geq c_{fuel_A} \times (1 + T_{AB})$$

However one of the operators we interviewed also explained they were not always interested by the saving in terms of price but also the time saved at arrival to refuel the aircraft, or even in some location it can simply be difficult to refuel the aircraft. In this case it may have a price, but this price is transferred to the client.

During the interviews pilots declared that when they practice overtankering, they use a *rule of the thumb* to compute the coefficient of transport. One of the pilots told us he was using 1/3 as transport coefficient which seems quite high for small aircraft.

2.3.4 TRACKING FUEL BURNT

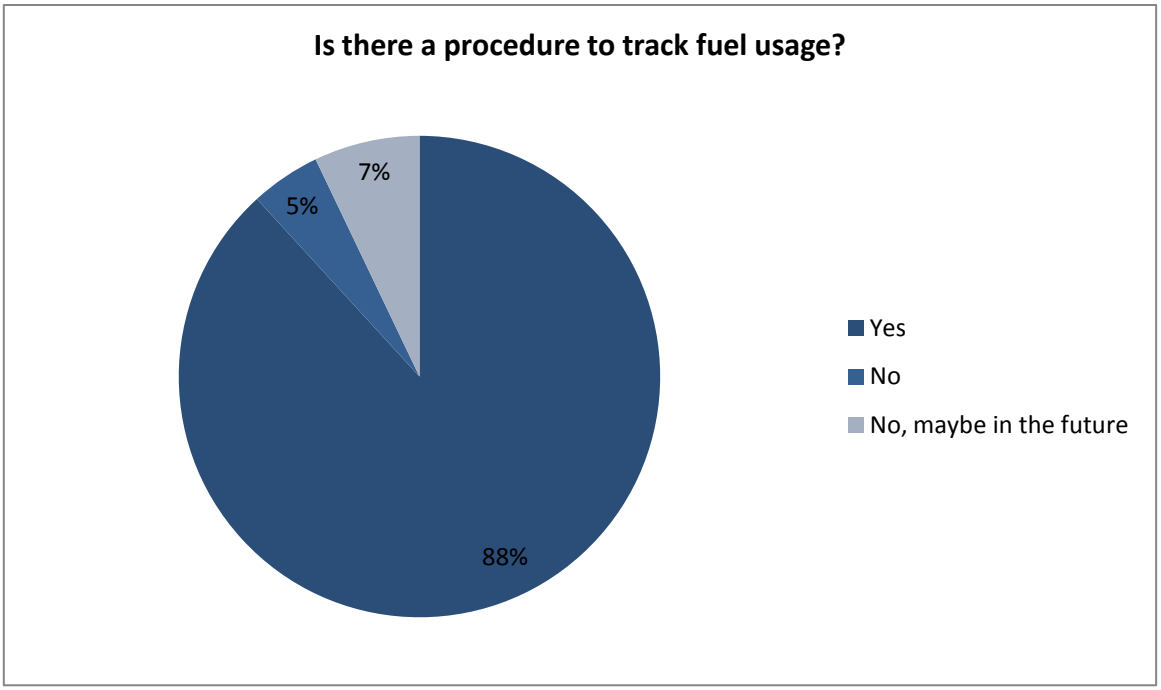


Figure 17 BASE Survey - Existence of a procedure to track fuel usage

This subsection has to be completed with on-site interviews to understand the procedure that are used. Our hypotheses are:

- Operators track fuel because they are submitted to EU-ETS (97% said yes)
- They track fuel for improvement

2.3.5 OTHER METHODS BIZ JET CAN USE TO TAKE ADVANTAGES OF FUEL PRICE

We will not detail in this report the following leads because this report is not on cost but on operation and practices. However we think it is interesting to quote:

- Hedging permits to anticipate and have a good vision on your budget. It removes the uncertainty on price. This practice for airline is described for example in *Flight straight and level* by Stephen Holloway (3rd edition, 2008) or in Clean Sky CARING report *WP5 Airlines operating Costs* by Antoine Montulé (2010)
- Association of operators to buy fuel together and gets lower prices.
- Asks discount to FBO, negotiate discounts, … In *Five easy ways to trim flight department costs* by Matt Thurber (online publication in Business jet traveler bjtonline.com)

2.3.6 CONCLUSIONS

- One of the main priorities of business jet operators is to keep efficient schedule for their clients. They will try to limit the number of legs in a long haul flight in order to refuel, which generally means they will take a higher quantity of additional fuel than classical commercial airlines.

- Business jet operators will often transport fuel for the next flight (fuel overtankering) for two reasons: reduce turnaround time (and be ready as soon as possible), buy fuel at a cheaper price (pilots can use a rule of the thumb to decide whether it is interesting or not)
- Most business jet airlines declare to have a procedure to track fuel (related to EU ETS ?)

3 FLIGHT OPTIMIZATION PRACTICES

In this section, we get into the flight optimization practices. In order to understand correctly the optimization we first surveyed the operators on their priorities and we surveyed them on their usage of the fuel saving best practices.

3.1 PRIORITIES

In order to understand the priorities of the business jet operators for flight optimization, we asked them to rank their priorities between:

