BUSINESS JETS – A PROFOUND ESTIMATION OF HOURLY OPERATING COSTS DEPENDING ON AIRCRAFT CLASS

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KEYWORDS

Business aviation, cost aspects, aircraft class.

ABSTRACT

Compared to airlines with a fixed schedule and direct flights only on busy routes, business jets provide an alternative to transport business leaders and other personnel on short-term notice and by direct air transport to nearly any destination worldwide. As hardly any specific numbers contributing to the total hourly rate are published in standard literature, this paper will analyze and unite data from all sorts of alternative resources, especially industry reports, publications of market operators and numerous branch publications on the internet. Some cost aspects adding up to the total hourly rate will be described more precisely, whereas other values will be presented in tables without detailed derivation for the purpose of keeping the extent of this paper within the required limit. However, it has been deemed important not to pool cost aspects but to demonstrate the full variety of all major influencing costs. Interested readers are encouraged to contact the author directly for additional information available in course of his doctoral thesis. The numbers presented within this study are part of this thesis and serve as the basis of a more detailed and individual evaluation whether it is economically reasonable for a corporation to operate an own aircraft rather than using third-party flight services.

CLASSIFICATION OF BUSINESS JETS

“Starting from Small Compact Light Jets, sometimes referred to as VLJs (Very Light Jets), informal classifications range up to what in industry lingo are called bizliners” (Gollan 2015). The common classification of airliners into short-range, medium-range and long-haul aircraft has been further refined in the business aircraft industry. While VLJs offer new perspectives in the operation of jet-driven aircraft, bizliners extend the upper demarcation of conventional business jets (Tremesberger 2008). Manufacturers and specialist companies offer individual cabin outfitting options (Harrison 2011; Hegmann 2016). Aspects such as takeoff mass, performance, range, avionics and cabin size play a major role regarding the following classifications now agreed upon and used internationally (Erdmann et al. 2005; Tremesberger 2008; Gollan 2015). The table below will provide an overview of the mentioned class division (Erdmann et al. 2005; Tremesberger 2008; Sterzenbach et al. 2009; Bean 2018a; Hebert 2019; Picheta 2018):

Table 1: Classification of business jets

Class	MTOM [lbs]	Number of seats	Range [NM]
Very light / Entry	5.500 – 13.000	4 – 7	1100 - 1300
Light	13.000 – 20.000	6 – 8	1400 - 2000
Light medium	20.000 – 33.000	7 - 9	1940 - 2700
Medium	33.000 – 50.000	8 – 12	2000 - 3400
Long-range	50.000 – 80.000	5 - 19	3100 - 4500
Ultra long-range	80.000 - 115.000	5 -19	5000 - 7700
Bizliner	> 100.000	8 – 120	up to 11645

The following paragraphs will provide more detailed information on the respective classes.

Very light / Entry class

Being the smallest available jet-driven aircraft, representatives of this class are the main competitors for piston and turbo-prop aircraft (Erdmann 2005). This class constitutes a very young and technologically innovative class with a large potential due to very good performance figures offering access to short runways as well as the possibility of being piloted by a single person (Biermann 2007; Budd and Graham 2009). Therefore, very light jets have a huge potential for usage especially by air taxi operators (Biermann 2007) and are subject of development of many designs (Duchaine 2010), including limited cabin amenities. Typical examples of this class are Cirrus Vision, ONE Aviation Eclipse and Honda HondaJet (Clarke 2018; Cox 2008).

Light class

This class represents the biggest segment in the market regarding fleet size (Kern 2008). Main advantages are as well performance capabilities in terms of takeoff and landing distances and therefore access to many small airfields (Erdmann 2005). Offering more in-cabin comforts, typical examples of this class are Embraer Phenom 300, Citation Citation CJ 1-4, Hawker 400 and Learjet 40/45.

Light-medium / Medium class

Aircraft of the light-medium category constitute the second largest share of the business jet fleet (Kern 2008). The rise of fractional ownership model has originally boosted the demand for medium class aircraft (Tremesberger 2005). Providing toilets and an environment for working, aircraft such as the Learjet 60, Falcon 2000 and the Bombardier Challenger 300 series are the most popular aircraft within this category with the bigger ones among them already providing limited intercontinental range (Erdmann 2005).

