Direct Operating Costs of Business Aircraft

Business Aviation for a Sustainable Economy (BASE)

A CleanSky Project

Work Package 4

T 4.2

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List of Abbreviations

ADS	Alternative Depreciation System
AOC	Aircraft Operating Certificate
ARG/US	Aviation Research Group/US
ATC	Air Traffic Control
BASE	Business Aviation for a Sustainable Environment
BCA	Business Commercial Aviation
CAMP	Continuous Airworthiness Maintenance Program
CFR	FAA Code of Federal Regulations
DMCs	Direct Maintenance Costs
DOCs	Direct Operating Costs
EU ETS	European Union Emissions Trading Scheme
EUROCONTROL	European Organization for the Safety of Air Navigation
FAA	US Federal Aviation Administration
FARs	FAA Federal Aviation Regulations
FBOs	Fixed-Base Operations
FSDO	FAA Flight Standards District Office
GA	General Aviation
GDP	Gross Domestic Product
IAS	International Accounting Standards
IBAC	International Business Aviation Council
ICAO	International Civil Aviation Organization
IFR	Instrumental Flight Rules
MACRS	Modified Accelerated Cost Recovery System
MSCI	Morgan Stanley Capital International
MSG	Maintenance Steering Group
MTOW	Maximum Take-Off Weight
NBAA	US National Business Aviation Association
PIC	Pilot in Command
PTO	Paid Time Off
R&D	Research and Development
VFR	Visual Flight Rules

1 Introduction

Only little research work has been done so far in the field of business aviation and especially with regard to the analysis of direct operating costs (DOCs) of flying business aircraft. The present paper sets out to analyses

- Single DOC positions and
- The DOC structure of different
    - business jet market segments,
    - manufacturers and
    - business models

The first part of the paper provides an introduction into the fundamentals of business aviation.

1.1 Clean Sky BASE

We present our findings from research performed under BASE. BASE stands for Business Aviation for a Sustainable Environment. It is part of the CleanSky initiative- the largest European R&D project on the future of an environmental friendly aviation. The BASE project consists of different work packages. Work package T4.2 specifies the questions that are answered in this paper.

1.2 Research Interest and Approach

The present paper analyses single DOC positions and the DOC structure of business jet aircraft. Some research has been done in the field of commercial aviation, but only little is known about direct costs of operating business jets.

Information and data presented throughout this paper are largely based on the findings obtained from the BASE online survey and interviews held with business aviation experts.

The online survey was designed by SustainAvia and OpenAirlines. It contains around 40 questions about the operational organization of corporate flight departments, environmental costs, flight OPS optimization, operational and technical fuel reduction measures and direct operating costs. DOCs have been disclosed by choosing from a drop-down list the percentage share of total DOCs for the cost items ownership, maintenance & refurbishment, personnel, fuel, hangar, insurance, training and flight expenses. 32 out of 133 participating aircraft operators disclosed complete DOC information. The bulk of them are corporate flight departments based in North America.

Besides the survey, we obtained DOC information by modeling costs for a selection of aircraft using ARG/US operating cost data (as published in the Business & Commercial Aviation 2011 Operations Planning Guide). The ARG/US database of operating costs is generated from real expenditures of US based operators. Aircraft were assigned to different aircraft categories depending on their performance. ARG/US provides the same average cost information for aircraft allocated to the same category. Based on ARG/US cost data, we modeled hourly or annual costs to test the DOC information obtained from a relatively low number of survey participants.

We interviewed 8 business aviation experts (representatives from the air charter and manufacturer industry) to back up the survey outcome and facilitate its interpretation.

2 Fundamentals of Business Aviation

Chapter 2 of the paper introduces the reader into the fundamentals of business aviation. We provide a comprehensive definition of business aviation and present the benefits of using a corporate jet. Subsequently, we segment business aviation by type of propulsion (piston, turboprop and turbojet) and business model. Turbojet aircraft are further sub-divided into different market segments depending on aircraft size and range capabilities.

2.1 Definition of Business Aviation

Business aviation is most commonly defined as the use of aircraft for the conduct of business activities. This definition refers to the purpose of the trip as criterion of differentiation and comprises the transport of passengers and goods. In the broader sense, it also covers business-class-only scheduled flights. Business aviation professionals may not agree with this definition and claim that business aviation is a subset of general aviation which in turn encompasses all civil aviation activities other than military and commercial flights. But the exclusion of scheduled airline services would also separate the commercial component of business aviation (on-demand air charter services[1]) from private, non-commercial business activities. The International Civil Aviation Organization (ICAO)[2] follows the same approach by dividing civil aviation into commercial and non-commercial services. As to what regards commercial business aircraft services, only the holder of an aircraft operating certificate (AOC) is allowed to carry passengers and goods against remuneration[3].

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[1] Air charter is also called air taxi, executive charter or Part 135 under the US Federal Aviation Regulations (FARs).

[2] ICAO (2009).

[3] To not be confounded with pilots operating third party owned aircraft for hire without offering aircraft and crew as package, online article: http://www.cfidarren.com/cpinfo.htm

A comprehensive definition of business aviation is provided by the International Business Aviation Council (IBAC)[4]:

Business aviation is "that sector of aviation which concerns the operation or use of aircraft by companies for the carriage of passengers or goods as an aid to the conduct of their business, flown for purposes generally considered not for public hire and piloted by individuals having, at the minimum, a valid commercial pilot license with an instrument rating"

Business aviation can be sub-divided into the categories commercial, corporate and owner-operated. Table 1 provides a definition for all three business aviation categories.

Category	Definition
Commercial	The commercial operation or use of aircraft by companies for the carriage of passengers and goods as an aid to the conduct of their business flown by professional pilots employed to fly the aircraft.
Corporate	The non-commercial operation or use of aircraft by companies for the carriage of passengers and goods as an aid to the conduct of their business flown by professional pilots employed to fly the aircraft.
Owner-operated	The non-commercial operation or use of aircraft by individuals for the carriage of passengers and goods as an aid to the conduct of their business.

Table 1: IBAC Business Aviation Categories

[4] ICAO (2005), 3.

2.2 Benefits of Using Business Aircraft

Business aircraft users share diverse benefits. This Chapter presents the advantages of using a business aircraft rather than commercial airline services. Table 2 provides a list of the most cited benefits of business aviation.

Benefits of Business Aviation	Description
Saving Employee Time	Business aviation allows users to travel on-demand and non-stop (as the range permits) between smaller airfields that are closer to the traveler’s destination. Time spent before departure and after landing for security and customs is kept to a minimum.
Increasing Traveler productivity and Ensuring Confidentiality	Passengers use the cabin (equipped with internet and phone access) as work place. Meetings can be held without fearing leakage of sensitive information.
Reaching more Destinations	Business jets start and land on 10 times more US airports than commercial airlines do. Better access to remote communities or less congested airports. It also brings the passenger closer to his final destination.
Allowing scheduling Flexibility and Predictability	Business aviation means on-demand travel allowing the user to plan his business trip according to his agenda and other travel needs. The destination can even be changed en route. Concerns over delays and cancellations are virtually nonexistent on business aircraft.
Moving Vital Equipment	Business aircraft allow the transportation of ship sensitive, critical or outsized equipment.
Increasing the Reactivity	Business aircraft enable companies to quickly respond to business opportunities.

Table 2: Benefits of Business Aviation

Source: NBAA (2011)
Harris (2009)

In 2009, Harris Interactive Inc. conducted a survey asking passengers for the reason of using business aircraft. Figure 1 reveals that 64 percent of all respondents justify the use of business aircraft with disadvantages related to rigid flight schedules of commercial airlines. This finding indirectly supports the time-saving argument. The second reason is that business aircraft serve around ten times more destinations.

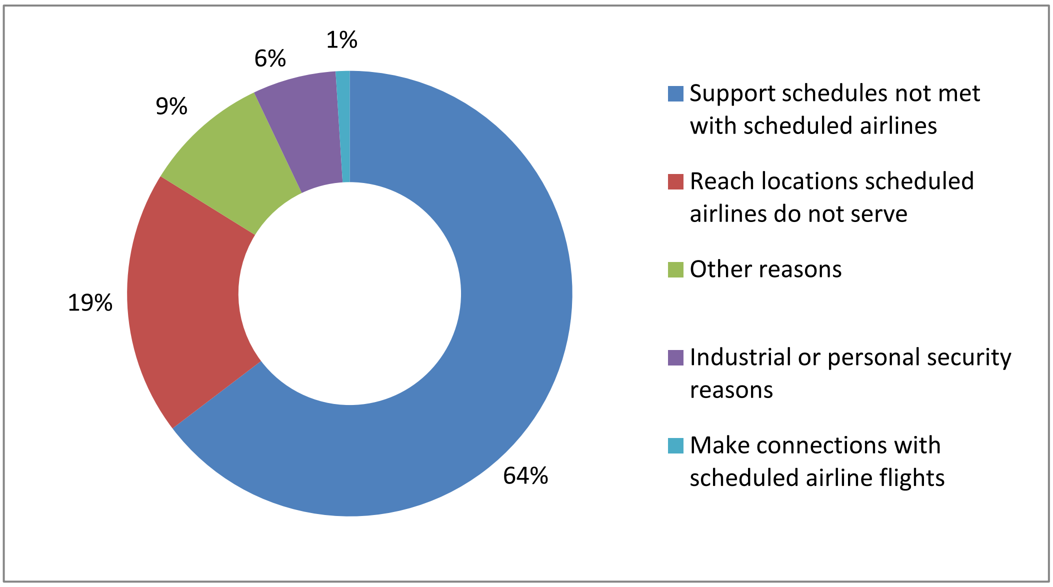

Figure 1: Reasons for Business Aircraft Use

Source: Harris (2009)

The Harris survey discovers that business travelers spend more time for work-related tasks aboard of business aircraft. It was found out that passengers are also more productive aboard of business aircraft (even more than in the own office).

The BASE survey was accompanied by interviews held with business aviation experts. They were asked to name the three most important benefits which business aircraft offer to their users. Time savings and scheduling flexibility were the most recurrent answers, followed by comfort, productivity, accessibility to smaller airfields and confidentiality.

2.3 Business Aviation Markets

Chapter 2.3 analyses the configuration of the business aircraft fleet. Figure 2 segments the business aircraft market by type of propulsion and sub-divides the jet aircraft fleet in eight market segments. The assignment of jet aircraft to one of the eight market segments depends on the aircraft's MTOW (a proxy of aircraft size), range capability (defined as the maximum distance the aircraft can fly) and purchase price.

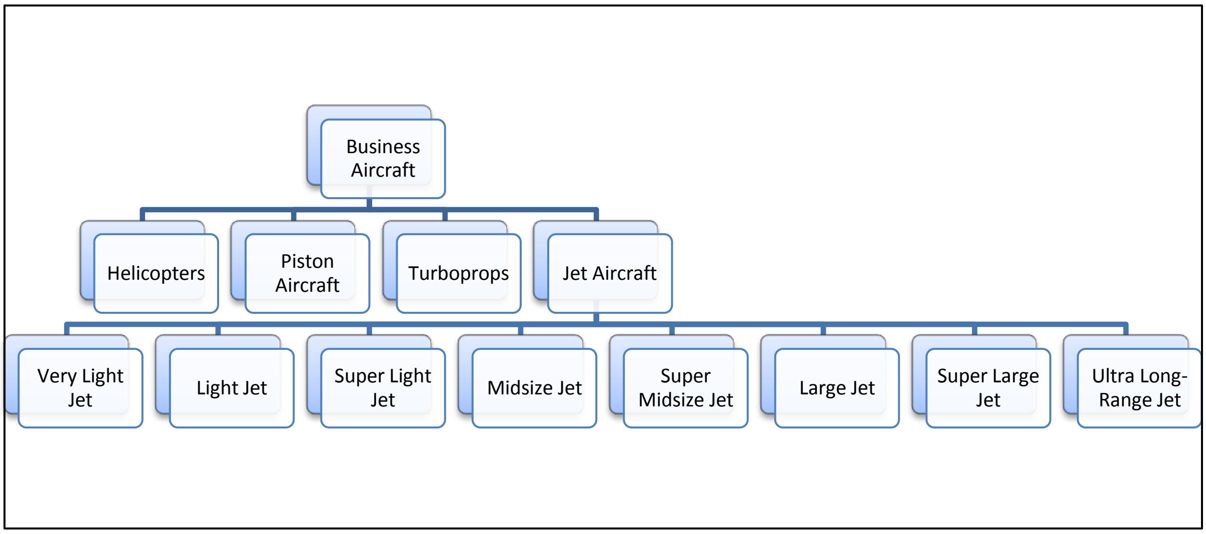

Figure 2: Business Aircraft Market Segmentation

Helicopters are left unconsidered throughout the whole paper because the focus lies primarily on fixed-wing aircraft.

2.3.1 Market segmentation by Type of Propulsion

Table 3 compares piston, turboprop and turbojet aircraft using different criteria, such as performance parameters, aircraft size and the price range within which new aircraft are available for purchase.

Types of Business Aircraft*	**Piston Engine Aircraft**	**Turboprop Aircraft**	**Jet Aircraft**
Type of Engine	Piston powered engine(s) with propeller (s)	Gas turbine engine(s) with propeller(s)	Gas turbine engine(s)
Type of Fuel	100 octane low-leaded fuel	Jet A	Jet A
Length (ft)**	25-30	30-70	40-100
Height (ft)**	8-15	10-50	13-26
Typical altitudes (ft)	< 15000	< 35000	20000 to 25000 or < 40000
Typical seating (nr. of passengers)	1-6 passengers	6-8 passengers	6 passengers and higher
Typical mission range (nm)	300-400	600-1000	1000 and more
Max mission range (nm)**	700-1400	900-1800	1100-6700
Price range (in Mio. $)**	0.3- 0.5	0.7- 8	1.5- 35
Manufacturers	- Cirrus - Cessna - Hawker Beechcraft - Diamond - Mooney	- Cessna - Hawker Beechcraft - Piaggio - Piper - Pilatus - Socata	- Airbus - Boeing - Bombardier - Cessna - Dassault - Embraer - Gulfstream - Hawker Beechcraft

Table 3: Overview of Business Aircraft

Source: NBAA website http://www.nbaa.org/business-aviation/aircraft/
Flightglobal (2012)
*Notes: * Helicopters remain unconsidered*
*** Aircraft out of production or in development remain unconsidered*

To put it roughly, aircraft size, performance and price are in general higher for business jets than for turboprop aircraft. Piston aircraft are ranked on the third place. Table 3 fails to provide an accurate picture of the variety of jet and turboprop aircraft. Take for instance the maximum mission range of jet aircraft which varies widely between aircraft of the same category.

In the following, we demonstrate by how much each aircraft type contributes to business travel in Europe and in the United States.

2.3.1.1 Business Aviation in the US

We used 2009 FAA (US Federal Aviation Administration) data to provide an accurate picture of the distribution of business travel in the United States. Figure 3 measures the number of US registered aircraft primarily used for business purposes against the size of total business travel (vertical axis) and the size of total business and non-business related travel of the same aircraft type (horizontal axis).

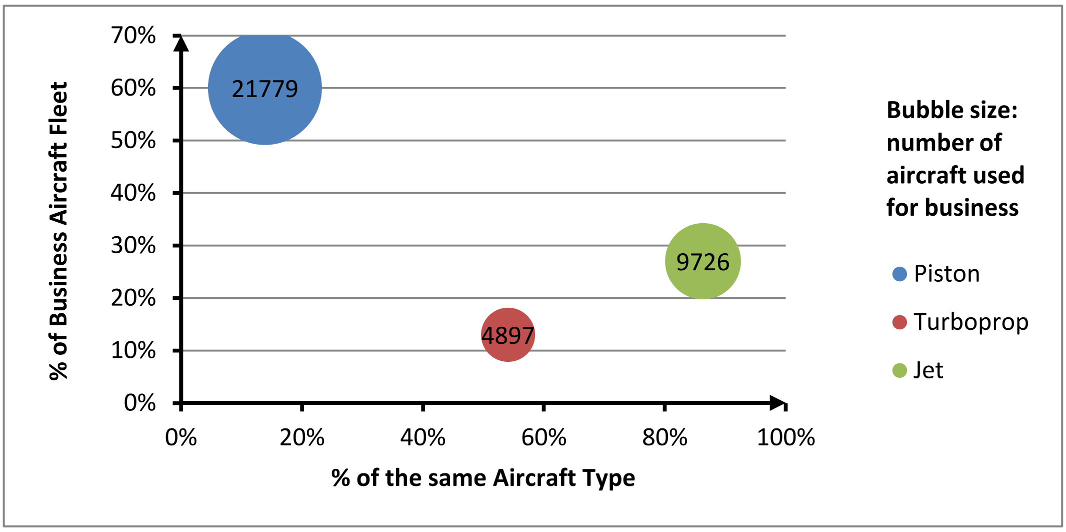

Figure 3: Primary Use of Aircraft Types for Business Activities
Source: FAA (2009)

As measured in absolute terms, more piston than jet aircraft transport individuals or goods for the primary purpose of supporting business activities. Turboprops are ranked third. We identified the size of the piston aircraft fleet as the reason for the domination of piston aircraft. It more than offsets the relatively lower rate of piston aircraft used for business travel. Around 80 percent of the piston fleet is primarily used for non-business activities. By contrast, almost all jet aircraft are primarily operated for business purposes. This may serve as an indicator that business men prefer flying with turbojet aircraft. Jets perform better in terms of range and speed. They allow business men to arrive faster at their final destination.