- Passenger comfort
- Low total cost
- Low fuel burnt
- Low flight time

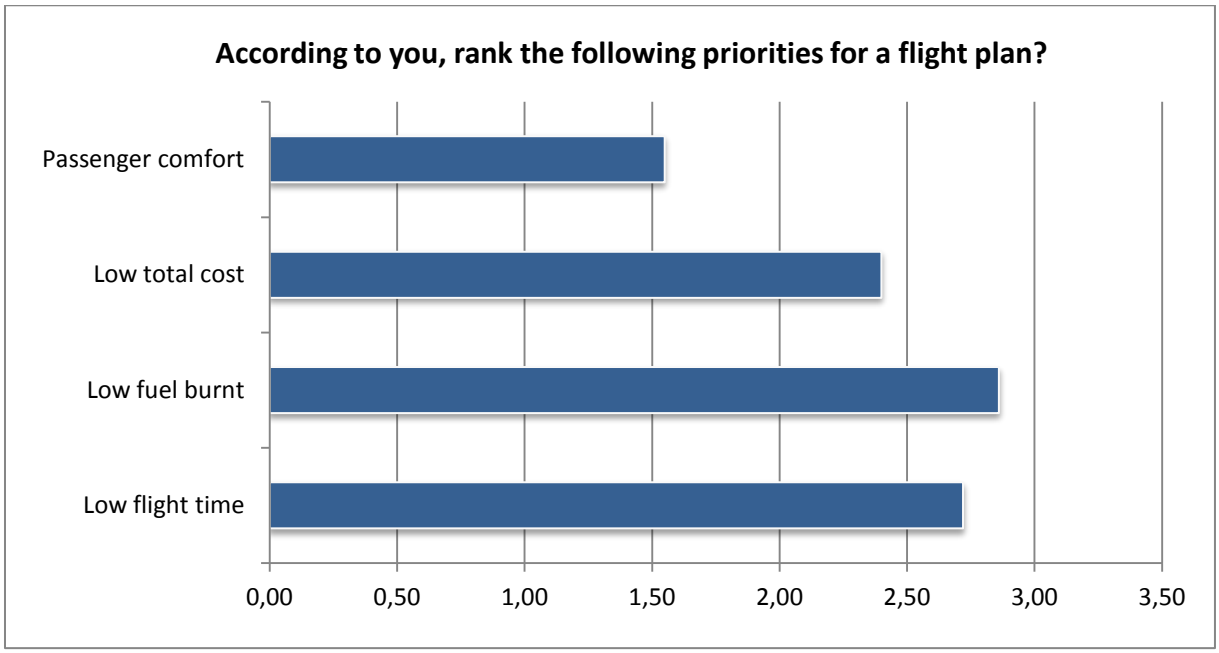
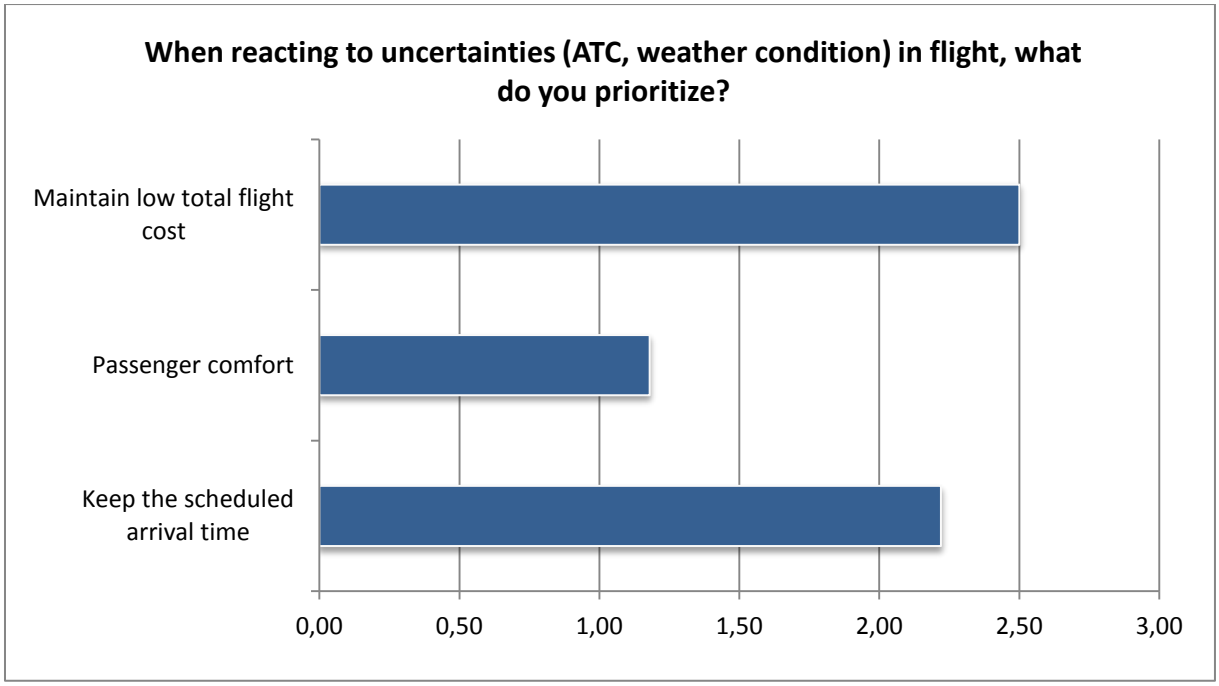


Figure 18 BASE Survey - Flight plan priorities average ranking

We reported the average ranking in Figure 18 for each priority we suggested. According to our survey, when preparing the flight plan the most important is to plan the flight for *low fuel burnt* then *low flight time* and after *low total cost* and *passenger comfort*.

It is paramount important to explain these answers. According to the interviews and comments we had on this topic, most business jet operators prepare flight plan for the most fuel efficient route: as they may need to reach remote location they want to ensure they reach the destination without needing to stop for filling up the tank with fuel.

When reacting to uncertainties (ATC, or weather condition) surveyed pilots answered they preferred to keep low total flight cost and keep the scheduled arrival time.



Passenger comfort in those questions seems a very low priority, however it may be a low priority regarding all flight techniques but according to the interviews we made it is one of the main interests of the air charter operators. The comfort is one of the criteria of choice for a fleet.

All the interviewed operators said one of their main concerns for their business is time, as we have seen most of their passengers want to keep efficient schedule which means to passengers will favour a:

- Low time to transport to airport, this is a reason to choose an airport located close to the final destination of the passenger (e.g. local regional airport, business airport, etc.)
- Low time to go through the security check
- Low time for boarding
- *Etc.*

3.2 NOISE

In this section, we report the result of our survey on noise, and the impact on the operations of the business jet operators.

According to the answers to the question *"Do pilots change their flying techniques in order to take into account environmental constraints related to [fuel or noise]?"* (Please see Figure 19), pilots of business jet take more into account noise constraints than fuel emissions.

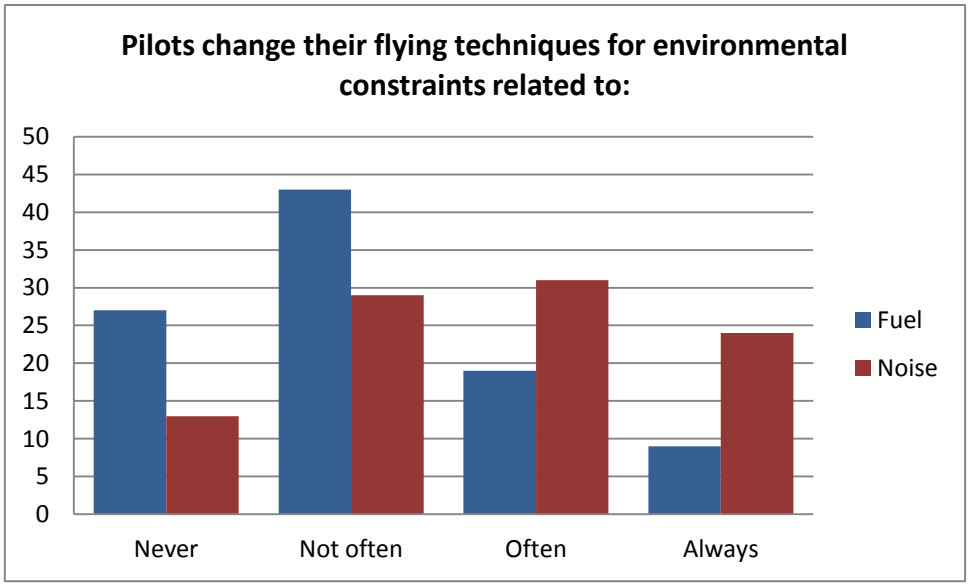


Figure 19 BASE Survey - Do pilots change their flying techniques in order to take into account environmental constraints related to fuel or noise?

This result reflects the differences of maturity of the aviation domain on consideration such as noise emissions or fuel emissions.

3.2.1 NOISE EMISSION AWARENESS

Noise has been an issue for Jet aircraft operations for very long time. In short, disturbance due to noise is more easily perceived by the side residents than emissions related to fuel burnt (CO2, NOx, etc.).