Long-range class

Featuring larger cabin sizes with further increased amenities and various options of customization (Hegmann 2016), long-range aircraft can cover flight times of ten hours and above (Padfield 2012), thus connecting Europe with any destination in North America or South Africa. The market is dominated by three manufacturers (Erdmann 2005; Tremesberger 2008): Bombardier (Challenger 650, Global 5000), Dassault (Falcon 7X) and Gulfstream (Gulfstream 350/450).

Ultra long-range class

This segment sets a new benchmark regarding performance and luxury as well as costs. Bombardier and Gulfstream have developed its top-of-the-range models for almost unlimited intercontinental travel (Tremesberger 2005). Featuring amenities such as high-speed internet for video conferences (Bombardier 2018a), distinct sleeping areas and optional bathrooms including showers (Harrison 2013), the Bombardier 7500 and Gulfstream 650ER promise a comfortable journey no matter how long it will take (Rimmer 2018).

Bizliner

The level of comfort on the above-mentioned aircraft can only be beaten by even more space (Mose 2014). On that basis, common airline manufacturers Airbus, Boeing and Embraer offer established airliners fitted with individual cabin interiors. They “feature private bedrooms, showers, board tables, media rooms and plenty of legroom to spread out in leather lounge chairs” (Gollan 2015). Standard single aisle aircraft as the Airbus 320 series and the Boeing 737 are the most common types in this class (Mose 2014; Tremesberger 2008), but beyond economical considerations regarding the operation, any airliner of any category (Hegmann 2016) can be converted and equipped according to personal requirements (Picheta 2018).

For easier reference, this paper will use only four combined classes of aircraft and respective abbreviations: Very light to light-medium (L), Medium (M), Long-range / Ultra long-range (LR) and Bizliner (BL).

TOTAL OPERATING COST ASPECTS

Seen from an economic view, “aircraft should be evaluated as business tools, just like a computer. They should justify their presence or be discarded” (Southwick 2017). This chapter will define a detailed view on the specific cost aspects contributing to a total hourly rate regarding pure operating costs. As this paper aims to provide reliable average values, a typical user profile has been applied and costs adapted accordingly. Many of the costs can easily be expressed in an hourly rate, such as fuel consumption, whereas average ground costs will vary with leg length. Other costs, such as crew salaries, are independent from any flight event and have a fixed value per year. At the end of this study, all these values will be entered into a matrix providing hourly rates for various yearly flight hour volumes. As aviation is a global business, all costs will be indicated in USD.
Those costs contributing to business jet operating costs, like any costs in general, are distinguished between fixed and variable costs. “Fixed costs are those that, in the short term, stay constant as changes in sales volume occur” (Tennent 2008). So, independent from the amount of applicable flight hours (Cannon and Richey 2012), these costs have to be covered and are “not escapable within one scheduling period” (Doganis 2002). Examples for fixed costs are depreciations, scheduled maintenance costs and salaries (Castro 2011; Mensen 2003) and they “do not vary in the short or medium term” (Seristö 1995) or with “level of activity” (McKnight 2010). Conversely, variable costs are “immediately escapable costs” (Doganis 2002) which are directly connected to a specific flight event (McKnight 2010) and once they occur, cannot be influenced or foreseen during a scheduling period (Cannon and Richey 2012; Mensen 2003).

In the ensuing subchapters, each contributor will be explained and respective numbers being retrieved. At the end of each of these subchapters, the same format of table will be shown, presenting costs of this particular subchapter divided into the discussed aircraft classes. As a final result of this study, all these values will be added and then broken down to an average hourly rate for several sets of yearly flight hours.

Crew salaries

On most aircraft a crew consists of two pilots and one flight attendant. On long-range flights, a third pilot might be necessary due to flight duty regulations, whereas some smaller aircraft air certified for single pilot operation (Horne 2017; Shook 2018). One of the arguments discussed above for using business jets has been flexibility for the user, which however is highly connected to the amount of crew employed and therefore is an important factor for total costs. Considering typical mission profiles and respective industry standard crewing factors for the respective classes and its operational potential, the following number of crew members does reflect industry standard:

Table 2 – Required amount of crew

Aircraft class	Number of captains	Number of first officers	Number of cabin crew
L	1	1	1
M	2	1	1
LR	3	2	2
BL	4	2	2

Standard industry monthly salaries for crew very much depend on aircraft size and are reflected in the following table (bizjetjobs.com 2019; aviationjobsearch 2019; Sparks 2018; Sherpareport 2013; Young-Brown 2016; Sherpareport 2014; betteraviationjobs.com; Wyndham 2020a; Raouna 2014):