Figure 3 measures the number of aircraft primarily used for business purposes. It means that the statistic counts non-business flights as business flights as long as the majority of flight hours are operated for business purposes (primary use). The FAA isolates business flights by relating the number of annual flight hours operated for business purposes to the total number of annual flights hours (actual use).

Figure 4 shows that the distribution of business travel amongst piston, turboprop and turbojet highly depends on the design of the statistic. It measures the actual and primary use of aircraft for business purposes.

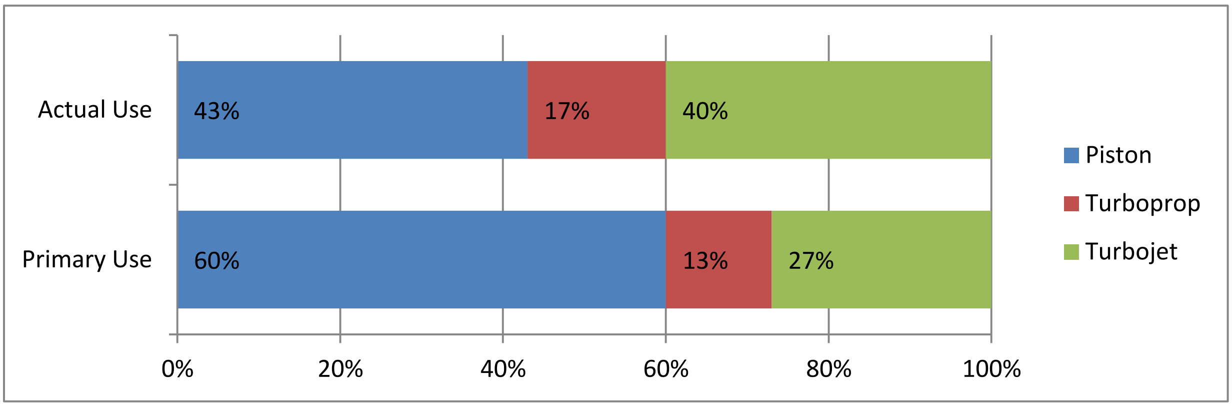

Figure 4: Business Travel as Actual and Primary Use by Aircraft Type

Source: FAA (2009)
Notes: Rotorcraft is left out of consideration.

The lower bar of Figure 4 shows the relative number of US registered aircraft primarily operated for business purposes. It corresponds to the vertical axis from Figure 3. The upper bar measures the relative number of flight hours operated for business purposes. Although piston aircraft are still ranked first, their share is relatively lower if measured in number of flight hours. The distribution of business travel amongst aircraft types depends on how business aviation is measured- either as number of aircraft (primary use) or number of flight hours (actual use). The later approach respects the IBAC definition by 100 percent because it counts business trips only. By contrast, the 'primary use' approach also includes non-business related travel.

2.3.1.2 Business Aviation in Europe

The European Organization for the Safety of Air Navigation (EUROCONTROL) monitors movements of aircraft models presumed to primarily serve business interests. Under this approach, non-business flights are considered business flights even if the aircraft primarily flies for e.g. personal reasons. Figure 5 compares the number of movements by aircraft type at European airports in 2009.

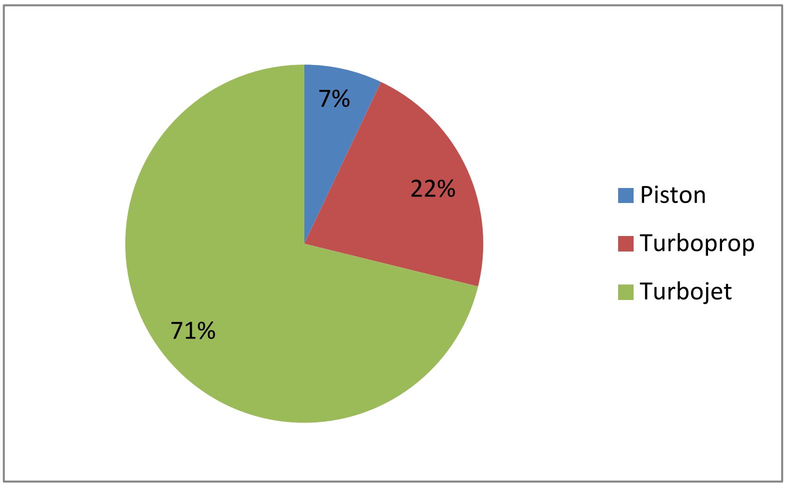

Figure 5: 2009 Movements by Business Aircraft Type in Europe
Source: Eurocontrol (2009), 2.

EUROCONTROL produces different results than obtained using FAA data (see Figure 4). Turbojet lead the statistic followed by turboprop and piston aircraft. Discrepancies between FAA and EUROCONTROL business travel pattern are related to the method of measurement and 'real life' differences in aircraft fleet and activity profile between European and US business aircraft operators. Concerning the methodology, the following differences have been detected:

- The relatively lower share of piston aircraft may be explained by VFR flights which do not appear in the EUROCONTROL statistic. FAA data indicates that piston aircraft operate more than half of total flights hours under VFR.
- EUROCONTROL movement data also contains aircraft registered outside Europe, whereas the FAA survey only refers to US registered aircraft
- EUROCONTROL measures flight movements and the FAA surveys the primary (as measured in number of aircraft) and actual use (as measured in

number of flights) of aircraft for business purposes. Two different units of measurement must inevitably bias the comparison.

A detailed description of the FAA and EUROCONTROL approach is available in the Appendix (A1).

To conclude, we found different pattern of business travel in Europe and in the United States. In Europe, jet aircraft contribute the most to business travel, followed by turboprop and piston aircraft. In the United States, the piston aircraft fleet is almost 14 times bigger than the turbojet fleet. Besides measurement related differences, this might be one of the main reasons why piston aircraft lead the ranking even though the majority of them are primarily operated for reasons other than business.

2.3.2 Segmentation of the Business Jet Market

The previous Chapter separates the business aircraft market in piston, turboprop and turbojet aircraft. Turbojets can further be subdivided into eight smaller market segments. Figure 6 segments turbojets by price, maximum range and MTOW (a proxy of aircraft size).

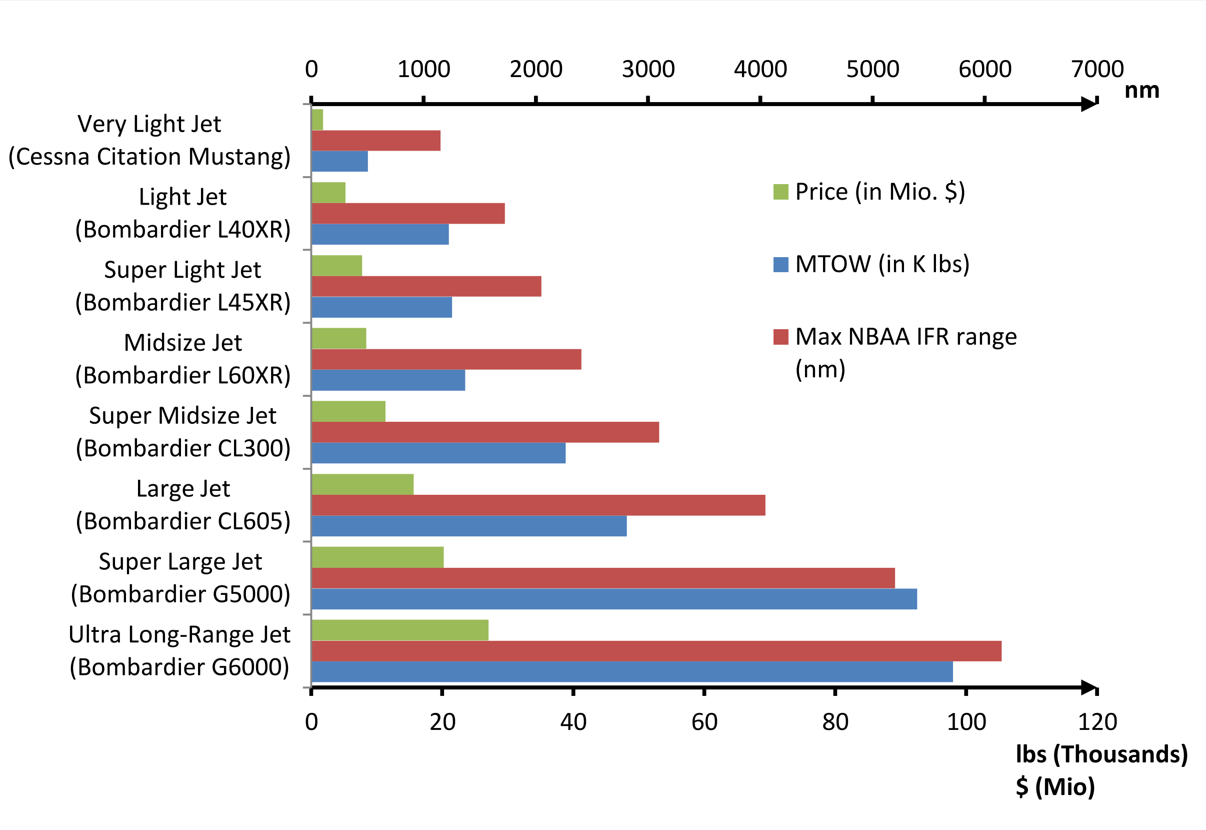

Figure 6: Business Jet Market Segmentation

Source: Bombardier (2009), 30.
Flightglobal (2012)

Data was retrieved from the Bombardier market forecast. Bombardier Aerospace, the second largest business aircraft manufacturer in the world, competes in almost all segments with its aircraft families Learjet, Challenger and Global. Figure 6 assigns different Bombardier aircraft to the corresponding jet market segment. Most important criteria governing the purchasing decision are the price and performance of the aircraft. Bombardier satisfies different price-performance combinations by producing a wide range of aircraft. Figure 6 shows that jet users have to pay more for bigger and more performing aircraft.

2.3.2.1 Market Forecast

Bombardier forecasts deliveries and revenues for the light, medium and large jet aircraft market segment for a period starting in 2011 until 2030.

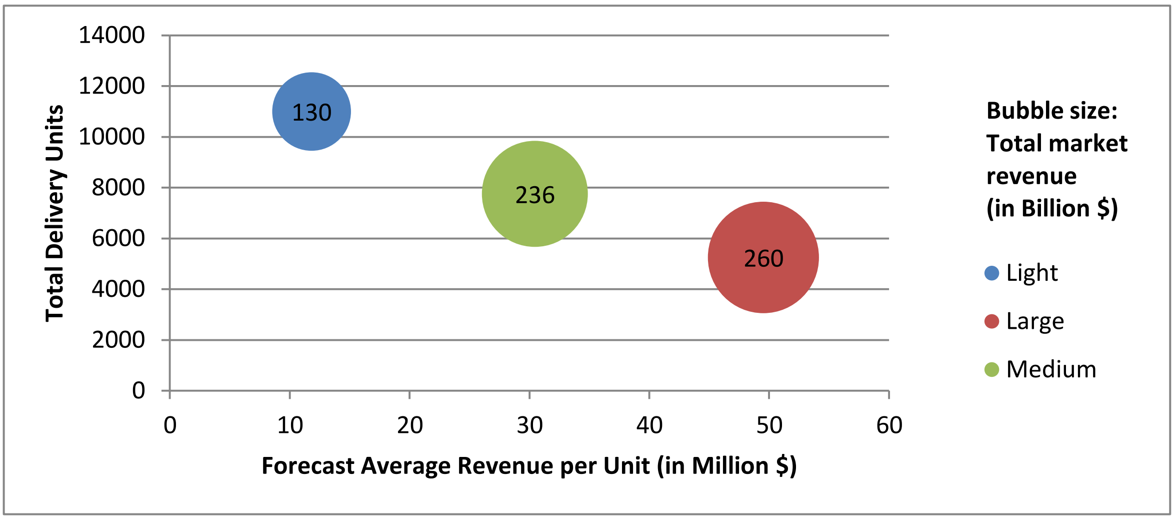

Figure 7: Business Jet Forecast by Segment

Source: Bombardier (2011)

Figure 7 estimates delivery units, average revenue per unit and total revenue of the *Light* (Light jet, Very light jet, Midsize jet), *Medium* (Super midsize jet, large jet) and *Large* (Super large jet, Ultra long-range jet) business jet market for a 20 years forecast period. The *Light* category is characterized by relative low prices, low operating economics and sufficient range for short haul missions. The *Medium* category provides enhanced cabin comfort and a superior range. The highest standard can be expected from aircraft assigned to the *Large* Category. They can fly the longest range and offer superior comfort to their users. Bombardier expects the highest revenues from the sale of large jets. The *Light* category leads the statistic in terms of delivery units, but it is estimated to generate less revenue than the *Medium* and *Large* category.

2.3.2.2 Market Drivers

Forecast delivery units and revenue are based on several assumptions about the development of the jet aircraft market and global economy. Bombardier identifies several parameters affecting the market performance such as the size of the pre-owned aircraft inventory. A relatively high number of aircraft for sale on the pre-owned market indicates that it is rather difficult for manufacturers to find buyers for new jets. Table 4 lists other market drivers.

Market Drivers	Unit of Measurement	Definition
Economy Growth and Wealth Creation	GDP	Higher GDP means more business opportunities for business men and a higher need for air travel.
	MSCI (Morgan Stanley Capital International) World Index	The MSCI World Index aggregates stock market indices of developed countries and is considered to be a good estimate for wealth creation.
	Number of Billionaires	The number of Billionaires, as measured by Forbes, can be used as an indicator for personal wealth.
Pre-Owned Aircraft Market	Pre-Owned Aircraft Inventory as % of the Fleet	Inventory of used aircraft for sale on the pre-owned aircraft market. Aircraft owners are not going to purchase new aircraft as long the old one wasn't sold.
	5-year Residual Value	Price that can be obtained from the sale of 5 year old aircraft.
New Aircraft Programs		New aircraft integrate the latest technology. Business aircraft operators are more likely to replace older aircraft if new aircraft promise higher technology improvements.
Emergence of new business models		Example: Fractional ownership. The business model of fractional ownership created new demand for aircraft manufacturers.
Aircraft Retirements	Aircraft Age	Aircraft retirement due to technical, operating or regulatory reasons. New aircraft necessary to continue operations.

Table 4: Aircraft Market Drivers

Source: Bombardier (2011)

2.3.3 Market Segmentation by Business Model

Business aircraft users are offered multiple ways to benefit from non-scheduled air travel aboard of business jets. It can be advantageous to rather fly on-demand using the service from air charter companies without requiring any long-term financial commitments of owning a private jet. The industry offers a number of different air travel options to meet the needs of its users. More recent developments, such as the introduction of fractional ownership or jet card programs, attract business men previously traveling on scheduled services and help the industry (manufacturers and any kind of service providers) to generate growth. Table 5 provides an overview of existing business models.

	Business Jet Ownership (non-commercial flights)					**On-Demand Service (commercial flights)**	
Business Model	Full Ownership	Co-Ownership	Interchange Agreement	Joint Ownership	Fractional Ownership	Jet Card Block Charter	Air Charter
Type of Ownership	Aircraft is fully owned by private person or company.	Aircraft is owned by more than one entity.	Aircraft is owned by private person or company.	Aircraft is owned by more than one entity.	Aircraft user purchases a fraction of an aircraft.	Aircraft user acquires time of aircraft use without committing to ownership.	Aircraft is provided and paid on a flight-by-flight basis.
Description	Flight department, staffed with flight crew, maintenance technician and the use of vendors for a variety of support services. Or an aircraft management company takes over all management responsibilities involved in aircraft operations.	Each co-owner is responsible for providing flight crew and covering all other aspects associated with aircraft operations. Aircraft can be operated with only minimal external aid. Or an aircraft management company is contracted to operate the aircraft on behalf of the co-owner.	It allows aircraft owners to swap time on an hour-to-hour basis. A fee can be charged to compensate for differences in the size of operating or maintenance costs between two aircraft.	Each joint owner pays his pro rata share of fix costs and variable costs according to use. But the flight crew is only provided by one registered joint owner. An aircraft management company may operate the aircraft on behalf of the joint owner.	The acquired fraction equates to a certain number of hours of aircraft utilization per year. Up-front payment is required at the beginning of contract term. Interchange agreement ensures the use of other aircraft. Service company is responsible for the management of the aircraft share.	Jet Card holders obtain access to business aircraft in increments of 25 or 50 hours. Regular charter users benefit from discounted rates. Jet Card programs are nothing different than block charter which offers blocks of time on a particular operator's fleet or on a multitude of operators.	Air charter companies provide instant access to business aircraft. Trips can be quoted for the time the aircraft is away from his base, or the charter company only prices the transport between departure and arrival point.