ICAO recommends a balanced approach to regulate noise including reducing noise of engines (or noise at source), reducing exposition to noise with a better planning of land use (noise area maps), reducing exposition to noise by publishing noise abatement procedures (climb profile, preferential runways, etc.), reducing noise at evening and night with curfews (and other restriction of operations) and in the end, if needed, reducing noise by imposing taxes and charges on noise.

ICAO has been setting rules on engines noise certification for more than 40 years. Those noise certifications getting stricter with time:

- chapter 2 (of annex 16 of ICAO) for aircraft designed until 1977,
- chapter 3 for aircraft designed between 1977 and 2006
- chapter 4 for aircraft designed since 2006

In order to limit noise received, ICAO also recommends a method to plan the land use around airports in order to have a usage compatible with the airports activities (*Recommended Method for Computing Noise Contours around Airports* - Circular 205).

ICAO also published different procedures of noise abatement which permit to reduce noise received due to aircraft operations and keep safety at a high level. For example those procedures include

preferential runways, climb profiles, management of thrust power on ground (taxi, reverse thrust), etc.

In order to reduce noise at night some countries has put into services curfews on sensitive airports. Some also have started to ban the noisiest aircraft from operating into their countries: during the 1990s developed countries have started a phase-out of the chapter 2 aircraft.

3.2.2 NOISE REGULATION IMPACT ON FLIGHT OPERATIONS

In order to understand the impact of noise on flight techniques we surveyed the business jet operators on how often they apply them. We reported in Figure 20 the answers to this question for the following procedures:

- Noise abatement procedures (NADP), i.e. specific climb profile constraints on acceleration and flap altitude
- Noise preferential routing / Preferred noise route (NPR/PNRs)
- Increase glide slope

We notice that for each of these procedures, more than 80% of the airlines answered they use them (i.e. they haven't answered "Never"). However, noise abatement procedures are usually performed only if required: 46% of the airlines answered they were performing NADP only if required, respectively 51% for NPR/PNR and 56% for increase glide slope.

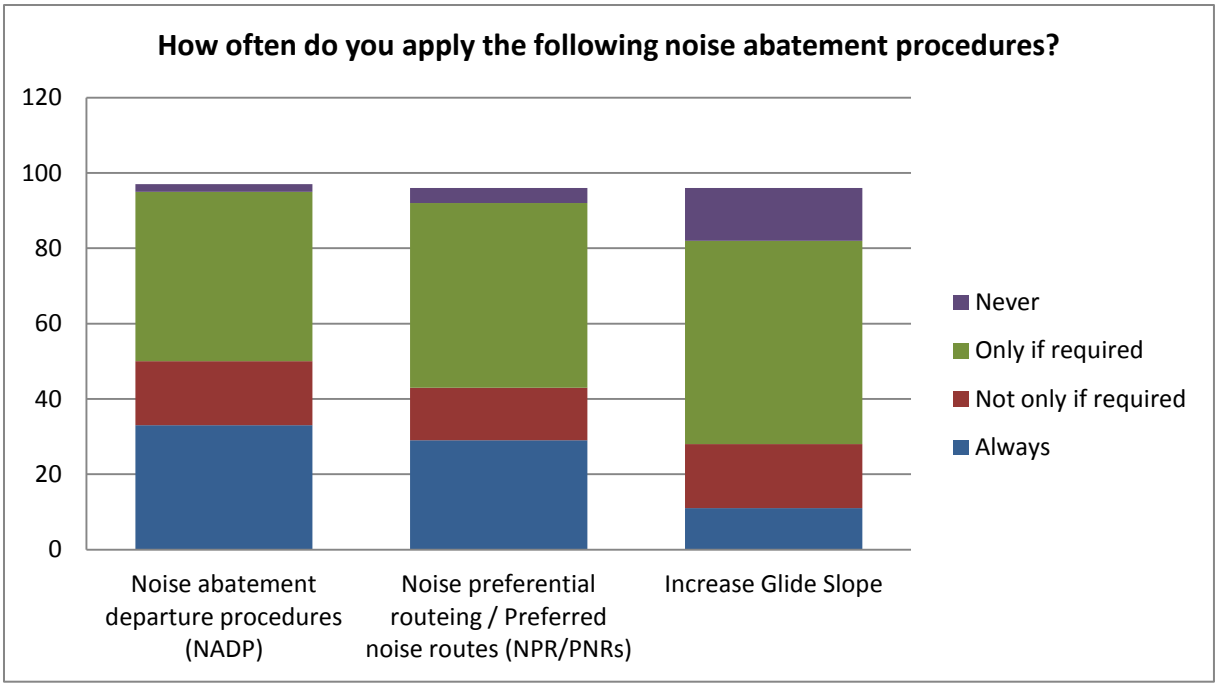


Figure 20 BASE Survey - How often do you apply the following noise abatement procedures?

We notice that the increase glide slope seems to be less popular practice[4] among those 3 practices. The increased glide slope procedure causes stability and certification issues for some large aircraft. For example London City airport (LCY) imposes a 5.5° glide slope (compared to the usual 3° glide slope) which forced Airbus to modify the A318 to ensure that this model of aircraft had a certification to operate at LCY. Dassault chief test pilots declared on this topic that *"most jet aircraft do arrive over the runway too fast to land"* and that *"Flying into London City requires precision and stability in the handling and speed of the aircraft,"* after the certification of the Falcon 7X to operate at London City had been acquired.

In the online survey we also asked the operators what operation restrictions due to noise limited their operations. We reported the answers on Figure 21, which gives the following percentages:

- 11% of the surveyed airlines declared to have their operations limited due to *Restrictions of the number of aircraft movements*
- 1% declared to be limited by the Chapter 3 restrictions (on marginally compliant aircraft)
- 15% declared to be limited by *Noise quotas*
- 16% declared to be limited by *Maximum noise level limits*
- And 52% declared to be limited by *Curfews*

[4] This practice has the smaller ratio of answers « Always » and the greater ratio of answers « Never » or « Only if required ».