Table 3 – Crew salaries per month

Aircraft class	Captain salary	First officer salary	Cabin crew salary
L	7.000	4.000	Not applicable
M	9.000	6.500	3.000
LR	12.000	8.000	5.000
BL	11.000	7.500	5.000

Combining data from table 2 and 3, accumulated yearly salary costs are as follows:

Table 4 – Crew salaries per year

Aircraft class	Yearly total crew salaries
L	132.000
M	330.000
LR	888.000
BL	636.000

Crew additional costs

Depending on type and frequency of operation, additional costs for crew will apply, such as costs for accommodation, crew travel (Grün and Wills 2018; Krautscheid and Sauter-Servaes 2016; Schober et al. 2018, kiwi.com 2017) and daily allowances. A typical operational and crewing scenario as per the previous chapter with associated industry rates leads to the following yearly costs:

Table 5 – Crew additional costs

Aircraft class	Yearly total crew auxiliary costs
L	39.600
M	108.000
LR	421.200
BL	314.400

Training costs

Pilot licences must be renewed each year, usually requiring a theoretical and practical training, including a check flight. This can either be done by certified in-house training or at an approved training facility (Cannon and Richey 2012). Like crew salaries, costs rise with size and complexity of the respective aircraft type, except for bizliners. As bizliners are built based on common airliners, there are way more training facilities available worldwide and due to a higher number of offers compared to pure business jets, prices are significantly lower. Recurrent costs for aircraft types well established in the aviation sector (Sparks 2018), the average value for respective recurrent trainings has been selected to be 10.000€.
The following table presents standard industry values for the minimum recurrent training required per year and pilot (Wyndham 2020a; Wyndham 2020b; Wyndham 2020c, Wyndham 2020d):

Table 6 – Recurrent costs

Aircraft class	Yearly recurrent costs per pilot
L	15.000
M	26.000
LR	43.000
BL	5.000

Using the scenario allocation as before and adding cabin crew (Corporate Flight Training 2020) as well as crew emergency training (Faruqi 2020), the following table presents the total yearly training costs per aircraft class:

Table 7 – Total yearly training costs

Aircraft class	Scenario number	Yearly total crew training costs
L	1	32.400
M	2	82.350
LR	4	266.700
BL	3	34.900

Key flight department personnel

A certain number of key positions must be filled within a flight department due to legal requirements, such as flight operations manager, training manager, safety manager and others (Cannon and Richey 2012). These positions can be filled with pilots who are employed anyway. Assuming two nominated persons and using adapted researched salary surcharges (bizjetjobs.com 2019), the total yearly costs for such a minimum flight department personnel will be as the following table:

Table 8 – Salary surcharges

Aircraft class	Yearly costs for management personnel
L	16.200
M	21.600
LR	34.560
BL	36.720

Administration costs

Even though administration is highly likely to vary with the individual operational setup, a lump value of 5.000 USD per year is realistic for a small office and basic IT equipment.

Fuel costs

The following table represents average fuel consumption per aircraft class for a sector length consistent to respective aircraft class (Young-Brown 2015; Chase 2015):

Table 9 – Average fuel consumption of aircraft classes

Aircraft class	Fuel consumption [gal/h]
L	135
M	280
LR	500
BL	700

Even though the price for jet fuel as traded by refineries is quite stable around the world (IATA 2021), “taxes, fees and markups do vary and are the reason for disparities in retail prices” (Thurber 2008). Except for states within Central Europe, where jet fuel for commercial flights is exempted from some taxes (Woods 2012), prices are the same for private and commercial operation. For this study, an operation within or mainly out of Europe will be considered and therefore an equally blended price between commercial and private operation (Fuelworx 2021) will be used to derive the values for the following table:

Table 10 – Fuel cost per hour

Aircraft class	Fuel costs per flight hour
L	498
M	1032
LR	1843
BL	2580

Ground costs

These costs are the sum of all services on the ground, including passenger handling, toilet and potable water services as well as crew support and apply per flight event. The following values for average ground fees per flight hour have been researched for a flight profile consistent with the respective aircraft class (JetNet 2021; Operations Planning Guide 2018):