Table 5: Summary of Existing Business Models

Source: NBAA (2011)
Wilson (online)

Please note that Table 5 seeks to give an overview of existing business models, but does not claim completeness. For instance, leasing and time sharing agreements are not included in the summary. When choosing between different arrangements (Jet Card, Fractional Ownership, Full Ownership), it is recommended to consider a wide range of factors, such as individual travel needs, convenience, tax considerations and availability[5].

[5] Wilson (online).

To give an idea of the distribution of business travel amongst the above listed business models, we show the percentage share of commercial (FAR Part 135) and non-commercial (FAR Part 91) flights of US registered business aircraft operators in the pie chart of Figure 8.

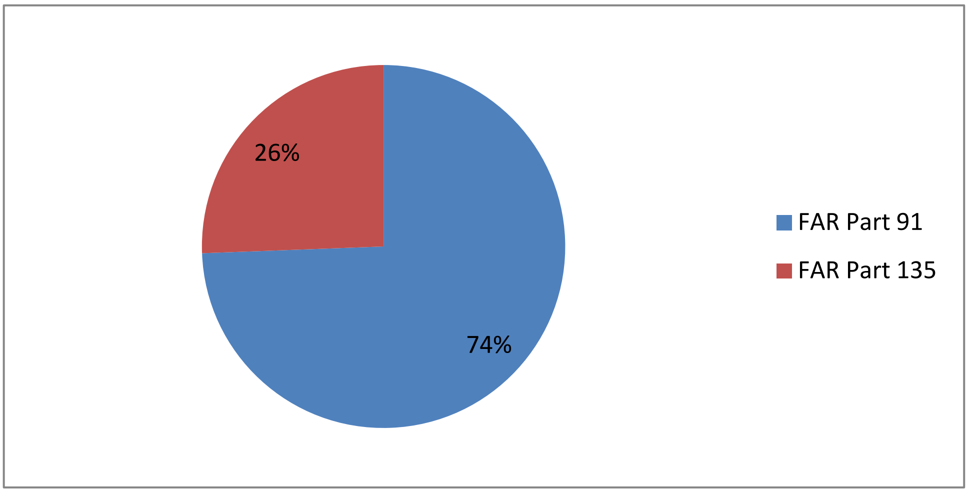

Figure 8: Percent of Business Jets operated under FAR Part 91 & 135

Source: FAA (2009)
Notes: Primary Use, Turbojets only.

Three-fourth of business jets are operated under non-commercial flight rules. The rest flies charter. It should be noted that the same aircraft can be used for commercial and non-commercial operations. Aircraft owners might wish to free the aircraft for charter services. They would sacrifice some degree of flexibility, but in turn use charter revenues to compensate one part of direct operating costs.

3 Direct Operating Costs of Business Jet Aircraft

Chapter 3 addresses the questions raised in work package T4.2. It analyses all direct costs associated with the operation of business jets. The introduction into a traditional cost concept is followed by the analysis of single DOC positions. Chapter 3 is rounded up with the comparative analysis of the DOC structure of business jets from different market segments, manufacturers and operated under different business models.

3.1 Introduction into a Traditional Cost Concept

The operation of business aircraft entails costs that can be assigned to different cost categories. This chapter distinguishes between the following cost categories:

- Non-Operating Costs vs. Operating Costs
- Direct Operating Costs vs. Indirect Operating Costs
- Fixed Costs vs. Variable Costs

Figure 9 assigns single cost elements to the categories non-operating costs and operating costs (direct and indirect operating costs).

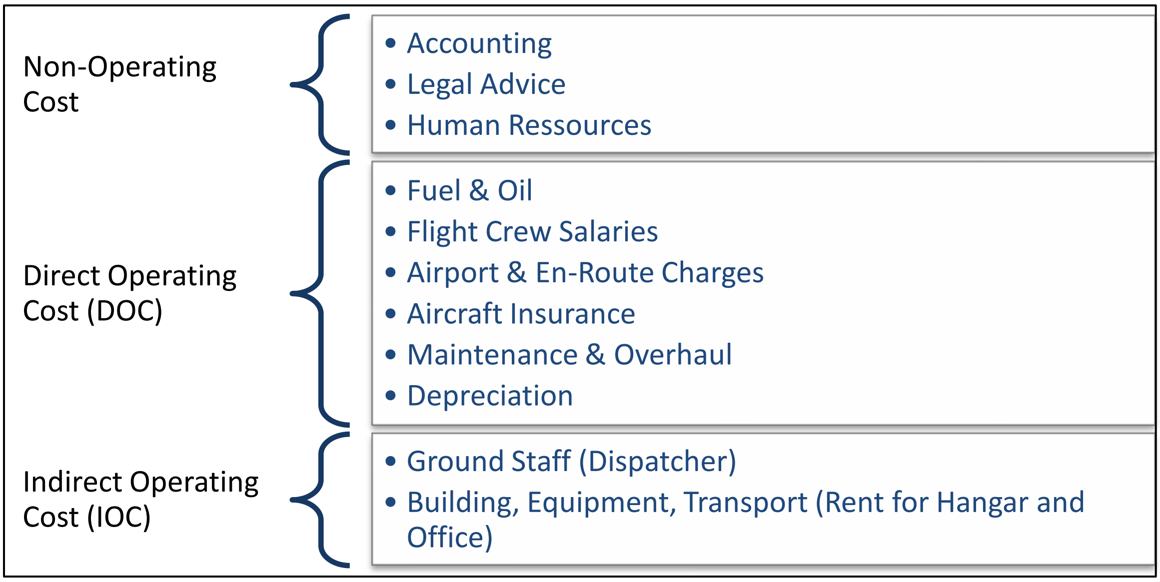

Figure 9: Categorization of (Non-) Operating Costs

Source: Doganis, R. (2002).

Operating costs are associated with the operation of business aircraft, whereas non-operating costs are related to non-aviation support and services needed to function as owner or operator[6]. Accounting, legal advice and human resources are examples for non-operating costs. They are unrelated to the provision of air transport services, but are necessary for running a business. Operating costs are further sub-divided into direct and indirect operating costs. Direct operating costs (DOCs) can be characterized as costs that depend directly on the type of aircraft being operated. Accordingly, direct operating costs would change if the aircraft type was changed. By contrast, indirect operating costs remain unaffected by aircraft type changes. Overhead costs are indirect costs because they cannot be attributed to a specific aircraft type. Figure 10 further sub-divides DOCs into variable costs, fixed costs and cross over costs.

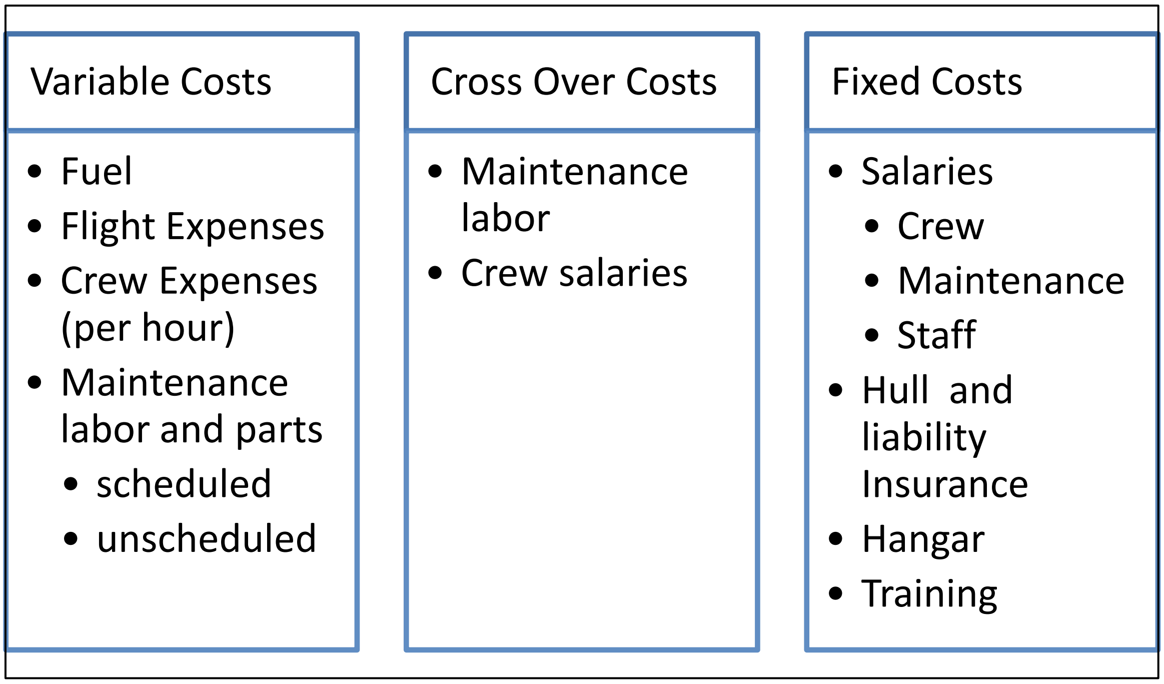

Figure 10: Allocation of Costs to Variable, Cross Over and Fixed Cost Categories

Source: NBAA (2009)

Fixed costs are defined as costs that are insensitive to output changes, whereas variable costs vary depending on how much the aircraft is used. It should be noted that all costs are variable as measured over a relatively longer time horizon. But it is common practice to speak from fixed costs if costs remain constant over one year. Figure 10 also refers to cross over costs combining a fixed cost block with a variable cost element sensible to changes in aircraft activity.

[6] NBAA (2009).

3.2 Analyzing Single Direct Operating Cost Positions

In the following, we analyses single DOC positions of business jet aircraft. Costs for aircraft ownership, maintenance, fuel, personnel, hangar, insurance and flight expenses are modeled for various business aircraft market segments using ARG/US data.

3.2.1 Ownership

The ownership or use of business aircraft entails costs. Ownership costs equate the price paid for the aircraft and interest payments. The aircraft may also be leased by the lessee and appear in his books in form of monthly or annual leasing payments. Besides full ownership and leasing, air charter services make traveling aboard of business aircraft more accessible. They provide business aircraft services on-demand and do not require up-front capital investments. The client can pay on a flight-by-flight basis. An hourly rate compensates for a fraction of total ownership costs.

An aircraft is an asset which depreciates over the time of operation. One way to account for the wear and tear of the aircraft is to depreciate the aircraft in accordance with the pattern in which the economic benefit is consumed. In practice, the size of the annual depreciation expense depends on the aircraft's useful life, residual value and depreciation method. As to what regards the accounting rules, one has to distinguish between tax and financial accounting. Tax accounting rules were designed for tax purposes, whereas financial accounting standards regulate the reporting of financial statements to company stakeholders, such as investors or creditors. Appendix 2 describes the difference between both methodologies in greater detail.

We modeled ownership costs for different Bombardier business jets to see how depreciation expenses vary with aircraft size. Several assumptions were necessary. The financial depreciation (also known as book depreciation) is better suited for our purposes. We assume a linear depreciation over 10 years. The residual value corresponds to 60 percent of the aircraft purchase price. When we say residual value, we refer to the base value of the aircraft. The base value only reflects the physical wear and tear of the aircraft. It differs from the market price because it does not account for external variables[7], such as economic growth, fuel prices or aircraft availability.

Figure 11 compares annual costs for aircraft ownership (= annual depreciation expense) between the Learjet, Challenger and Global aircraft family. The calculation is based on the Business Commercial & Aviation (BCA) equipped aircraft price[8]. The average aircraft utilization of US based aircraft operators is written in parenthesis on the horizontal axis in Figure 11. We don't present *hourly* depreciation expenses because ownership costs of most corporate flight departments are insensitive to aircraft utilization.

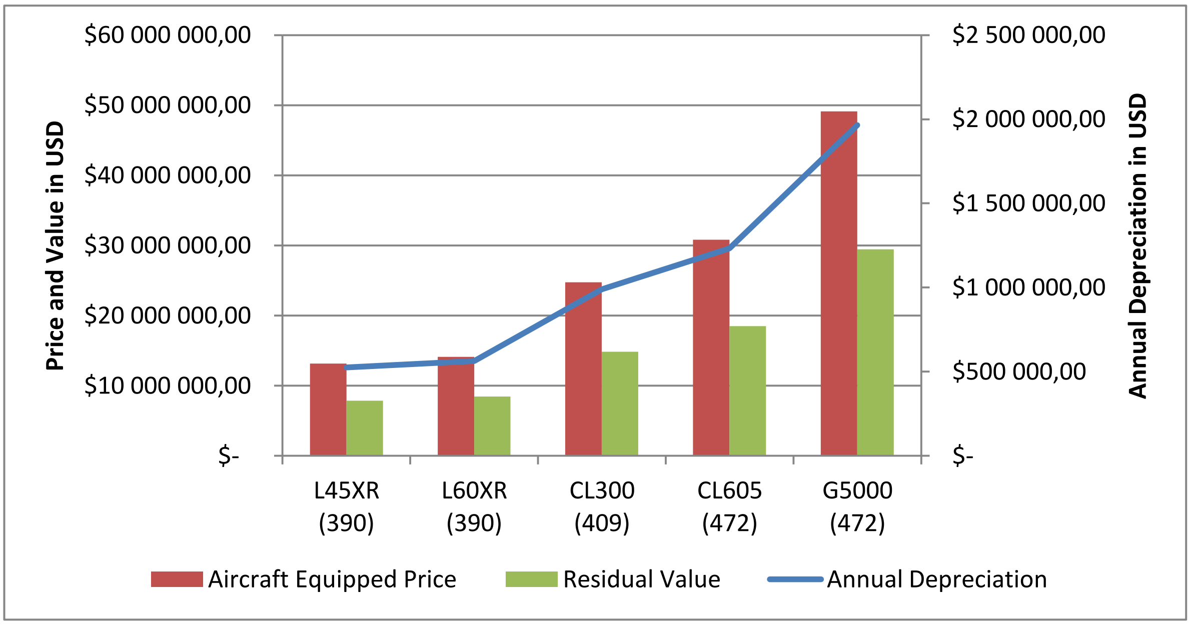

Figure 11: Annual Depreciation Expenses by Aircraft Segment

Source: BCA (2011)

Figure 11 shows that depreciation expenses are higher for bigger aircraft. This outcome was expected because the model assumes the same depreciation rate for aircraft with different purchase prices.

[7] Following the definition of the International Society of Transport Aircraft Trading (ISTAT), the base value arises from a stable market environment and a reasonable balance of supply and demand.

[8] The BCA equipped aircraft price refers to an aircraft with standard configuration (no extras).

3.2.2 Fuel

Hourly fuel costs depend on the aircraft fuel consumption and on the price of Jet kerosene. This chapter sets out to analyses strategies which seek to lower the fuel bill.

Price of Jet Kerosene

Fuel costs highly depend on the price that has to be paid for one gallon Jet A fuel. Figure 12 shows that the price for jet kerosene is closely tied to the price of crude oil.

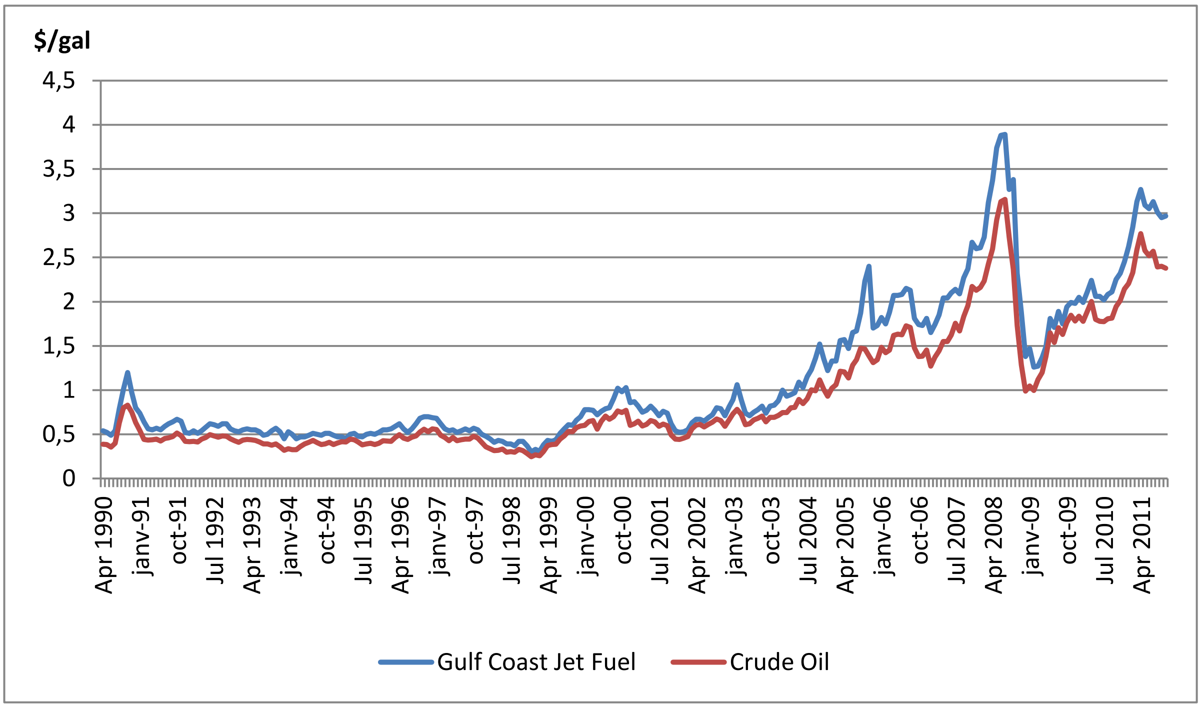

Figure 12: Price of Gulf Coast Jet Fuel and Crude Oil from 1990- 2011

Source: http://www.indexmundi.com

The difference between kerosene and crude oil prices (known as crack spread) equates the profit margin obtained by refineries which task consists in cracking crude oil into aviation fuel. Figure 12 refers to the wholesale price for jet fuel. But business aircraft operators usually pay a higher price. Fixed-Base Operators (FBOs) are on average about $ 2-4 higher than what the wholesale price for one gallon of Jet-A is. Costs for transportation, marketing and fuel supplier margins add to the wholesale price. In addition, governmental taxes on jet kerosene add to the fuel bill. For instance US FAR Part 91 operators are levied a cents-per-gallon tax. As illustrated in Figure 12, jet fuel prices underlie fluctuations that are often hard to predict. Fuel hedging can be a mean of stabilizing fuel costs and decrease the vulnerability to currency fluctuations. For instance a fall in dollar jet fuel prices may be negated by a strengthening dollar. As jet fuel is USD denominated, non-USD operators pay more (less) if the dollar appreciates (depreciates) in value. Fuel hedging is largely applied by airlines and rather unknown to business aircraft operators. The latter are less sensitive to price changes, require far less jet fuel than commercial airlines and often don't fulfill the organizational, economic and financial requirements necessary to become a member of a futures exchange.