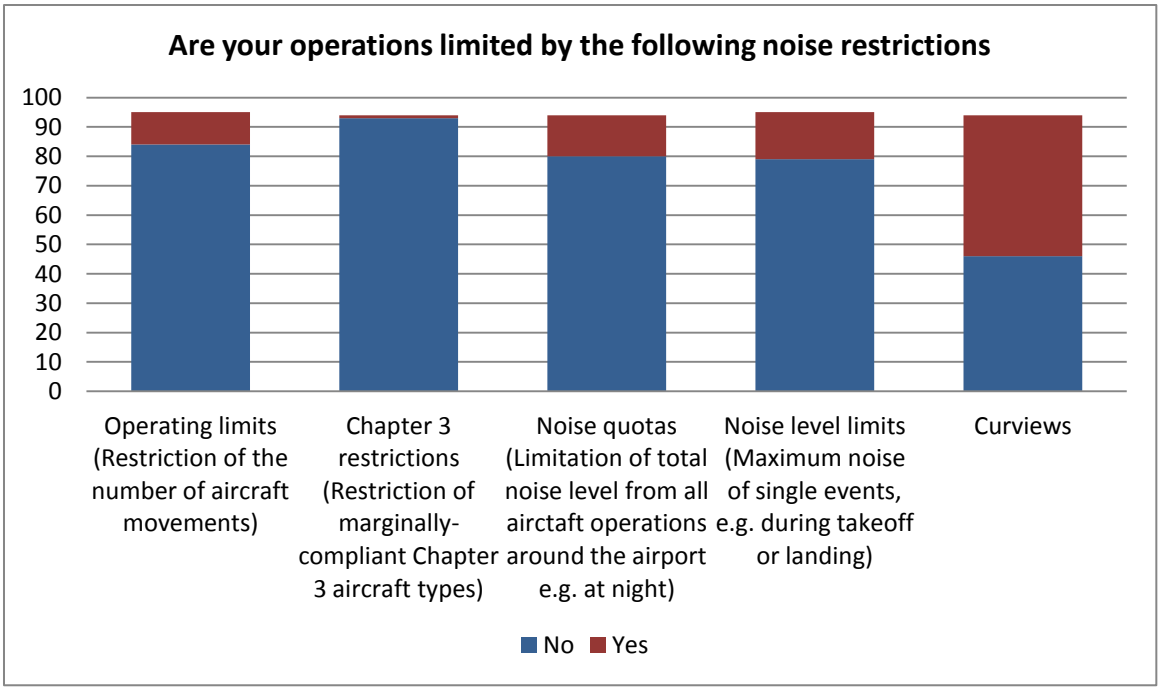


Figure 21 BASE Survey - Are your operations limited by the following noise restrictions

In short, the most stringent restriction for business jet operators seems to be the curfews. The chapter 3 restriction is the restriction that has the lesser impacts because most business fleets are composed of at least chapter 3 compliant aircraft[5] and not only marginally compliant.

And last, concerning the noise charges and the fines, surveyed airlines mostly answered they didn't have specific noise charges and generally they were not receiving fines due to noise (see for example Figure 22)

[5] According to the interviewed pilots business fleets are not very old, with an average of 5 years old.

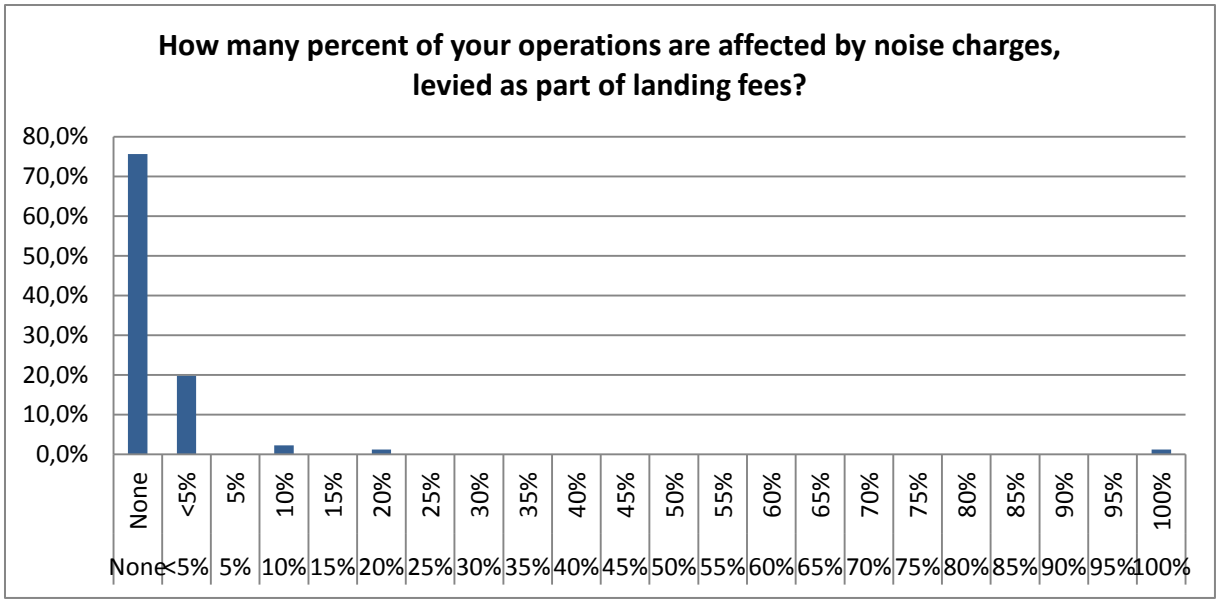


Figure 22 BASE Survey - How many percent of your operations are affected by noise charges, levied as part of landing fees?

3.2.3 NOISE BEST PRACTICES

We regrouped in this part of the report the results of the survey on the best practices suggested to reduce noise in the IATA "*Guidance Material and Best Practices for Fuel and Environmental Management*" (4th edition, 2009):

- Taxiing with one engine shut-off
- Reduced thrust takeoffs
- Conduct Continuous Descent Approach
- Use idle reverse thrust

Figure 23 shows that the most used noise best practices is the idle reverse thrust (54% of operators already use it), before reduced thrust takeoffs (30%) and CDA (28%). *Engine out taxi* and *reduced thrust takeoffs* are the two best practices which seem to face the most opposition: the results are 53% of *definitely not* and *unlikely* answers for single engine and 42% respectively for reduced thrust takeoffs in comparison to the 12% of "opposition" for CDA and 6% for Idle reverse thrust.

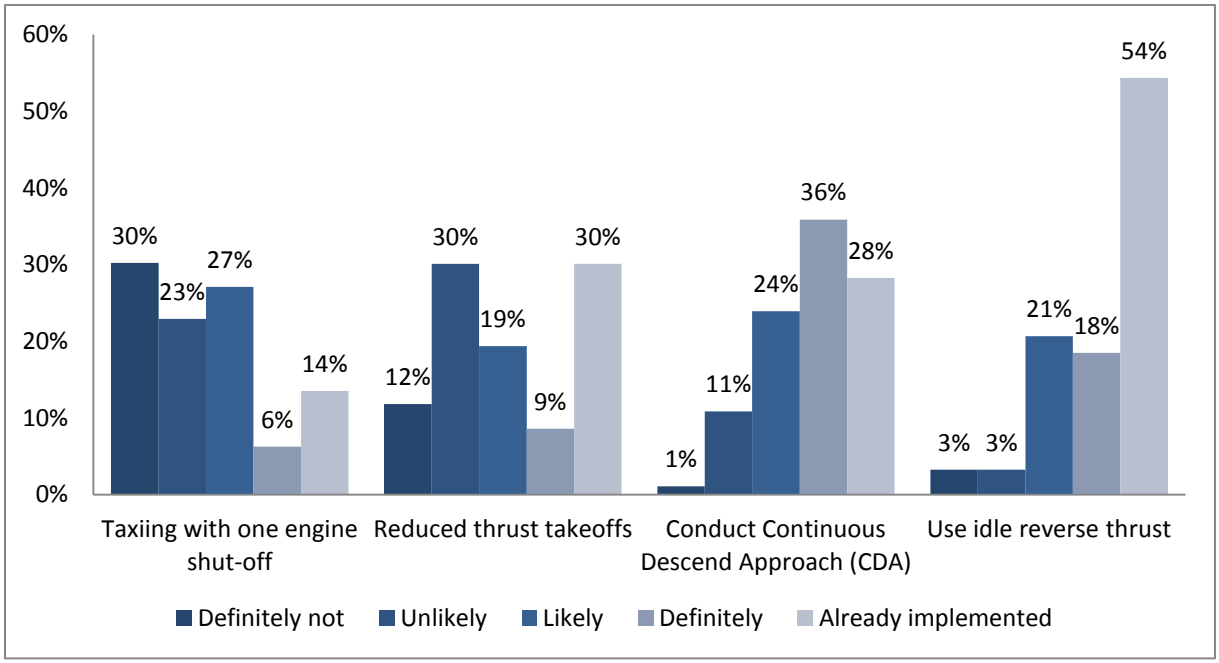


Figure 23 BASE Survey - Noise best practices

Question 39 of survey: "*Which of the following fuel (and CO2) saving measures are likely to be taken in the near future?*"