Table 11 – Ground cost per hour

Aircraft class	Average ground fees per flight hour
L	50
M	120
LR	250
BL	400

Flight planning and dispatch

Costs for slot bookings, overflight permits and route planning (Cordes 2007) are usually charged by specialized service providers per flight event. Combining respective prices (Schaller 2021) with an average sector length of 50% of the maximum endurance in terms of time of the respective aircraft class (Ellis 2019), the following costs per flight hour apply:

Table 12 – Costs for flight planning per hour

Aircraft class	Flight planning costs per leg	Average sector length [hrs]	Average flight planning costs per hour
L	60	1,5	40
M	120	2,5	48
LR	250	6	42
BL	250	5	50

Aircraft software and databases

A profound flight operation requires modern digital aircraft documentation and support software, such as performance calculations and chart as well as performance and navigation databases. Average costs for software licences and databases satisfying basic requirements are as per the following table (Sherpareport 2013; Sherpareport 2014; Young-Brown 2016; Copley 2018; Operations Planning Guide 2018):

Table 13 – Software costs per year

Aircaft class	Yearly license and database fees
L	5.000
M	40.000
LR	63.000
BL	63.000

CAMO management

Each aircraft has to be taken care of by a CAMO department whose task it is to constantly monitor and maintain the airworthiness of an aircraft according to certified manufacturer instructions (De Florio 2006), organizing and documenting all scheduled and unscheduled maintenance and keeping all certification papers as per the respective state of registry up to date (Cannon and richey 2012). A market salary for a well-trained CAMO manager including necessary software can be estimated at 95.000 USD (Avjobs.com 2020; Wyndham 2020a; Wyndham 2020d).

Maintenance costs

Maintenance events are referred to as both, scheduled and unscheduled actions. Scheduled maintenance is required to maintain the aircraft in serviceable condition (Ahmadi 2010) and depends on either total flight hours, total cycles or total flight time of an aircraft and therefore can easily been predicted and planned (Hessburg 2000; Hölzel and Gollnich 2015). Contrary, unscheduled maintenance covers spontaneous malfunctions impeding aircraft operation (Ahmadi 2010), including AOG conditions which immediately ground an aircraft as per manufacturer provisions until the problem has been rectified (Wagner and Fricke 2006). The following table shows average total maintenance costs for the different aircraft classes as well as the share of included reserves for long-term engine overhauls (Operatinal Planning Guide 2018; Wyndham 2020a; Newby 2015; Sherpareport 2013; Wyndham 2020b; Wyndham 2020c; Young-Brown 2016; Wyndham 2020d; Copley 2018; JetNet 2021; Humeira et al. 2016; Aircraft Commerce 1999; Liberty Jet 2020):

Table 14 – Maintenance costs per hour

Aircraft class	Average total maintenance costs per flight hour	Average share of reserves included [%]
L	900	50
M	1500	50
LR	2000	65
BL	1500	60

Aircraft software and databases

Legal requirements call for respective insurances for each individual aircraft, varying with maximum takeoff mass and the number of approved passengers (Department of Transportation; European Council 2004). The next table presents yearly average insurance costs depending on aircraft class as a sum of realistic hull and liability insurance (Wyndham 2020a; Wyndham 2020b; Wyndham 2020c; Wyndham 2020d; Newby 2015; Sherpareport 2014; Operations Planning Guide 2018; JetNet 2021; Copley 2017):

Table 15 – Insurance costs per year

Aircraft class	Insurance fee per year
L	25.000
M	40.000
LR	75.000
BL	130.000

Total hourly costs

For a better overview and as a preparation for the matrix intended to break down all respective figures to hourly costs referring to a certain yearly flight hours volume, the following table will provide a summary of all cost factors discussed before:

Table 16 – Sum of hourly costs

Cost aspect	Aircraft class			
	L	M	LR	BL
Fixed costs per year				
Crew salaries	132.000	330.000	888.000	636.000
Add. costs	39.600	108.000	421.200	314.400
Training costs	32.400	82.350	266.700	34.900
Key personnel	16.200	21.600	34.560	36.720
CAMO	95.000	95.000	95.000	95.000
Insurance	25.500	40.000	75.000	130.000
Admini-stration	5.000	5.000	5.000	5.000
Software / DB	5.000	40.000	63.000	63.000
TOTAL	**350.700**	**721.950**	**1.848.460**	**1.315.020**
Variable costs per hour				
Fuel	498	1032	1843	2580
Flight planning	40	48	42	50
Ground	50	120	250	400
Mainte-nance	900	1500	2000	1500
TOTAL	**1.488**	**2.700**	**4.135**	**4.530**