The Impact of Jet-A Price Changes on DOCs

Figure 13 illustrates which effect jet fuel price changes can have on the DOC structure of a Dassault Falcon 7X flying 472 hours per year. We used ARG/US cost data to simulate DOCs under five different fuel price scenarios ($2, $4, $6, $8, $10 per gallon for Jet-A).

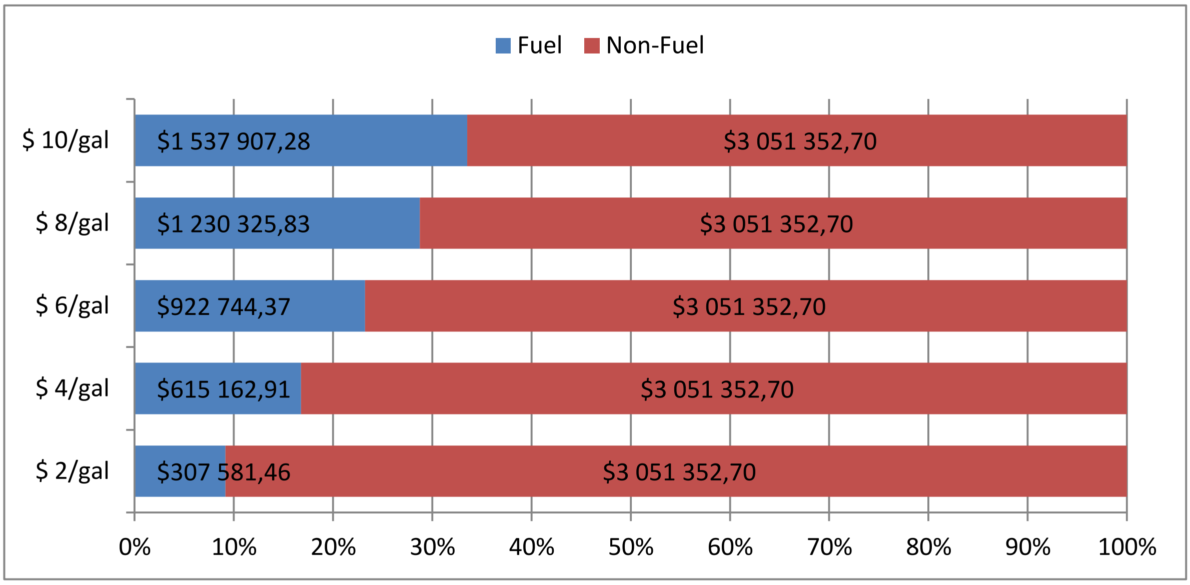

Figure 13: Fuel vs. Non-Fuel Direct Operating Costs

Source: BCA (2011)
Notes: Example Dassault Falcon 7X.

Figure 13 demonstrates that (1) total DOCs go up with increasing fuel prices and (2) the share of annual fuel costs increases relative to non-fuel DOCs. In 2010, the US wide average price for one gallon of Jet-A amounts to $ 6.04. Jet fuel price changes are most likely to affect total DOCs and the DOC structure as modeled in Figure 13.

Fuel Cost Reduction Strategies

Aircraft operators can take certain measures to minimize fuel costs. For instance they can negotiate direct deals with fuel suppliers (airports, FBOs or maintenance shops). Fuel contracts or pre-purchase plans reward the fuel buyer for his long-term commitment by offering fuel to more advantages conditions. Fuel suppliers also benefit from long term agreements because revenue streams get more predictable. You also can get discounted fuel at other than your ‘home’ airport if you are enrolled in a fuel program. Fuel buyers are recommended to not only include the fuel price in their purchasing appraisal, but also other costs, such as hangar rent, ramp or parking fees. These costs may outweigh cheaper fuel prices and favor airports where Jet-A is more expensive. Operators also consider price differences between different regions of the world. Fuel tanker strategies can be implemented to reduce the fuel bill. All interview partners who participated in BASE confirmed that fuel tankering is a common practice. From an economic viewpoint, it can make sense to carry additional fuel even though, as a rule of thumb, one third of tankered fuel gets burned due to additional fuel load. The drawback is that fuel tankering increases the aircraft fuel consumption and leads to additional emissions. Another strategy is to perform tech stops at airports with relatively lower jet fuel prices. BASE survey participants confirmed that higher fuel prices provide sufficient incentives to perform tech stops where fuel is cheaper. Aircraft operators were also asked whether the European Union Emissions Trading Scheme (EU ETS) has any impact on flight route planning. Some US operators stated that they would rather avoid going through Europe (where the EU ETS applies) and choose longer, indirect routes when flying from North America to regions in Africa, Asia or the Middle East. We found out that the EU ETS related administrative burden is even more a reason for corporate flight departments than costs related to the purchase of emissions allowances.

Technical Fuel Reduction Measures

Technical (airframe, engines) and operational parameters (such as aircraft load, cruise speed, flight level) determine the quantity of fuel burn during all stages of the flight. New generation business aircraft fly more fuel efficient thanks to technical progress achieved over past decades. New engine technologies allowed significant fuel reductions (high-bypass and geared turbofans). Drag could be reduced by redesigning airframe and wings. Lighter electrical systems (fly-by-wire) and the increasing use of light-weight “composite” materials also contributed to a lower fuel consumption. We demonstrate the fuel efficiency improvements achieved over the last 20 years using the F900 series of the French manufacturer Dassault Aviation. Figure 14 compares hourly fuel expenses across F900 aircraft. The year of entry into service is written in parentheses.

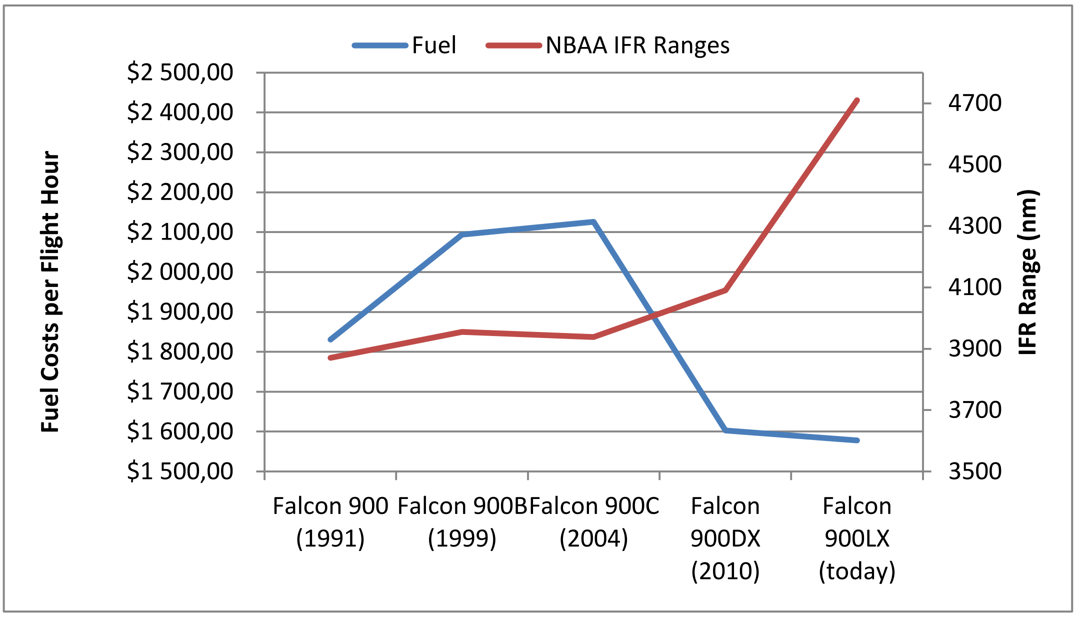

Figure 14: Fuel Expenses of F900 Series

Source: BCA (2011).

Figure 14 shows that new F900 aircraft burn less fuel which leads to lower hourly fuel costs. As a result of higher fuel efficiency, Dassault Aviation could increase the maximum achievable range (NBAA IFR range). New F900 models provide business aircraft users additional time savings and higher accessibility to remote destinations.

Fuel Costs by Aircraft Segment

ARG/US operating cost data was also used to model hourly fuel expenses of aircraft from different market segments. Bombardier Learjet (L45XR and L60XR), Challenger and Global aircraft cover the market from super light business jets to super large business jets. Figure 15 shows hourly fuel costs for the Bombardier aircraft family.

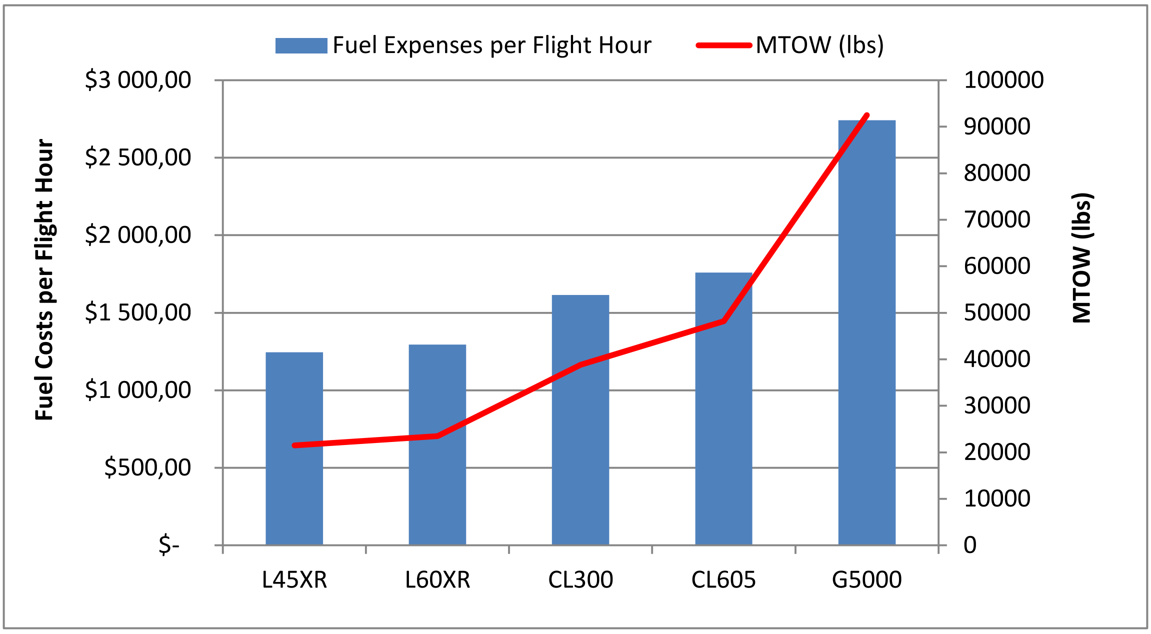

Figure 15: Fuel Costs and MTOW of Bombardier Jets
Source: BCA (2011)

Figure 15 illustrates that hourly fuel costs increase with aircraft size. The larger and heavier the aircraft is, the more fuel is burned. We expected this outcome because weight and drag increase with aircraft size so that more thrust is needed to move the aircraft through the air.

3.2.3 Maintenance

This chapter presents the results obtained during the analysis of direct maintenance costs (DMCs). Readers with limited knowledge of maintenance requirements are invited to read Appendix 2 to learn more about aircraft maintenance under FAA regulation. We modeled DMCs using ARG/US data published in the Business & Commercial Aviation (BCA) 2011 Operations Planning Guide.

Labor and Parts Expenses by Aircraft Segment

Figure 16 sheds light on hourly costs for maintenance labor and parts of in-production Bombardier aircraft (Learjet, Challenger and Global). The hourly labor expense is computed by multiplying the ratio of maintenance hours per flight hour with the US wide model-specific average service center hourly maintenance labor cost. It comprises costs for scheduled and unscheduled maintenance while under warranty (five years). ARG/US also publishes manufacturer information about the model-specific average hourly parts expense for the five year warranty period including scheduled, unscheduled and consumable items (such as oil or hydraulic fluid).

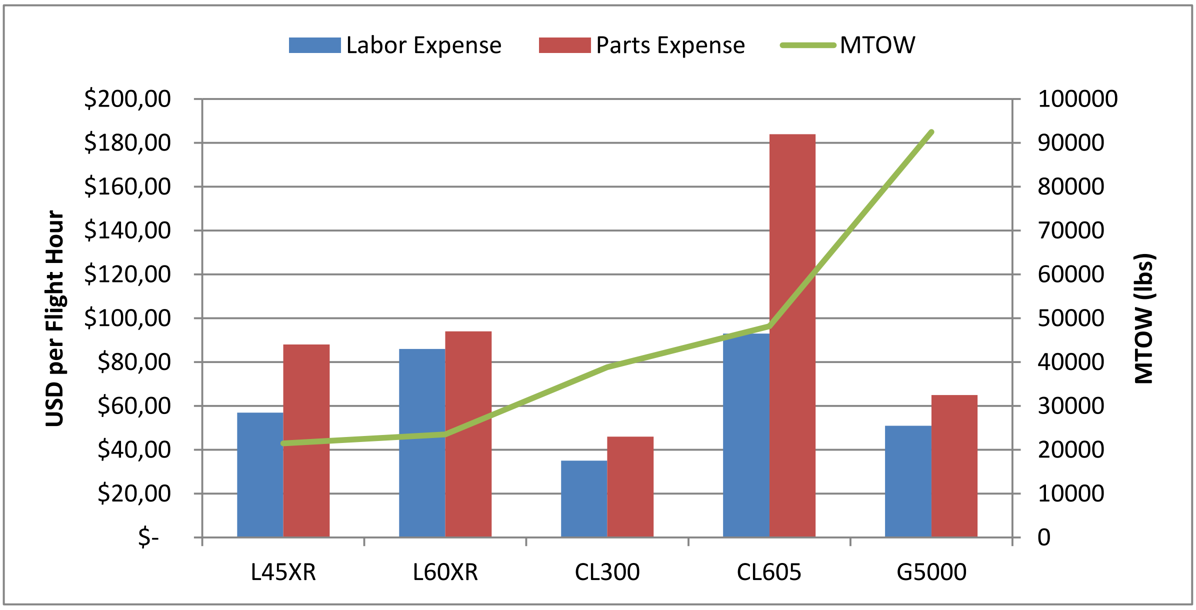

Figure 16: Labor and Parts Expense by Aircraft Segment

Source: BCA (2011)

Figure 16 indicates that there is seemingly no positive relation neither between labor expenses and aircraft size, nor between parts expenses and aircraft size. The Bombardier CL300 and G5000 perform better than the L45XR and L60XR although they are much bigger. Only the CL605 confirms a positive correlation between costs related to labor/parts and aircraft size. The idea is that bigger aircraft contain a greater number of parts and systems which can break and require repair work. As to what regards the Challenger 300, the maintenance program is based on work performed by the Maintenance Steering Group 3 (MSG-3). The MSG-3 brings major business aviation stakeholders (government, operators, and manufacturers) together to maximize safety and minimize maintenance costs. The maintenance of the CL300 follows an 'on-condition' inspection plan which eliminates any unnecessary maintenance activities and component removal[9]. It should also be noted that Learjet was purchased by Bombardier Aerospace in 1990 and still acts independently from the Challenger aircraft family.

Labor and Parts Expenses of the F900 Series

We observed that labor and parts expenses could be reduced thanks to improvements made during the development of aircraft as the following example proves. Figure 17 shows hourly labor and parts expenses for F900 aircraft operated 472 hours on average. The date of the last production is set in parenthesis. Cost data of out-of-production aircraft (all F900 except F900LX) was reported by US based aircraft operators and published by ARG/US.