96 answers for single engine,
93 answers for reduced thrust take-off,
92 answers for CDA,
92 answers for idle reverse thrust

However the difficulty to analyze noise best practices comes from the ratio of application which may differ a lot from one airport to another:

- Taxi with one engine shut-off depends on cool down time of the engines for taxi-in: if taxi is shorter than cool down time then the shut-off during taxi is not applicable. The practice doesn't seem popular at all during taxi-out due to difficulties to have a visual check on the engine start up after leaving the parking.
- Continuous Descent Approach are dependent on traffic and ATC, it means that even at a business airport like Paris le Bourget[6] you can have difficulties to apply the practices due to traffic in the vicinity of Paris (CDG airport and Orly airport).
- Use of full thrust reverse on wet runways can be justified to shorten the deceleration distance which may results in shorter taxi (using of fast exit taxi) and lower fuel burnt.

[6] First European business airport

3.2.4 CONCLUSIONS

- Business jet pilots are aware of noise problems and take into account noise constraints.
- However they perform noise abatement procedures when it is required.
- The impact of operation restrictions and noise charges on business jet operations seem quite low except for curfews which seem to impact a large number of the surveyed business jet operators (around 52%).
-

3.3 FUEL PRACTICES

3.3.1 POPULAR BEST PRACTICES

In order to understand which best practices are popular among the biz jet operators, we asked them in our survey to rank the best practices according to the likeliness to use them. The possible ranks (answers) were:

1. Definitely not,
2. Unlikely,
3. Likely,
4. Definitely,
5. Already implemented

In Figure 24, we produced a ranking of the best practices according to the average likeliness to see them in use by the biz jet operators. An average score of 5 means every operators answered the best practice was already in use, whereas an average score of 1 would mean a best practice is definitely unlikely to be used by all the surveyed operators.

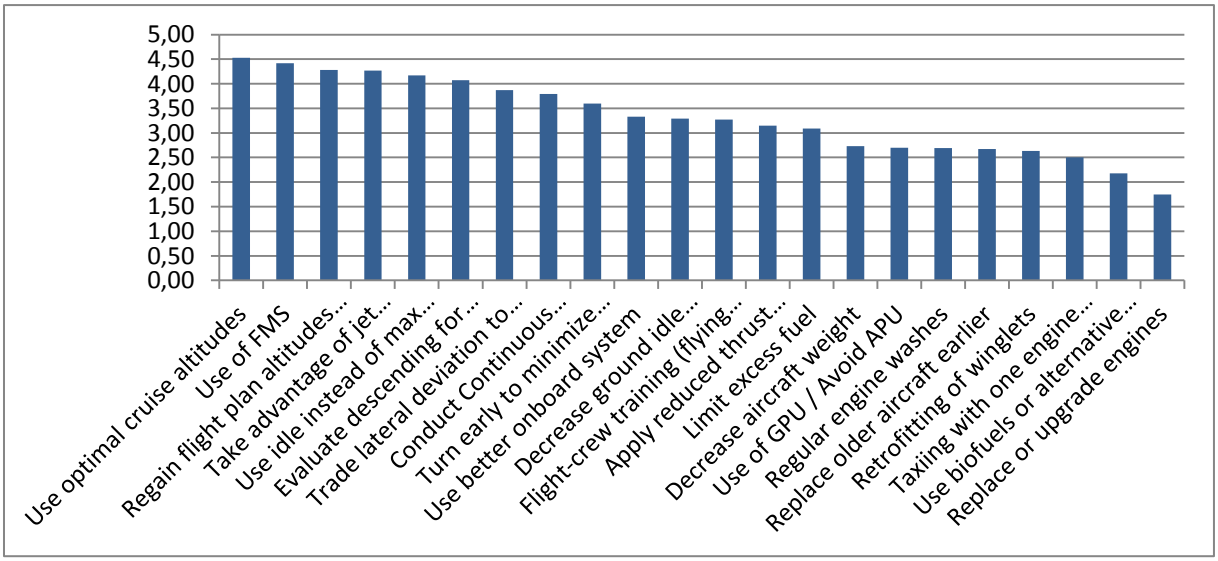


Figure 24 BASE Survey - Best practices rating

The Figure 24 shows that the best practices with the best ratings are the practices relatives to either *"flight techniques"* or *"on board technologies":*

- Use optimal cruise altitude
- Use of FMS (which is already in use in most by most of the surveyed operators that answered this question ~ 70%)
- Regain flight plan altitudes as soon as possible
- Use idle instead of max thrust for reverse
- Trade lateral deviation
- Conduct Continuous Descent Approach
- Turn early to minimize distance in the wrong direction after takeoff
- Use better onboard system
- Etc.

On the opposite, Figure 24 shows that expensive technology changes such as replacing or upgrading engines, retrofitting of winglet, or replacing older aircraft are not popular among the surveyed biz jet operators. The reason we were given during the interviews were that those measure were not interesting when operators don't fly a lot of hours each year.

The use of biofuels or alternative fuels is not popular either. Based on our understanding operators do not invest in this practice because of the low availability of these types of fuels for the moment being: biofuels are not seen as mature. Even the Aviation Transport Action Group (ATAG) in its *Beginner's Guide to Aviation Biofuels* (2009) states that in 2040 only 50% of the fuel of commercial aviation will be biofuels and that biofuels still need to undergo testing process to meet the safety standards required by aviation.

In Figure 25 we ranked the 15 best practices that had the most of "*already in use"* answers. It is interesting to notice there are only minor changes among the best practices that ranked well in term of likeliness and the best practices that are already in use except for the retrofitting of winglets.