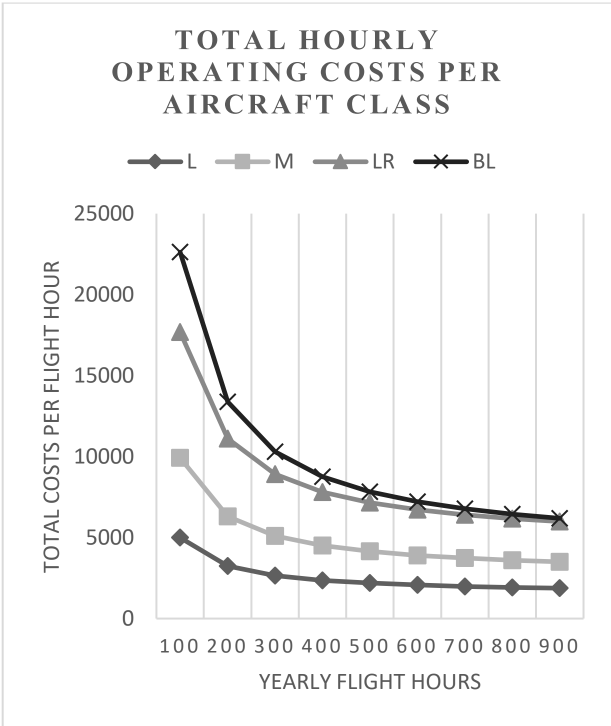
HOURLY RATES

The following matrix will combine all values from the previous chapters and derive an hourly rate for each aircraft class by summing up all applicable fixed and variable costs and dividing them by a set of yearly total flight hours per aircraft. It is important to state that these are pure operating costs and based on a user profile equivalent to respective aircraft design. Neither financing costs, costs for depreciation nor gains due to opportunity costs are considered at all at this point.

Table 17 – Total hourly rates

Yearly flight hours	Aircraft class			
	L	M	LR	BL
100	4995	9920	22620	17680
200	3242	6310	13377	11105
300	2657	5107	10297	8913
400	2365	4505	8756	7818
500	2189	4144	7832	7160
600	2073	3903	7216	6722
700	1989	3731	6776	6409
800	1926	3602	6446	6174
900	1878	3502	6189	5991

The following diagram clearly indicates the effect of the hourly rate decreasing with increasing flight volume.



Figures 1 – Total operating costs

The interesting effect of hourly costs showing a significantly lower rate of reduction with increasing flight hour volume for all aircraft classes considered, , especially above 400 hours. This trend can be traced back to the fact that fixed costs per hour reduce when being spread over more hours, whereas variable costs only increase linear with yearly flight hours.

CONCLUSION

This study has provided a well-researched idea of pure operating costs of the major classes of business jets.

While there certainly are differences between specific types within these classes, the presented numbers do represent a clear magnitude. Researching apparently easy to find material does however pose a challenge in the context of the chosen topic as such data is not published within standard literature but needs to be drawn from industry-specific material which to a large extend is available on respective internet sources. This data set will be used for the superior objective of the associated doctoral thesis of finding the break-even flight hours above which the operation of an own business jet does pay off compared to external flight services of the same extent in regards of flight volume. Expanding the values presented in this study with cost reducing factors such as potential tax saving effects caused by depreciation (Bean 2018b) or opportunity costs caused by saved travel times and effective time to work enroute (Jorge-Calderón 2014) converted into monetary terms, the hourly rates as stated above have the potential to be lowered significantly and thus the break-even flight hours as well. Therefore, they are a vital element for the further progress of the respective PhD thesis.

AUTHOR BIOGRAPHIES

Matthias Bieberbach was born in Nuremberg, Germany and started his career within the German Air Force in 1997 as a cadet. As a young officer he graduated form the University of the Federal Armed Forces in Munich with a diploma in aeronautical engineering before completing pilot training at Lufthansa`s pilot school. While serving as a pilot for the German governmental squadron, he completed studies of business administration as an MBA at the University of Applied Sciences in Wildau. After his military career, he continued to work as full-time pilot with various operations as captain on the Bombardier Global Series. Aiming to top off his wide experience and exceptional combination of piloting, engineering and managerial experience, he his currently working on his PhD thesis at the Tor Vergata University of Rome. His e-mail address is: matthias.bieberbach@t-online.de and his professional profile can be found at linkedin.com/in/mbieberbach.

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