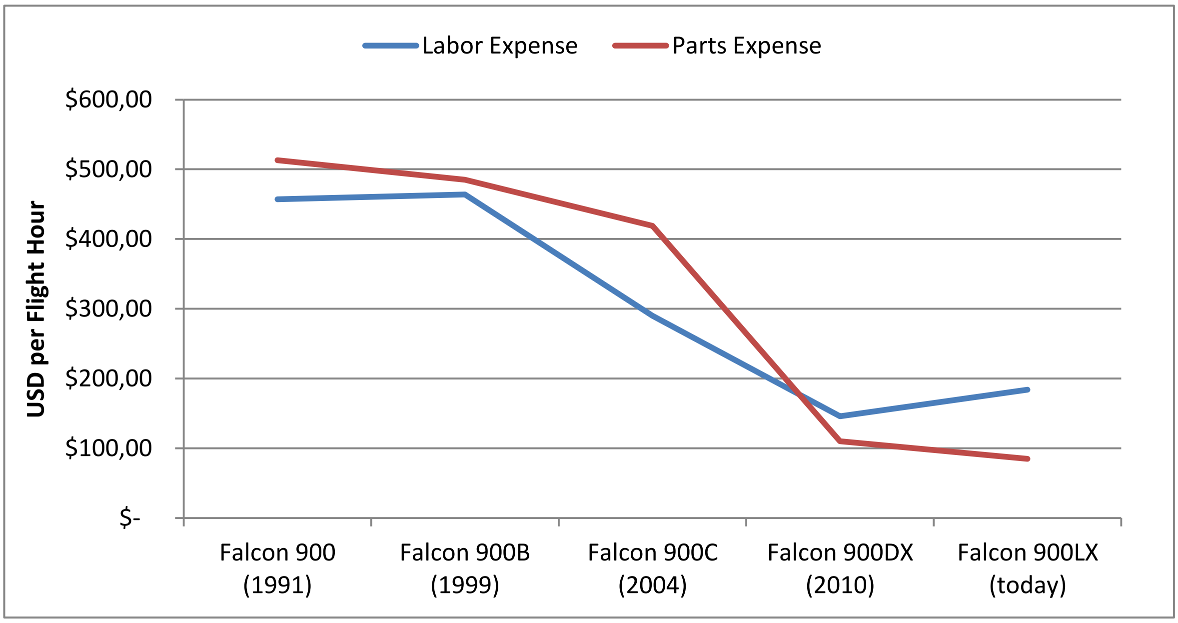

Figure 17: Maintenance Cost Development over Time
Source: BCA (2011)

Figure 17 illustrates the historical downward trend of hourly expenses for labor and parts. The design of new generation Falcon aircraft accounts for aircraft maintenance right from the start of the design process. Physical mockups were replaced by digital mockups. Engineers can now visually display the "digital" aircraft in 3D and so

[9] BCA (2003)

determine the optimal position of each individual part of the aircraft. Maintenance labor costs could be significantly reduced because parts are now more accessible and so easier to replace. Lower costs for parts are related to on-condition maintenance programs, as described earlier for the Bombardier CL300.

Periodic Maintenance Costs

Figure 16 does not address periodic maintenance, such as scheduled inspections (mid-life/hot section inspection), engine overhaul, aircraft refurbishment and paint. These activities are necessary to keep the aircraft in working condition and allow the owner of the aircraft to preserve the residual value. Figure 18 gives an overview of annual maintenance costs which are relatively fix and insensitive to aircraft utilization.

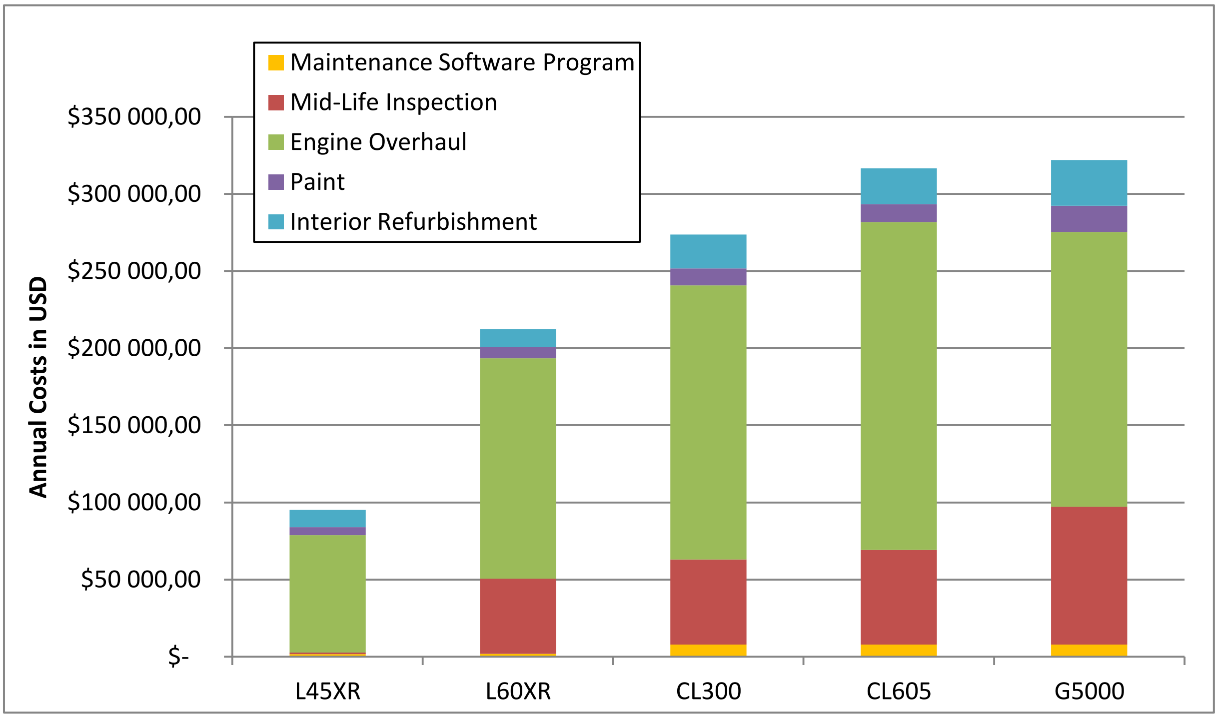

Figure 18: Annual Fixed Maintenance Costs
Source: BCA (2011).

The calculation of annual fixed maintenance costs underlies the assumption that periodic costs are evenly spread of a period of 10 years. Figure 18 demonstrates that annual fixed maintenance costs go up with increasing aircraft size.

3.2.4 Personnel

Flight departments incur costs for employing flight crew, maintenance staff, dispatcher, management or other supporting staff. We provide an overview of tasks performed in a corporate flight department. Since maintenance labor has already been discussed in the previous chapter, we will focus primarily on the flight crew and related costs.

Corporate Flight Department

The number of staff employed in a corporate flight department highly depends on the scope of annual flights activities, as Figure 19 shows.

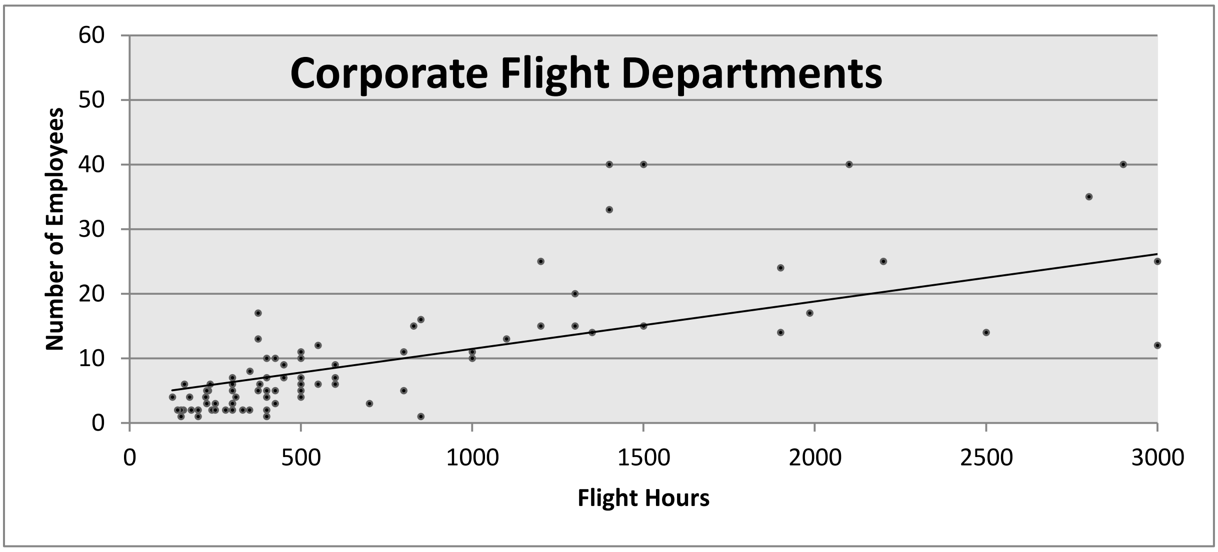

Figure 19: Relationship between Number of Employees and Annual Flight Hours

Source: BASE survey results

Figure 19 reveals that more staff are needed to maintain a flight department if flight activity increases. Work performed internally can also be outsourced to external service providers. These service providers are often highly specialized. They can realize economies of scale and pass through the cost savings to their customers. We were interested in the question whether 'high activity' flight departments perform more services in-house than 'low activity' flight departments do. To find out, we compared the 'in-house service concentration' amongst flight departments with lower and higher than 500 flight hours per year[10]. Figure 20 shows that flight departments with more than 500 flights hours per year perform a greater number of services in-house. This is especially true for services related to safety/security and maintenance work.

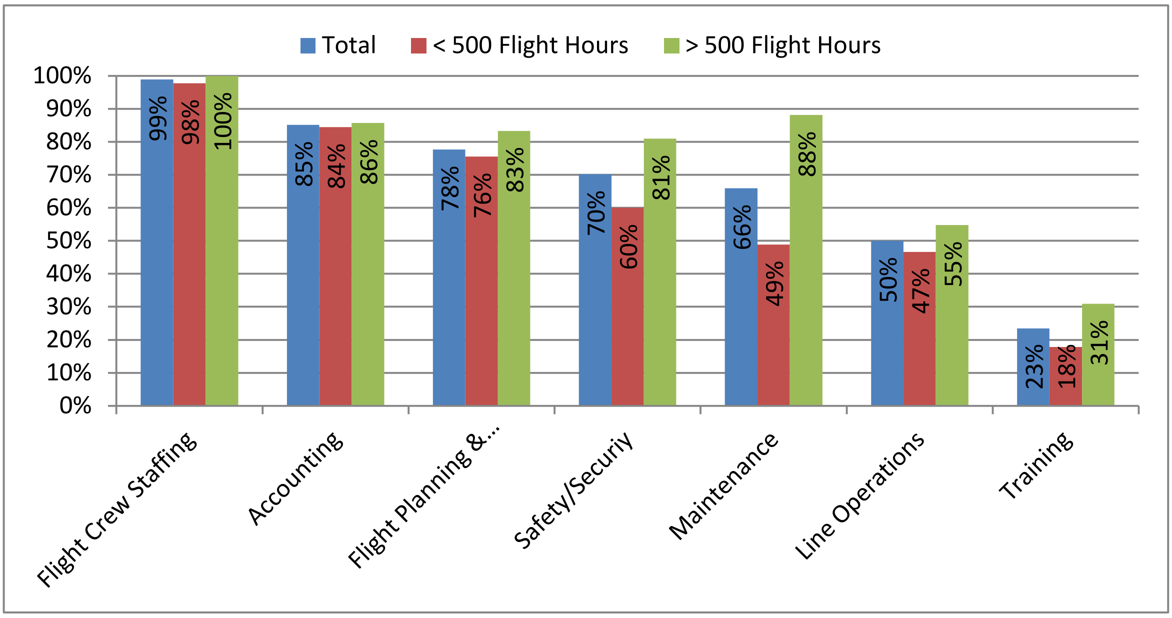

Figure 20: Services performed In-House by Corporate Flight Departments

Source: BASE survey results

A lower 'in-house service concentration' means that operators receive more external assistance from specialized flight support companies. Aircraft owners may also give all responsibilities related to flight operations to aircraft management companies. Figure 20 disregards managed aircraft. It only refers to aircraft operators employing its own flight crew.

[10] 500 flight hours is the median number of flight hours of business aircraft operators who participated at BASE.

Flight Crew

Virtually all surveyed flight departments hire their own flight crew. Pilots require a commercial certificate with the appropriate rating to fly company aircraft. This includes a type rating[11] for the specific aircraft model and an instrument rating which allows pilots to fly under Instrument Flight Rules (IFR). Holders of a commercial pilot license (or certificate) must demonstrate a minimum level of English, have received specific training and hold a second-class medical certification. It should be noted that commercial pilots are not allowed to fly around passengers against remuneration if airplane and pilot services are offered as a package, unless they hold an Air Operator Certificate (AOC). Pilots are often assigned other responsibilities than operating the company aircraft. Take for instance the compliance with legal obligation, such as monitoring and reporting under the European Union Emissions Trading Scheme (EU ETS).

The typical working month of a pilot highly depends on the work schedule that is agreed with the company. Table 6 provides an overview of different types of work schedules applied by NetJets- the world leading fractional ownership company.

Type of Work Schedule	Description
7 Days On / 7 Days Off	As the name suggest, pilots are 7 consecutive days in service and get 7 days off work after each working period.
15 Day Flex	Flexible work schedule with 15 work days maximum per month. Duty tours cannot last longer than 5 days and pilots receive a minimum of 3 days off following each tour.
18 Day Fixed	Fixed work schedule with a maximum of 18 work days. Duty tours can last a maximum of 7 work days followed by a minimum number of days off per contractual rules.

Table 6: Types of Work Schedules NetJets 2007

Source: NetJets Aviation (online)

[11] A type rating is needed for turbojet s or aircraft with MTOW higher than 12500 lbs.

Flight Crew Salaries

Figure 21 shows the annual base wage for a Captain and First Officer flying an aircraft with MTOW higher than 40000 lbs under a ‘7 days on / 7 days off’ work schedule.

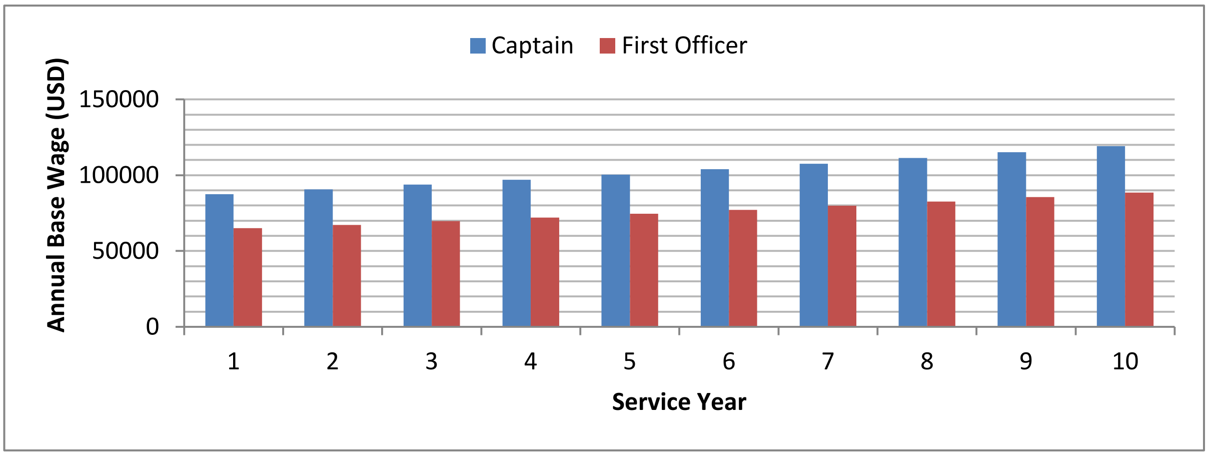

Figure 21: Annual Base Wage of NetJets 7 Days On / 7 Days Off Work Schedule
Source: NetJets Aviation (online)

It comes out very clearly that pilots receive higher annual wages with increasing experience (number of years in service) and if they fly the aircraft as captain. Other benefits, such as Paid Time Off (PTO)[12], medical benefit or benefits from loyalty programs add to the annual base wage. Figure 22 shows that the annual base wage also depends on the work schedule and number of work days.