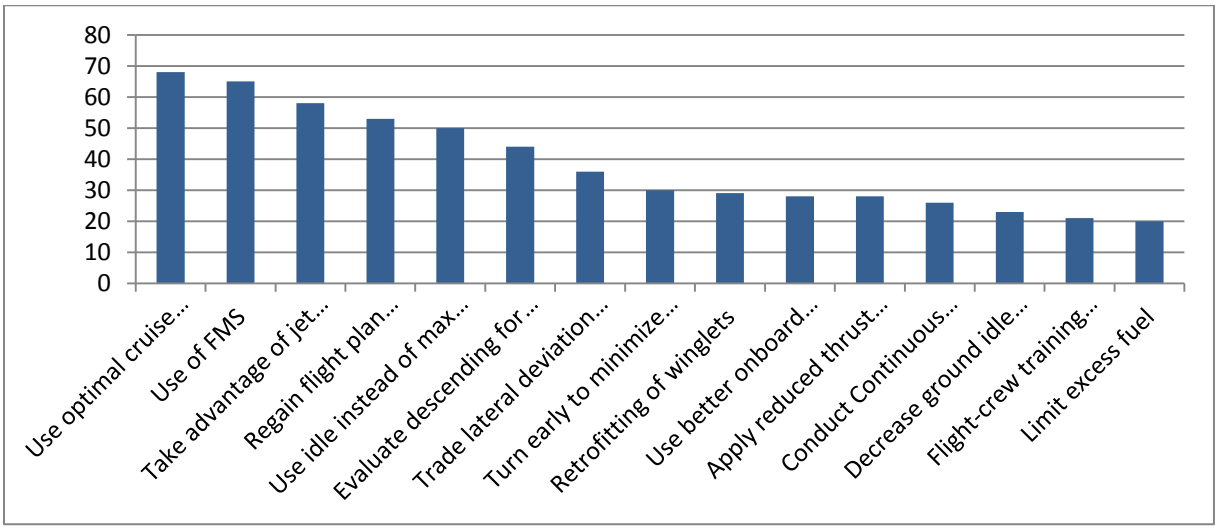


Figure 25 BASE Survey – Popular best practices that are already implemented by more than 19 of the surveyed airlines

The fact the ranking of the "*likely*" and "*already in use*" practices are alike stresses the comments we already had from the operatosr during the survey and interviews campaign: operators are often

under the impression that they already do the best they can and that the best progress to do in term of fuel efficiency relies in improving the current ATC system.

However it is interesting to study more in details the distribution of the answers of our survey for the case of the retrofitting of winglets (Figure 26).

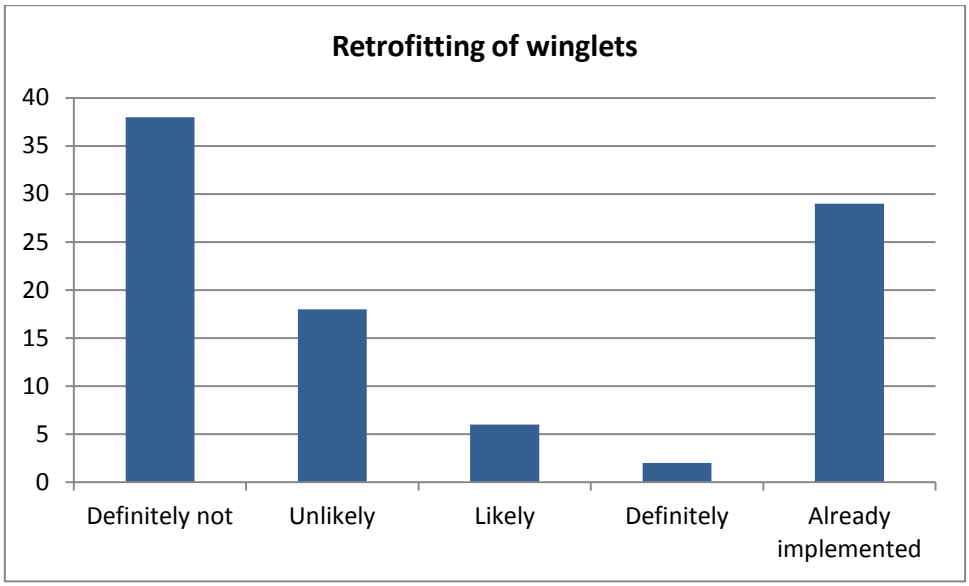


Figure 26 BASE Survey - Are you likely to retrofit winglets on your fleet?

The retrofit of winglet is a very interesting case because the dispersion of the answer shows two strong tendencies regarding this best practice: either the operator has done it already or is going to do it, or either the operator doesn't want to do it. This is quite easy to understand, retrofitting winglet is expensive, if the operators flies few hours per year with its aircraft it is not profitable to retrofit winglet on the aircraft. One of the interviewed operators even gave the following comment:

> *"If it takes 5 years to have a return on investment with winglets for an operator that flies 5000 hours/year, imagine how long it takes to get even when flying 500 hours/year."*

However, it is often indicated that operators should benefit of winglet because it:

- Increases the max range of the aircraft
- Allows to flight faster in cruise by a few knots
- Improves fuel efficiency

It is also remarkable because it is the only best practices were we have such distribution of the answers. Usually, we can see a real tendency (like the extreme cases in Figure 27 and Figure 28): the best practice is popular or the best practice is not popular whereas for the retrofitting of winglet it's two opposite side (yes or no).

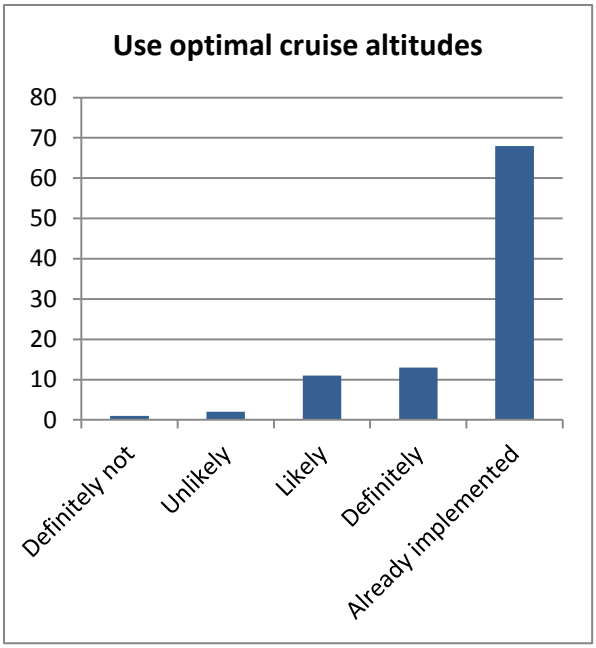


Figure 27 BASE Survey - Are you likely to use optimal cruise altitudes best practice

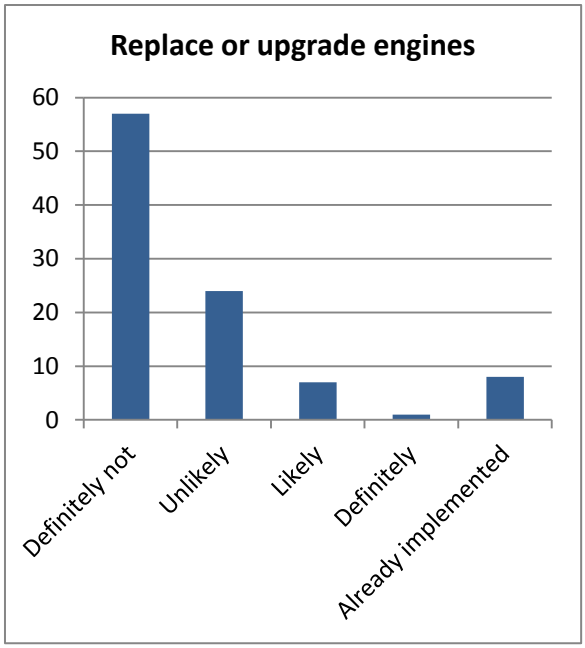


Figure 28 BASE Survey - Are you likely to retrofit the engines on your fleet?

3.3.2 TENDENCIES

In this section we put the emphasis on a few tendencies about the best practice and the willingness to change toward new technologies as the ones in the scope of the Clean Sky project.

In Figure 29 (and Figure 30) we show that among the 91 operators (96% of the answers) that declared they were at least likely to use an FMS:

- 64% declares they already use a “better on-board system”
- 21% are likely to use a “better on-board system” (we regrouped answers *likely* and *definitely* here)
- 15% are not willing to use a “better on-board system” (we have regrouped answers *not likely* and *definitely not* here)

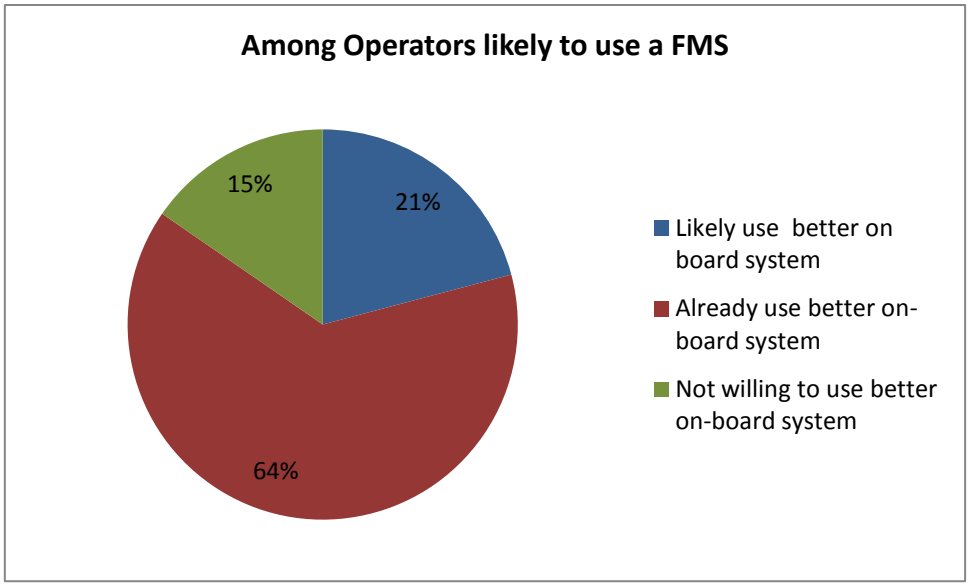


Figure 29 BASE Survey - Use of a better on-board system knowing operator is likely to use a FMS

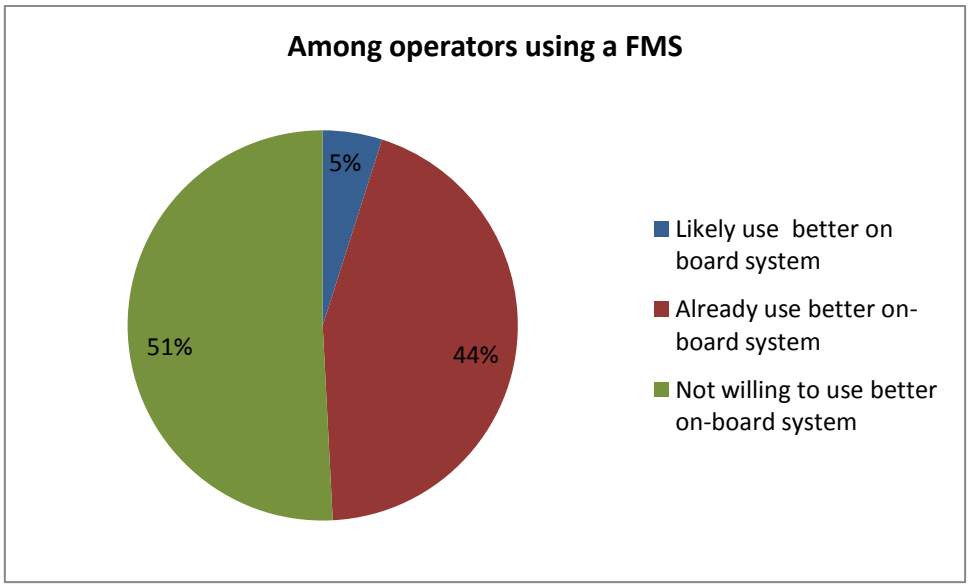
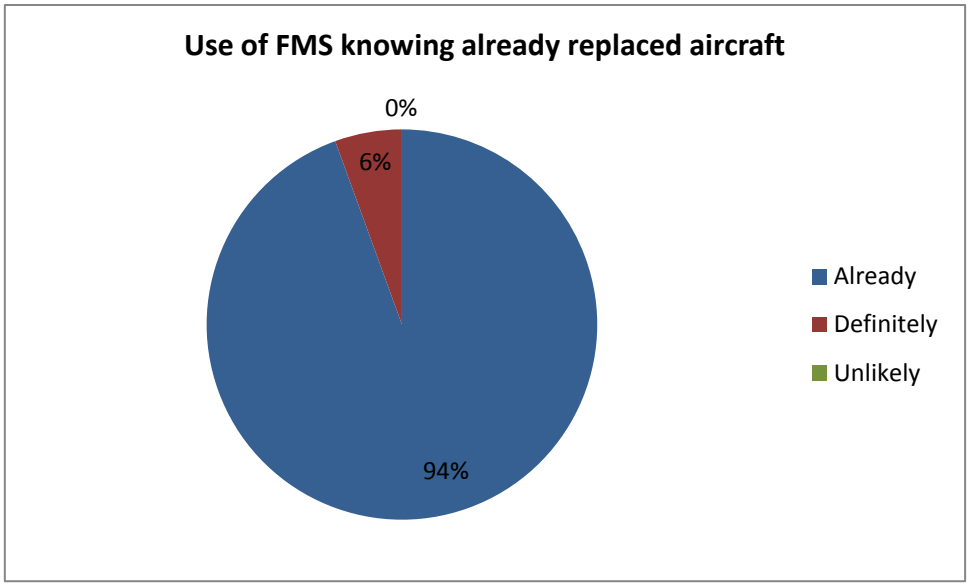
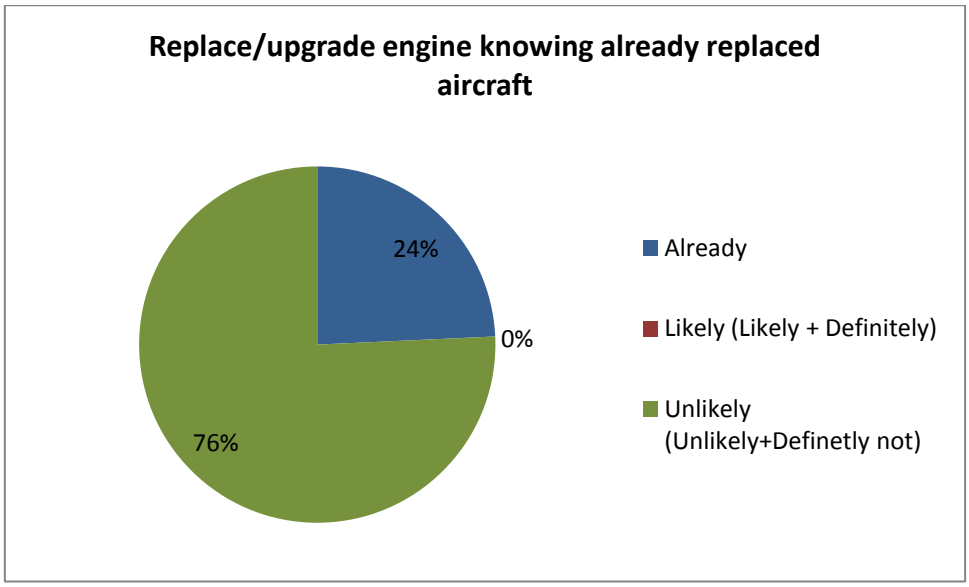