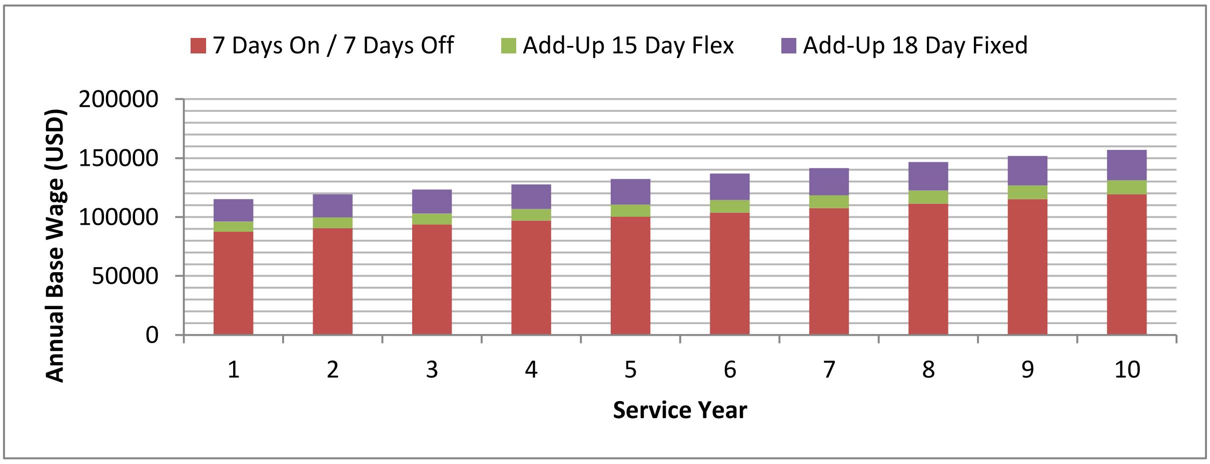

Figure 22: Annual Base Wage by NetJets Work Schedule
Source: NetJets Aviation (online)

[12] Beyond vacation time, pilots receive paid time away from work for personal injury or illness (“sick time”) and for other reasons (“personal days”).

We were also interested in the question whether aircraft size affects the level of hourly flight crew salaries. ARG/US provides information of captain and first officer salaries not including benefits. The numbers represent the US wide average.

Figure 23 shows hourly flight crew salaries for Learjet, Challenger and Global aircraft. The flight crew is composed of the captain and first officer. The number of average flight hours is written in parenthesis.

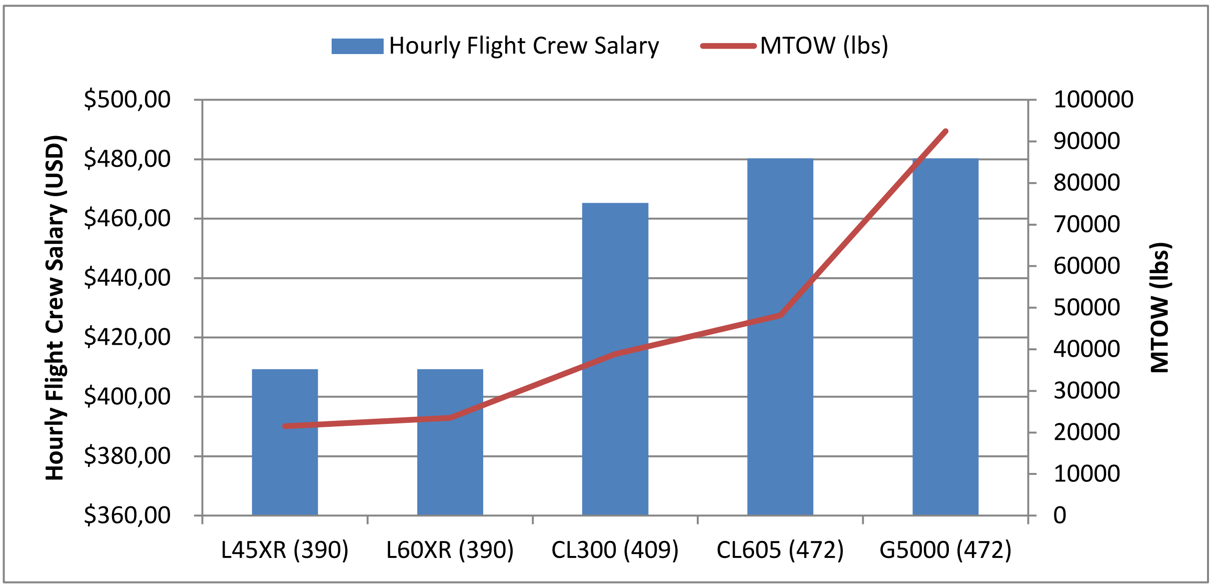

Figure 23: Salary for Flight Crew of Bombardier Business Jets

Source: BCA (2011)

To conclude, the annual base wage depends on the pilot's position (Captain or First Officer)[13], aircraft size, year in service, type of work schedule and the number of work days.

[13] Captain (or PIC) = First in-command; First Officer = Second in-command.

3.2.5 Hangar

Costs for hangar represent fixed costs for business aircraft operators. ARG/US and Conklin and de Decker are specialized in providing operating cost data of business aircraft based in the United States. Both companies estimate costs for hangar use. The methodology is very straightforward. They multiply aircraft length by wingspan to obtain the aircraft square footage. Aircraft square footage is than multiplied by US costs per square foot for different large metropolitan areas. Rental costs vary widely from area to area and so do annual hangar costs. We were not able to capture the variation in annual hangar costs. However, ARG/US provides information on the US wide average of annual hangar and office rent (including costs for utilities, lawn service, snow removal etc.). The average US business aircraft operator spends annually around USD 95.000 for hangar and office[14]. This figure ignores the square footage of different aircraft types and regional deviations in the rent of hangar and office buildings.

[14] BCA (2011)

3.2.6 Insurance

Aircraft are insured against damage (hull insurance) and against claims by third parties for bodily harm and property damage (liability insurance). Conklin and de Decker underline that the insurance premium can differ between operators of the same aircraft. Insurance companies calculate the size of insurance payments based on pilot and flight department safety records[15].

We modeled insurance costs for selected Bombardier aircraft using ARG/US cost data. Expert interviews revealed that aircraft utilization has in practice no impact on neither hull nor liability premium because of a highly competitive North American insurance market[16]. Figure 24 therefore presents *annual* costs for hull and liability insurance. However, average flight hours of US based operators are written in parenthesis and can be used for the calculation of hourly insurance costs. It was assumed that all listed aircraft carry $ 200 million in liability insurance coverage.

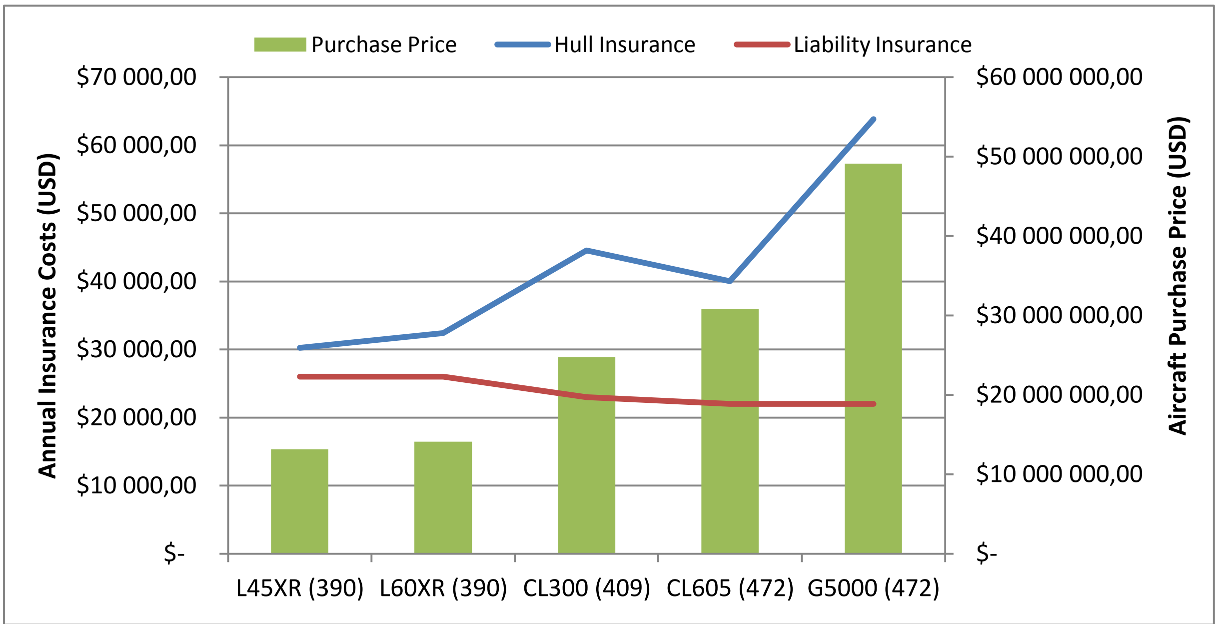

Figure 24: Insurance Costs for Bombardier Business Jet

Source: BCA (2011)

Total insurance costs are higher for larger aircraft because costs for hull insurance go up as the guaranteed insurance coverage increases.

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15 http://www.conklindd.com/

16 Regional differences in the insurance premium and war coverage remain unconsidered.

The US National Business Aviation Association (NBAA) recommends operators to regularly review their insurance contract. Changes in the market or how the aircraft is operated may allow operators to save money while ensuring appropriate coverage. Insurance contracts can be adapted to the new situation at renewal time[17].

3.2.7 Flight Expenses

Flight (or trip) expenses are miscellaneous expenses for any kind of services provided to the aircraft operator during the flight or on the ground. Table 7 lists typical flight expenses faced by business aircraft operators.

Flight Expenses	Description
Crew Expenses	Costs incurred when crew is away from home base for accommodation, transportation and meals.
Landing and Parking Fees	Weight based landing fees vary amongst airports and with season and time. Depending on the airport, they can include noise and emissions related surcharges. Parking fees depend primarily on MTOW and location of parking position.
Handling Fees	Handling fees are paid for baggage handling, aircraft towing, ground power, air conditioning services and other services.
Cabin Supplies and Catering	Transfer and transport of catering supplies. Unload/load and stow catering supplies from/on aircraft, supply of food, beverage and decoration
Line Service Fees	Deicing, cleaning (exterior and interior), potable water and lavatory services
Air Navigation Fees	The size of en-route charges depends on aircraft MTOW, unit rate of en route charging zone, distance between entry and exit point of en route charging zone.
Flight Support Services	ATC and ICAO flight plan filings, landing permits, general declarations, customs and immigration
Miscellaneous Airport Fees	Airport tax, security fees, late charges and other fees

Table 7: Overview of Flight Expenses

[17] Business Aviation Insider (2010)

We analyzed the distribution of the above mentioned flight expenses using real expenditures of an US based operator with 21 flights on a Gulfstream IV from/to European airports[18].

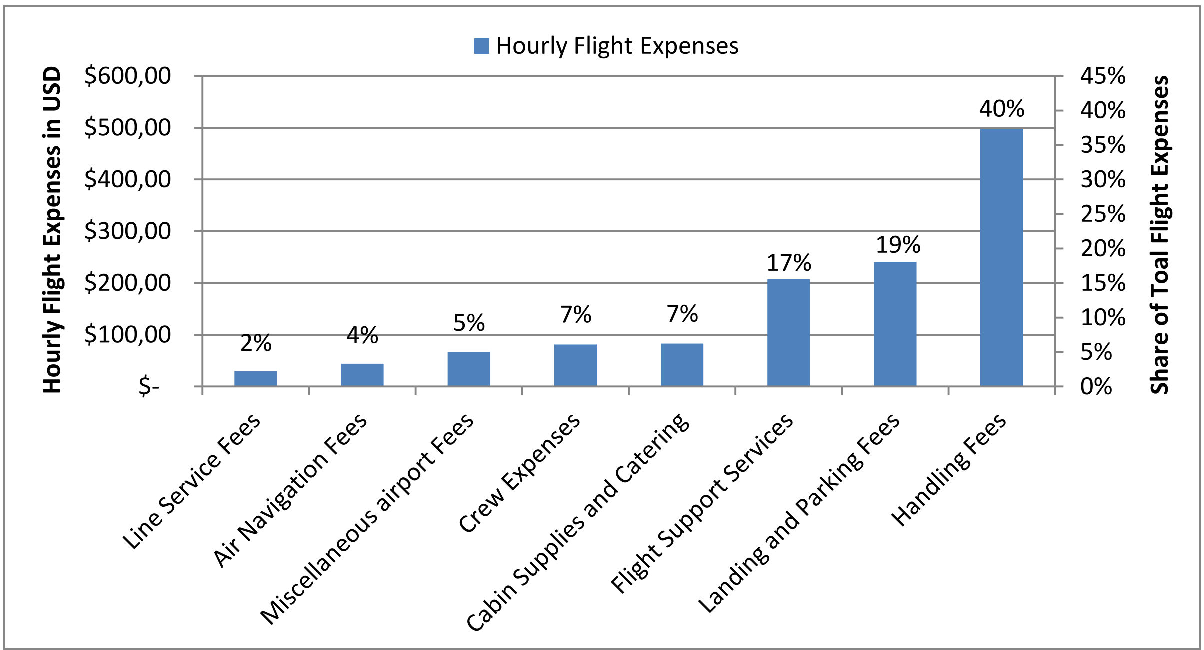

Figure 25: Hourly Flight Expenses for a GLF4

Source: VerifAvia

Figure 25 shows that the first three positions (handling fees, landing and parking fees, flight support services) represent more than 75 percent of total flight expenses. Taxes (harmonized sales tax, passenger tax, goods and service tax) were not considered. It should be noted that Figure 25 does not claim to be representative.

[18] 15 long haul flights between the US and Europe, and 6 Intra-EU flights. No flight hour information available. We estimated 89 flight hours using the Rockwell Collins GCD calculator (airspeed of 460 kts).

ARG/US provides information on hourly flight expenses of US based business aircraft operators. Figure 26 visualizes hourly flight expenses for different Bombardier aircraft.

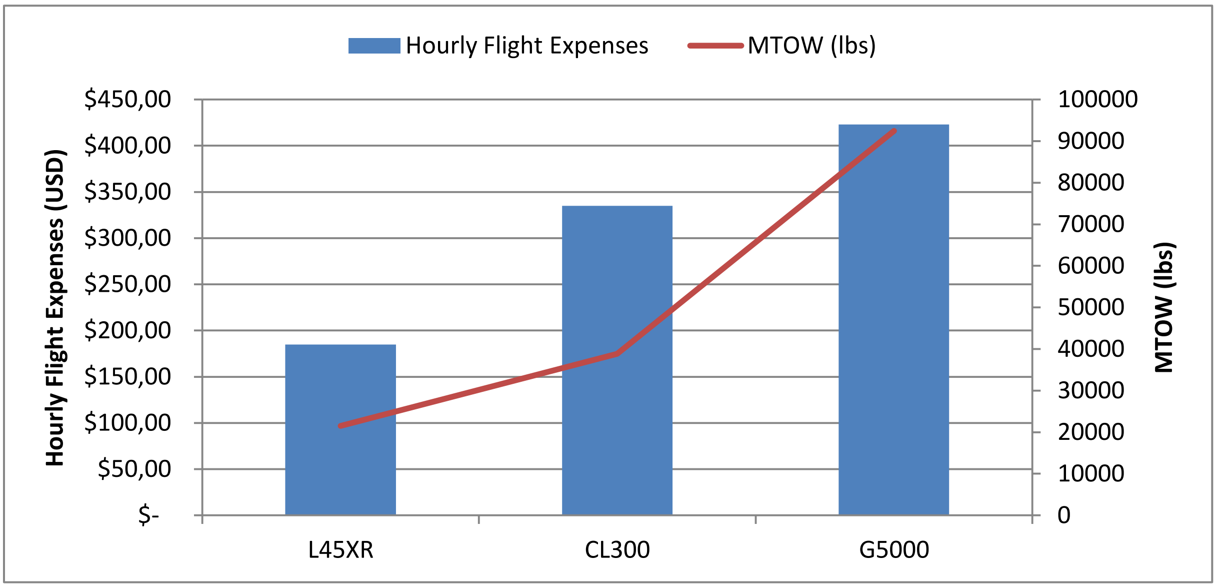

Figure 26: Hourly Flight Expenses for Bombardier Business Jets

Source: BCA (2011)

Figure 26 reveals a positive relation between aircraft size and hourly flight expenses. The size of MTOW directly affects air navigation charges, landing and parking fees.

However, flight expenses presented in Figure 25 are between 2 and 3 times higher than those illustrated in Figure 26. We identify three main reasons for the perceived discrepancy:

1. *Variation around the mean value:* The GLF4 operator may be above the US average compiled by ARG/US.

2. *Definition of flight expenses:* The ARG/US statistic covers not all flight expenses such as flight support services, navigation fees or line service fees.

3. *Regional price differences:* ARG/US refers to the USA whereas the GLF4 operator primarily pays handling, parking and landing fees at European airports.

3.3 Comparative Analysis of the DOC Structure of Business Jets

This section sets out to analyze the DOC structure of business jets. We used ARG/US operating cost data to test the DOC information received from the BASE survey. ARG/US data also allowed us to answer questions which we would not have been able to answer with the survey alone. This is because a waste majority of survey participants did not want to disclose detailed DOC information. In order to increase the rate of response, we had to revise the survey and ask operators to report DOC information as *percentage* share of total DOCs. As a consequence, the survey outcome is only of limited use for the purposes of the analysis. A meaningful comparison of the DOC structure requires detailed cost information expressed in *absolute* dollar values.

32 out of 133 participating aircraft operators disclosed complete DOC information of 44 aircraft. 6 operators have more than one aircraft in operation. The bulk of the 32 operators is based in the US and mainly operates aircraft models produced by Bombardier, Dassault Aviation and Gulfstream. To validate and back up BASE cost data, we modeled costs for the same aircraft using cost information provided by ARG/US in the Business & Commercial Aviation 2011 Operations Planning Guide.

Figure 27 shows the average DOC structure of 32 business aircraft operators who disclosed DOC information of 44 business jets (red columns). Appendix 4 gives you a detailed overview of the DOC distribution of each of the 32 operators. The blue columns reflect the DOC structure calculated on the basis of ARG/US data.

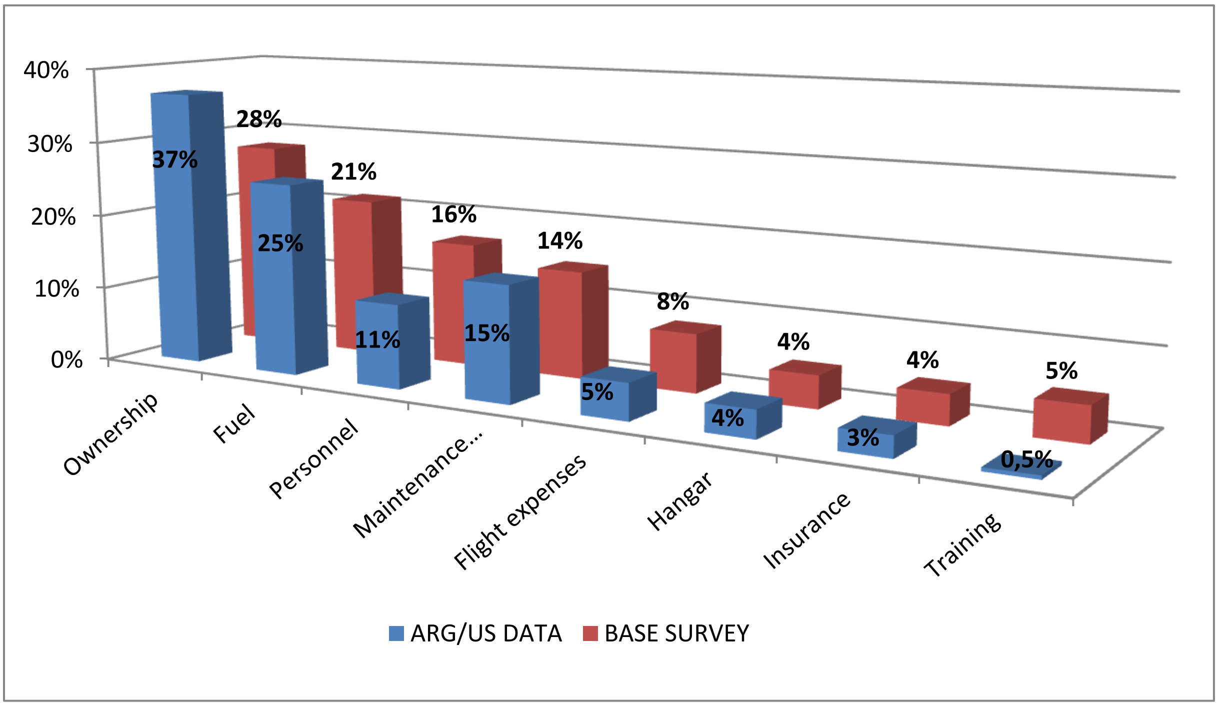

Figure 27: DOC Structure BASE Survey vs. ARG/US

Source: BCA (2011)
Assumptions:
***Ownership** costs: 10 year book depreciation, residual value after 10 years corresponds to 60 percent of BCA price[19] (new aircraft) or Vref retail price (pre-owned aircraft), depreciation expenses reflect the historical trend of base values (not market value)*
***Maintenance** costs: New and pre-owned aircraft incur periodic maintenance costs evenly spread over 10 years, Maintenance & Refurbishment covers 50 percent of costs related to maintenance labor, maintenance parts, maintenance software and periodic maintenance expenses (Mid-life inspection, engine overhaul, paint, interior refurbishment)*
***Fuel** costs are based on US wide average price of $ 6.04 per gallon of Jet-A in 2010*
***Insurance** costs cover hull and liability insurance*
***Personnel** costs for 2 pilots and 50 percent of costs related to maintenance labor*
***Training** expenses only refer to **initial** training of two pilots and two maintenance staff evenly spread over 10 years*

Figure 27 shows that the survey results fairly represent aircraft direct operating costs even though the sample size does not exceed 32 aircraft operators. Ownership, maintenance, fuel and personnel contribute the most to total DOCs (BASE: 79

[19] BCA (Business & Commercial Aviation) Equipped Price is for a standard equipped aircraft. Price estimates are first quarter, current year dollar for the next available delivery.

percent, ARG/US: 88 percent). Costs for hangar, insurance, training and flight expenses play a minor role.

BASE survey results also confirm the adequacy of the assumptions we made to model annual depreciation costs. As Figure 27 shows, ownership costs represent around one-third of total aircraft operating costs. Assumptions on the residual value or length of the depreciation period are very critical because they can easily bias the percentage distribution of direct operating costs.

Our cost calculation underestimates costs for personnel and flight expenses. As to what regards costs for personnel, we only account for the flight crew salary and 50 percent of maintenance labor costs. 50 percent of maintenance work is assumed to be performed in-house and the other 50 percent in external maintenance centers. Deviations from the 50/50 assumption and the non- coverage of other positions then flight crew and maintenance staff may explain one part of the perceived difference between BASE and ARG/US. As discussed in Chapter 3.2.7, flight expenses may not match because of regional price differences (9 operators are not based in North America). Differences in the measurement of DOC information also bias the cost comparison. The inaccuracy of reported DOC information (estimation error), the relatively low number of operators who disclosed DOC information and the coverage and assignment of cost items to broader categories (*definition of single DOC positions*) can all lead to deviations.

The identification of a relationship between a dependent (DOC) and explanatory variable (aircraft age, region, utilization, aircraft type, mode of operation) requires all other explanatory variables to be held constant. The BASE survey could not provide the minimum number of data points starting from which a cost comparison would make sense. In addition, variable DOCs could not be normalized (dividing costs by the annual number of flight hours) because only percentage values were available.

3.3.1 By Business Jet Market Segments

We modeled DOCs for different business jet market segments based on ARG/US cost data. DOC information gathered in the BASE survey could not be used because of the relatively low number of reporting operators and the impossibility of normalizing variable DOCs such as fuel costs and flight expenses. For the cost simulation, we have chosen in-production Bombardier aircraft, because the Canadian manufacturer serves all market segments from light jets to very large jets.

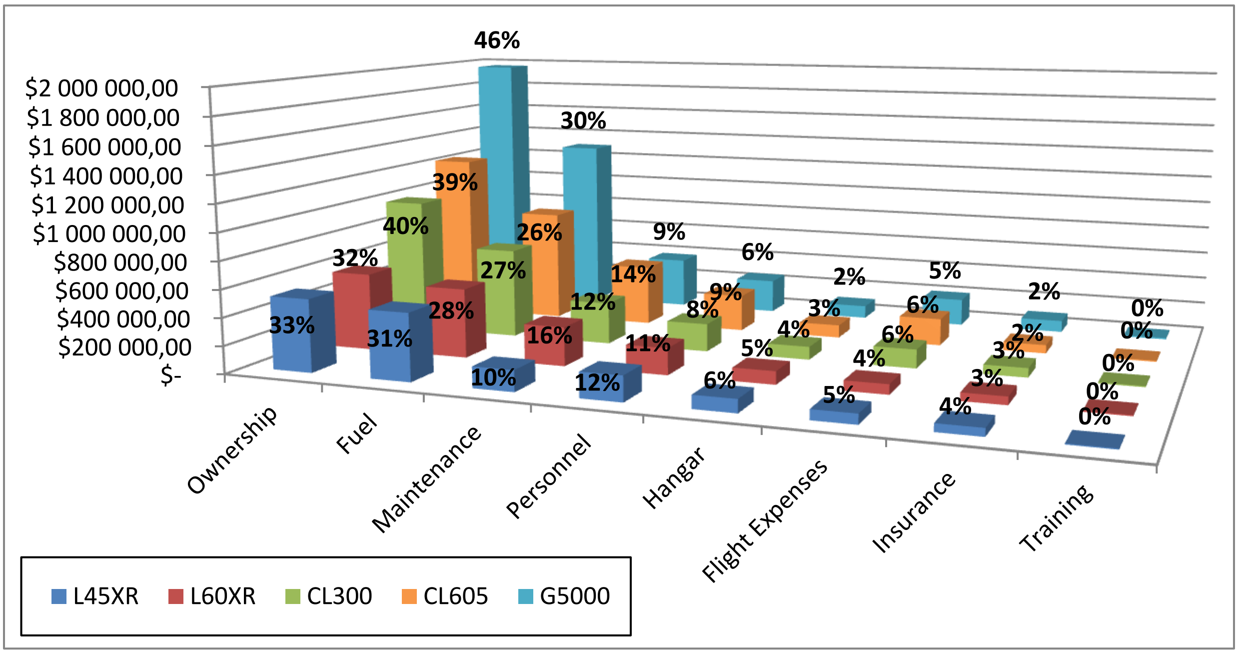

Figure 28: DOC Structure of Bombardier Aircraft by Aircraft Segment
Source: *BCA (2011)*

Figure 28 compares the DOC structure of different market segments. The four biggest cost positions are ranked in the same order (except for L45XR). The highest costs occur for aircraft ownership, followed by fuel, maintenance and personnel. As described in Chapter 3.2, ownership costs, flight crew expenses, fuel expenses, hull insurance and trip expenses increase with aircraft size. That is the reason why aircraft models display similar operating cost patterns.

It should be noted that model assumptions have the potential to bias the DOC comparison. Take for instance hangar costs. They generally increase with aircraft size. For the sack of simplicity, we used an industry wide average covering all size of business aircraft. As a result, Figure 28 overestimates hangar costs for smaller aircraft.

3.3.2 By Aircraft Manufacturer

This chapter compares the DOC structure of aircraft produced by different manufacturers. We control for time of entry into service (as proxy for aircraft generation), market segment and aircraft utilization. The Dassault Falcon 7X and Bombardier Global 5000 both belong to the segment of long range business jets. The date of certification only differs by three years. The cost calculation was based on ARG/US cost data. We assumed that both aircraft operate 472 flights hours which corresponds to the average segment-specific aircraft utilization of US based operators. Figure 29 shows the DOCs of the F7X using a pie chart.

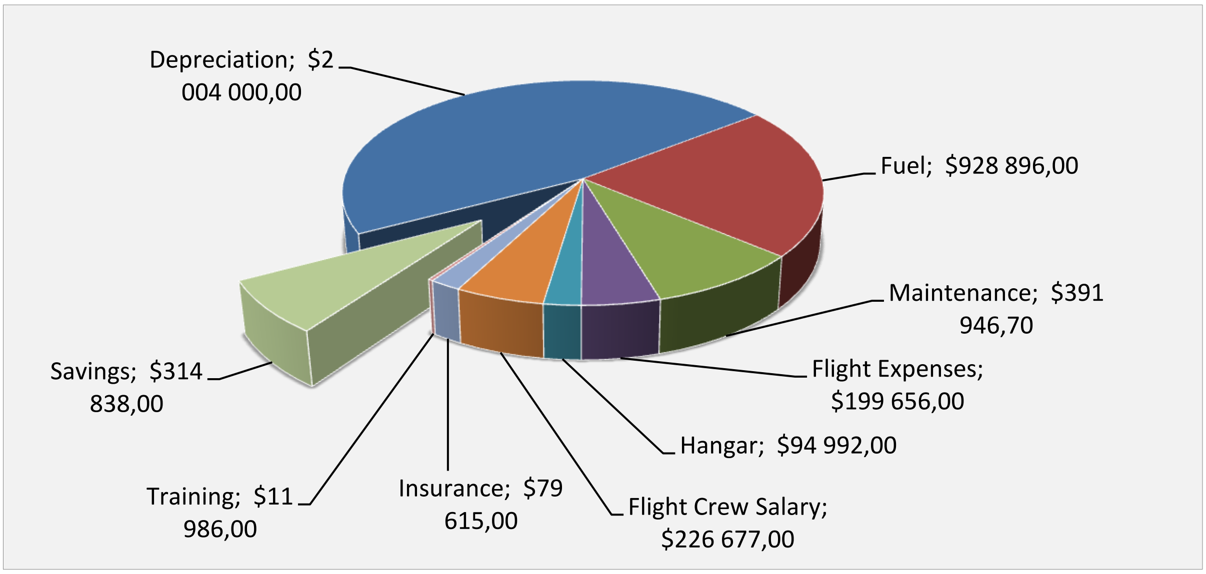

Figure 29: Direct Operating Costs of a Falcon 7X

Source: BCA (2011)

Depreciation costs, fuel expenses, maintenance costs, costs for the flight crew and flight expenses represent the biggest share of the pie. Figure 29 also reveals that the operation of a Falcon 7X costs around $ 315.000 USD less than operating a G5000.

Figure 30 discovers the reason of the cost advantage held by the Falcon 7X over its Bombardier counterpart.

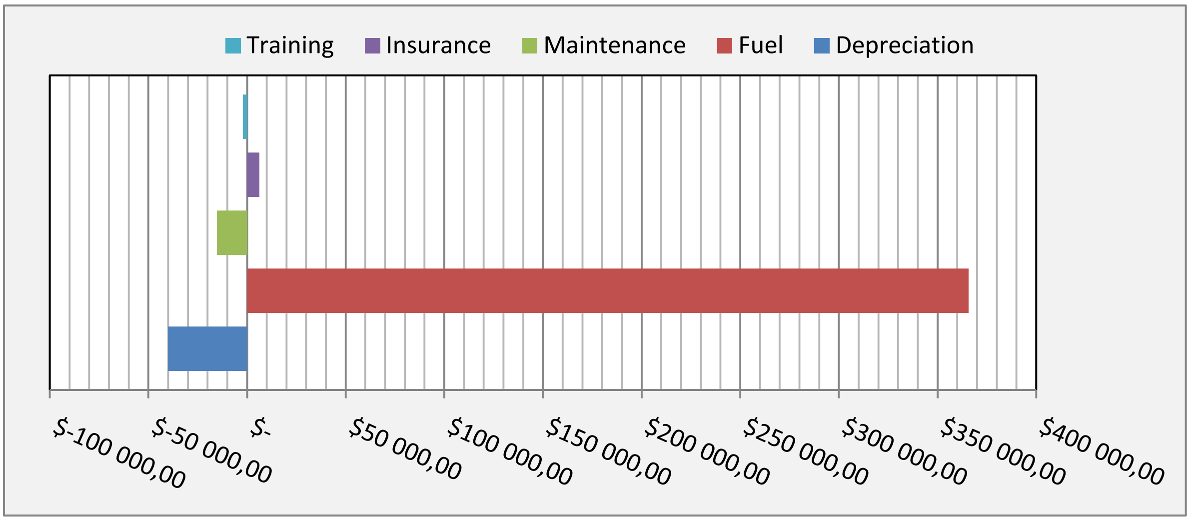

Figure 30: DOC Comparison Falcon 7X vs. Global 5000

Source: BCA (2011)

It comes out very clearly that the F7X is better off thanks to lower fuel costs. The F7X operates more fuel efficient and thereby benefits from lower total fuel expenses. The G5000 gains some ground thanks to lower depreciation expenses, maintenance and training costs but cannot make up for higher fuel costs. Superior fuel efficiency on the side of the F7X translates directly into longer range capacity. Bombardier had to build bigger tanks and reinforce the aircraft structure to carry additional fuel load that is needed to reach the range of the F7X. The G5000 is around 6 m longer than the F7X. However, The F7X and G5000 cabin has almost the same size. Both aircraft can transport a maximum of 19 passengers.

3.3.3 By Business Model

This chapter addresses the question whether corporate flight departments incur the same costs for the operation of a given aircraft than air charter companies. An empiric analysis could answer this question provided sufficient cost information from both business models was available. The BASE survey failed to provide high-quality primary source data because of confidentiality reasons. However, interviews held with business aviation professionals revealed that air charter companies may benefit from volume discounts on fuel, insurance and other support services. This applies especially for mid and large size air charter companies which operate on a higher scale than corporate flight departments.

We modeled operating costs for a Falcon 7X under two different scenarios. The first scenario refers to a corporate flight department which runs flight operations with only limited help from flight support companies. Flight crew staffing, maintenance or flight planning is all performed in-house. Aircraft owners can also have their aircraft managed by an aircraft management company which takes over all responsibilities related to flight operations. To compensate one part of operating costs, they can sacrifice some flexibility and free the aircraft for charter services.

It should be noted that our calculation does not account for charter revenues or management fees. We only consider the impact of volume discounts on aircraft operating costs. Another assumption is that corporate flight departments pay a listed retail price for flight support services. This is not always true because even small aviation departments can negotiate the fuel price with their preferred FBO or enroll in fuel programs. Figure 31 provides an estimation of the operating cost reduction potential if the aircraft (here: Falcon 7X) is operated by an air charter company.