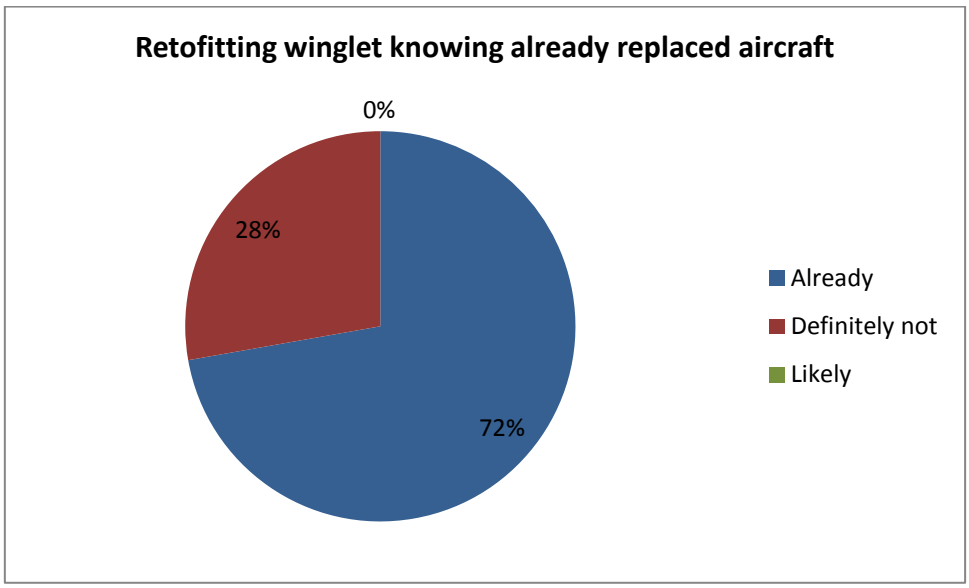
Figure 30 BASE Survey - Use of a better on board system knowing operator is using a FMS

It is interesting to see that operators that think positively of using an FMS are mostly positive about better on-board system. However it is interesting to notice that among the 61 operators (64% of the answers) that are already using an FMS most are not likely to buy a new on-board system because 44% estimates they already are using a “better on-board system” and 51% are not likely to use a “better on-board system”.

We also studied the answers of the operators that claimed to have already replaced older aircraft (i.e. we suppose they are not against investment in new technology even if expensive), they are unlikely to retrofit winglet, to replace, or start using an FMS. The main reason is that they already have (or think they have) the latest technologies (FMS, winglet), and an operator will not replace/upgrade engines of a brand new aircraft.







3.3.3 CONCLUSIONS

- The most popular best practices are the best practices on cruise altitude such as usage of optimal altitude and the use of an FMS.
- The best practices related to the investment into new technologies (aircraft, engine, winglets, biofuels) are not very popular among the business jet operators. Only the usage of a better FMS seems to be popular.
- Retrofitting winglet is a best practice that is either already done by the business jet operators, or the operator absolutely does not plan to do it.
- As a tendency business jet operators using new aircraft also use an FMS, business jet operators that have already invested into new technologies seem not to be willing to invest into new technologies in the near future.

4 CONCLUSIONS & FURTHER WORKS

4.1 CONCLUSIONS

The aim of work packages 4.1 and 5.2 was to understand the organization and practices of the business jet operators. To accomplish these tasks we have made and distributed an online survey to a large number of business jet operators. We obtained up to 159 partial answers, and about 100 complete answers. Most of the answers we received were written by non-commercial business jet operators (especially corporate aviation flight department).

We have completed the results of this survey with interviews of air charter and aircraft management operators (i.e. commercial business jet operators), in order to have a full insight of the practices and organization among the business jet operators. We also used results from previous studies conducted by EUROCONTROL or NBAA.

From the different sources we used we can conclude that business jet operators are generally small structures (less than 5 employees), with a very small fleet (generally one aircraft), and that don't fly a large amount of hours each year (around 350 hours per year per aircraft). These operators are often run by the pilots themselves, they'll do most of the paper works, preparation, and debrief inside these small structures and they basically outsource what they can't do such as training, part of the maintenance, etc.

The passengers of business jet operators fetch efficiency in their business flight, i.e. to keep an efficient schedule (fast boarding, fast check-in, last minute schedule, fast security check) and to get as close as possible to their final destination which can be more complex to achieve with regular commercial airlines because there is no or only few scheduled flights to regional airports from their departure airport (and may implies inefficient connections).

When choosing the fuel on board, business jet operators have to make a tradeoff between the risk of diverting the aircraft to refuel if necessary and the cost of transporting a quantity of fuel not necessary for the flight (above the minimum required by the regulations). Another parameter to take into account in this tradeoff is the possibility to take more fuel than required in order to use to its own advantage the variation of the price of fuel in different part of the world. These ''overtankering'' practices also permit to reduce turnaround time, and allow the operators to be ready to fly sooner (to estimate the cost of overtankering pilots use a rule of the thumb or a transport factor).

We have noticed that pilots of business jet operators seemed to be more aware of the noise emissions issues, and take into account the noise practices more than the fuel practices. In fact, noise has been an issue since jet aircraft have been popular. It has an impact in the way of pilots flight their aircraft due to imposed procedures such as NADP or increase glide slope (which also impose additional certifications for crew and aircraft)

And last, the best practices on fuel, operators declares they try to do the best they can, which results with best practice on flight conduct (such as optimal altitude, regain flight plan altitude as soon as possible, etc.) being largely adopted. The use of FMS is now also largely adopted, and it seems that replacing or modifying airframes are among the less popular with the use of biofuels and the taxi

with one engine shutdown. As a tendency when an airline has invested in the new technology best practice it seems less likely to invest in any other technology.

4.2 FURTHER WORKS

We want to complete this study with interviews of pilots based on works made in WP3.

APPENDIX A - REFERENCES

In order to write this report we have used the following sources:

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NBAA

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Online magazines

- Matt Thurber, *Five easy ways to trim flight department costs*, online publication in Business jet traveler bjtonline.com, December 2006

APPENDIX B – LIST OF FIGURES