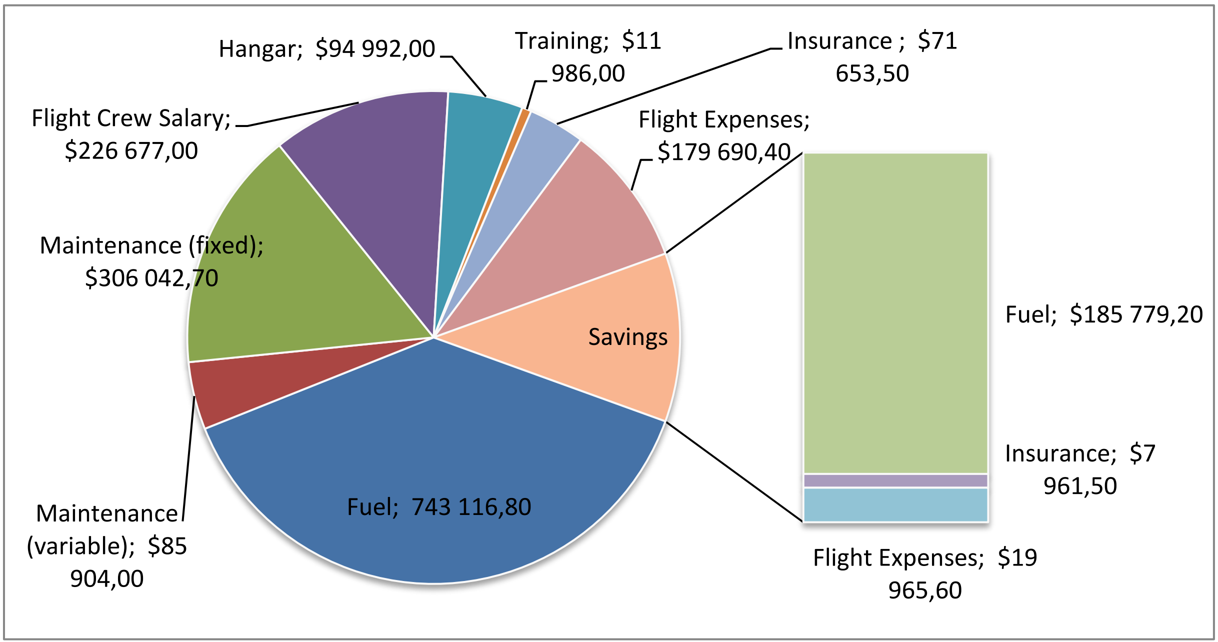

Figure 31: Cost Advantage of Aircraft Management

Source: BCA (2011)
Notes: Costs of ownership (depreciation) unconsidered. Cost simulation assumes 20 percent fuel discount and 10 percent discount on insurance and flight expenses (ground handling, other services, such as accommodation, transport)

The cost savings associated with discounts on Jet fuel, insurance and flight expenses amount to $ 213.000 per year. More precisely, air charter companies can benefit from cheaper FBO services, insurance deals, or lower handling and travel expenses.

4 Conclusion

The present paper provides an introduction into business aviation and analyzes direct operating costs of business aircraft. What needs to be retained from the introductory section is that the size of business related travel depends very much on how one defines and measures business aviation. We found out that the FAA survey approach is relatively costly, but provides more accurate information on the distribution of business travel. It measures the primary and actual use of aircraft for business purposes. By contrast, EUROCONTROL monitors movements of *presumed* business aircraft. The purpose of the trip remains unconsidered. We analyzed by how much piston, turboprop and turbojet aircraft contribute to business aviation. In Europe, jet aircraft are most often used for business travel, followed by turboprop and piston aircraft. In the United States, the number of piston aircraft used for business purposes is higher than any other aircraft type. This can be explained by the size of the piston aircraft fleet which is almost 14 times bigger than the turbojet fleet. Piston jets lead the ranking even though the majority of them are primarily operated for reasons other than business. We were also interested into the benefits of business aviation. We asked business aviation professionals what they think are the most important benefits of flying aboard of business aircraft. Time savings and scheduling flexibility were the most recurrent answers, followed by comfort, productivity, accessibility to smaller airfields and confidentiality. We analyzed business aircraft market segments. It turned out that manufacturers expect the highest revenue from the sale of large business aircraft. In term of delivery units, the market of small business jets promises best results. The analysis of existing business models revealed that business aircraft users can choose amongst a wide range of air travel options. They can either operate the aircraft by themselves with only little help from outside, or get the aircraft managed by an aircraft management company. Managed aircraft are often used for charter which allows the owner of the aircraft to compensate one part of operating costs through charter revenues.

The second part of the paper provides a comprehensive analysis of single direct operating cost positions and compares the operating cost structure by business jet market segment, manufacturer and business model. As to what regards ownership costs, annual depreciation expenses increase with aircraft size. The same applies for fuel costs. Bigger aircraft require more fuel to move the aircraft through the air. We also found out that fuel price increases change the DOC structure in favor of variable costs. Differences in fuel costs between two aircraft may also be explained by technology. We proved that new generation aircraft burn less fuel than their predecessors. Aircraft operators are required to keep the aircraft in airworthy condition. We provided evidence that fixed maintenance costs increase with aircraft size. As to what regards maintenance labor and parts, we found out that aircraft size is not the only determining variable. Costs related to labor and parts highly depend on the maintenance program itself. Bombardier and Dassault Aviation achieved cost reductions through the implementation of on-condition maintenance and by putting more emphasize on maintenance in the development phase of the aircraft. The analysis of flight crew related costs revealed that they depend on the pilot's position (Captain or First Officer), aircraft size, year in service, type of work schedule and the number of work days. Costs for hull insurance increase with aircraft size, whereas liability insurance premiums are relatively constant across business aircraft jets. We also detected a positive relation between flight expenses and aircraft size.

The analysis of the DOC structure of business jet aircraft revealed that ownership, maintenance, fuel and personnel contribute the most to total DOCs (BASE: 79 percent, ARG/US: 88 percent). Costs for hangar, insurance, training and flight expenses play a minor role. Difference in the DOC structure between small and large business aircraft are relatively low because the bulk of direct operating costs increases with aircraft size. We compared DOCs of the Falcon 7X and Bombardier G5000 to check whether DOCs vary across aircraft manufacturers. We found out that the F7X flies more fuel efficient than the G5000. It allows F7X operators to save annually around USD 315.000. Cost savings can also be realized if aircraft are operated by aircraft management companies. Discounts on fuel, insurance and other flight support services provide cost advantages against corporate flight departments.

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Appendixes

A1: Measuring Business Related Activities

The distribution of business travel amongst piston, turboprop and turbojet aircraft is highly sensitive to the way business related activities are measured. Two different measurement approaches are known. We distinguish between the methodology applied by the FAA and the one used by EUROCONTROL.

The FAA releases each year the General Aviation (GA) and Part 135 Activity Survey. Aircraft are randomly selected from the Civil Aviation Registry. The registrant of the aircraft is asked to estimate the percent of total hours flown under the categories business transportation (owner-operated), corporate transportation (corporate) and air taxi (commercial)[20]. The FAA method measures the share of flight hours operated for business purposes. It is closer to the IBAC definition because it focuses on the specific use of the aircraft and, contrary to the approach chosen by EUROCONTROL, does not presume e.g. Bombardier or Gulfstream aircraft to be exclusively flown for business purposes.

EUROCONTROL monitors movements of aircraft models commonly used for business travel[21]. It does not distinguish between the use of aircraft for business activities and non-business activities, such as training, military/state, hospital flights or flights operated for personal reasons[22]. The survey is considered to be too burdensome albeit more accurate. EUROCONTROL states that the use of Air Traffic Control (ATC) data is the simplest way of measuring business related activities. Aircraft are identified with the help of ICAO aircraft codes from ICAO Doc 8643/33. EUROCONTROL is only able to monitor and record flights operated under 'instrument flight rules" (IFR). Flights operated under 'visual flight rules' (VFR) do not require ATC assistance and, consequently, are not included in the EUROCONTROL statistic. To exclude scheduled air transport services, EUROCONTROL omits aircraft

[20] FAA (2009): The FAA defines **Business Transportation** as "individual or group use for, or in the furtherance of, a business <u>without</u> a paid flight crew". **Corporate Transportation** refers to "individual or group business transportation <u>with</u> a paid flight crew" including fractional ownership.

[21] Eurocontrol (2005), 47.

[22] Eurocontrol (2005), 9.

types that are partially operated by airlines (such as Boeing business jets and Boeing conversions). It is estimated that 10 percent of business jets are not covered because of the mentioned shortcomings.

A2: US Tax vs. Financial Accounting Rules

A FAR Part 91 operator has the choice of depreciating aircraft either under the Modified Accelerated Cost Recovery System (MACRS)[23] or under the Alternative Depreciation System (ADS). MACRS allows an accelerated depreciation and accordingly greater depreciation deduction at the beginning of the five-year long recovery period. ADS is based on a straight-line depreciation. The aircraft owner loses the option to choose between MACRS and ADS if more than 50 percent of annual flight hours are related to non-business activities. Only the fraction reflecting the share of qualified business use can be deducted under ADS. Under financial depreciation (also known as book depreciation), aircraft are depreciated following a straight-line approach over a recovery period of typically 10 or 12 years. The financial depreciation is obviously more realistic, since most business aircraft are operated longer than 5 years.

[23] Section 168(b) of the Internal Revenue Code (IRC)

A3: Aircraft Maintenance under FAA Regulation

Title 14 of the Code of Federal Regulations (14 CFR) Part 39 (also known as Airworthiness Directive) requires US registered aircraft to be maintained in an airworthy state[24]. More precisely, the aircraft shall conform to its type design (type certificate) and follow an approved maintenance program. Operators are recommended to stick to a maintenance program not only because it is compulsory, but also to keep up the aircraft asset value. Maintenance procedures underlie strict standards and regulations. First, the aircraft operator is required to follow specific inspection intervals. Inspections can be routine checks, as performed by the pilot in command (PIC) prior to departure, or more detailed inspections during which the aircraft is out of service. As to what regards FAR Part 91 (non-commercial operations), aircraft have to be inspected at least one time annually by certified aviation maintenance technicians. Stricter rules apply for aircraft carrying passengers for hire (FAR Part 135). The inspection takes place within each 100 hours of time in service (or one time annually if the aircraft displays fewer than 100 flight hours). Operators can reduce aircraft downtime by following *progressive* inspections. It allows them to divide the scope and detail of the annual inspection into smaller sections. Progressive inspections are subject to upfront approval by the competent FAA Flight Standards District Office (FSDO). Another way to comply with the FAA regulation is the enrollment in a continuous inspection program, typically used for larger aircraft. It can be developed as part of the Continuous Airworthiness Maintenance Program (CAMP) by the operator itself and requires FAA approval. The operator needs to make the aircraft available for so called “checks” (A/B/C/D checks, ordered by increasing level of detail) after a pre-defined number of months and/or aircraft usage. However, non-commercial operators typically use the maintenance manual recommended by the manufacturer. It respects all legal requirements, since all stakeholders (manufacturer, aviation authority and industry groups) have worked together through consultations to determine the maintenance plan. During inspections, it is the task of maintenance staff to evaluate the overall condition of the aircraft. The inspection spectrum reaches from simple visual checks to the use of ultrasonic detection equipment. Maintenance technicians follow a detailed inspection

[24] FAA (online).

checklist. The list contains checks on fuselage, wings, tail, landing gear and wheel well, engines, communication systems, instruments and electrical components[25]. Inspection plans can be calendar-based or require a certain number of flight hours before the aircraft goes into inspection. The same applies for replacement and overhaul of parts and appliances. The maintenance plan specifies under which conditions aircraft components need to be replaced and overhauled. Depending on the manufacturer, aircraft operators may be obliged to either follow hard-time maintenance or on-condition maintenance procedures[26]. As the name suggest, hard-time maintenance prescribes the overhaul or replacement of life-limited parts after a certain amount of flight hours or calendar weeks. By contrast, on-condition maintenance only requires maintenance staff to replace parts if they don't meet the inspection standards. Defect parts have to be removed before failure during normal operation occurs. On-condition maintenance saves time and lowers costs for parts.

Unforeseen errors, malfunctions or discrepancies trigger unscheduled maintenance work. For instance the PIC may detect irregularities during pre-flight inspection when walking around the aircraft or during the flight. The error may be corrected en-route or overnight (line maintenance) or result in longer aircraft downtime. Flight departments try to optimize aircraft utilization which often requires a strong cooperation between dispatcher, pilots and maintenance staff[27].

Costs for unscheduled maintenance are naturally less predictable than costs of scheduled maintenance. Being enrolled into a maintenance program can smooth costs for unforeseeable maintenance events where the manufacturer's warranty does not apply.

[25] Aviation Safety Bureau (online).

[26] AmtOnLine (2011).

[27] Business Aviation Insider (2010).

A4: BASE DOC Distribution

One-Aircraft Flight Departments												
Operator ID	Aircraft ID	ORIGIN	Annual number of flight hours	Aircraft Type	OWNERSHIP	FUEL	PERSONNEL	MAINTENANCE	FLIGHT EXPENSES	HANGAR	INSURANCE	TRAINING
1	1	EU	472	Dassault Falcon 2000LX	43%	20%	11%	6%	6%	3%	6%	6%
2	2	Middle East	380	Gulfstream G200	20%	23%	16%	12%	21%	2%	4%	2%
3	3	North America	230	Dassault Falcon 900C	25%	20%	10%	15%	10%	10%	5%	5%
4	4	North America	500	Bombardier GLEX BD 700	30%	15%	34%	7%	4%	7%	1%	2%
5	5	North America	400	Bombardier Global 5000	35%	20%	25%	15%	2%	1%	1%	1%
6	6	South America	150	Dassault Falcon F900B	10%	24%	23%	21%	5%	8%	5%	4%
7	7	North America	125	Bombardier CHALLENGER 601-3R	5%	31%	9%	20%	15%	5%	5%	10%
8	8	EU	200	Cessna Citation 525B	41%	11%	20%	9%	12%	2%	4%	1%
9	9	North America	375	Bombardier Challenger 604	38%	14%	22%	9%	8%	4%	3%	2%
10	10	EU	363	Bombardier Learjet 60	13%	12%	18%	30%	24%	0%	1%	1%
11	11	North America	500	Dassault Falcon 50EX	40%	10%	20%	10%	3%	4%	10%	3%
12	12	North America	300	Hawker 850 XP	49%	15%	15%	15%		2%	2%	2%
13	13	EU	317	Gulfstream G550	54%	9%	6%	5%	16%	6%	2%	2%
14	14	North America	240	Bombardier Challenger 300	1%	29%	29%	18%	13%	1%	5%	3%
15	15	North America	222	Dassault Falcon 2000 EX	23%	14%	33%	3%	3%	4%	15%	5%
16	16	EU	220	Cessna Citation 550 B	10%	40%	10%	35%	2%		2%	2%
17	17	North America	300	Gulfstream G550	10%	40%	4%	1%	10%	10%	10%	15%
18	18	North America	235	Bombardier Challenger 605	23%	18%	31%	20%	1%	2%	2%	3%
19	19	North America	400	Gulfstream GLF4 Astra SP	5%	57%	3%	19%	0%	5%	2%	10%
20	20	North America	275	Gulfstream G450	35%	35%	9%	8%	5%	3%	2%	3%
21	21	North America	300	Dassault Falcon 7X	50%	15%	10%	20%	2%	1%	1%	1%
22	22	North America	425	Bombardier CL30	37%	20%	18%	10%	7%	2%	1%	6%
23	23	South America	200	Gulfstream G550	10%	25%	10%	10%	20%	5%	5%	15%
24	24	EU	180	Hawker 850B	58%	14%	12%	8%	0%	4%	1%	2%
25	25	North America	225	Dassault Falcon 2000EX	56%	10%	13%	13%	4%	2%	2%	1%
26	26	Middle East	250	Cessna Citation 525B	76%	7%	8%	4%	2%	0%	2%	0%

Flight Departments with more than one aircraft												
Operator ID	Aircraft ID	ORIGIN	Annual number of flight hours	Aircraft Type	OWNERSHIP	FUEL	PERSONNEL	MAINTENANCE	FLIGHT EXPENSES	HANGAR	INSURANCE	TRAINING
27	27	North America	400	Dassault Falcon 2000EX								
27	28		400	Dassault Falcon 2000EX	5%	30%	15%	15%	5%	15%	5%	10%
28	29	North America	449	Bombardier Challenger 300								
28	30		409	Bombardier Challenger 300								
28	31		492	Gulfstream G500	20%	35%	20%	10%	1%	5%	3%	6%
29	32	North America	200	Gulfstream G550								
29	33		700	Gulfstream G450								
29	34		400	Dassault Falcon 2000EX								
29	35		400	Dassault Falcon 2000EX								
29	36		400	Dassault Falcon2000LX	10%	10%	20%	30%	5%	10%	10%	5%
30	37	North America	550	Bombardier Learjet 45								
30	38		550	Bombardier Learjet 45								
30	39		415	Gulfstream G500								
30	40		470	Bombardier Global 5000	10%	15%	15%	25%	22%	2%	1%	10%
31	41	North America	400	Gulfstream G150								
31	42		300	Gulfstream G550	27%	21%	18%	12%	7%	4%	5%	6%
32	43	North America	280	Gulfstream GLF4 Astra SP								
32	44		300	Dassault Falcon 2000LX	20%	20%	20%	20%	5%	5%	5%	5%