[EN-025] "Analyzing airlines potential cost savings when reducing delays in international air traffic"

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Abstract: Delays in international air traffic have garnered great attention over the past few years. Passengers, airports as well as airlines are hit by the impacts of delays and suffer from their financial burden. In order to cut costs and keep competitiveness in the global market, strategies of managing delays are of prime importance for aircraft operators. Especially in times of consolidations or airlines merger attempts, evaluating the performance and optimizing operations are the keys to success in the global aviation market.

This paper focuses on airlines most important cost drivers being influenced by changes in delay. It does not deal with any passenger or national economy related costs arising if flight operations are delayed. Actual delay statistics of Europe's leading hub airports offer the basis for the calculation of the potential benefit that may arise if delays could be reduced marginally. Depending on the airport and accordingly its aircraft mix, movements per year and further characteristics, intervals of potential savings can be assessed respectively.

Keywords: benefit, marginal delay costs, ground / airborne delay

Nomenclature

APU	Auxiliary Power Unit
ASMGCS	Advanced Surface Movement Guidance and Control System
ATM	Air Traffic Management
AZ	Alitalia
BA	British Airways
CDG	Paris Charles de Gaulle
CDM	Collaborative Decision Making
DOC	Direct Operating Costs
EC	European Commission
FAA	Federal Aviation Administration
FCO	Rome Fiumicino
ICAO	International Civil Aviation Organization
IOC	Indirect Operating Costs
LCC	Low Cost Carrier
LH	Lufthansa
LHR	London Heathrow Airport
MTOM	Maximum Take-Off Mass
MUC	Munich Airport
SES	Single European Sky
TOC	Total Operating Costs
US DOT	US Department of Transportation

1. Introduction

Focusing on the airlines perspective this paper starts with an overview of recent delay situation. Various causes and consequences of delays are analyzed and presented in chapter 2.

The definition of the respective flight phases in which delays occur is inevitable when calculating airlines marginal delay costs. Therefore, a short overview about typical airline’s cost structure is given in chapter 3 and significant operative costs are chosen to evaluate the amount of additional costs to airlines in case of ground or airborne delay (chapter 4).

The calculation of the potential cost savings when reducing delays is done for selected leading European hub airports such as London Heathrow (LHR), Munich (MUC) or Rome Fiumicino (FCO) and will be presented in chapter 5.

2. Delay Situation in Europe

The Department of Transportation (DOT) defines a flight as “delayed” if it departs more than 15 minutes after its scheduled departure time. This 15-minute window is also used to define arriving flights as delayed. If a flight is cancelled it has no effect on an airline’s delay rate [19].

Using this definition, about 22 % of all commercial flights in Europe in 2007 could be described as delayed which equals an annual 0.4 percentage increase.

The following Figure 1 gives an overview of the development of departure delay in Europe from 2004 to 2007.

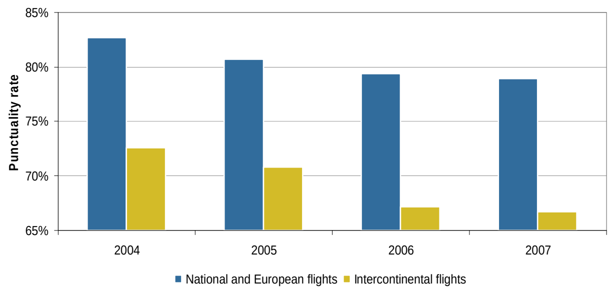

Figure 1 Development of punctuality rate in Europe from 2004 to 2007

Source: [21]

Decreasing punctuality figures of both national/European and intercontinental flights might be the consequence of steady growth in international air transport. As airspace and infrastructure on the ground (runways, aprons, taxiways, gates and terminals) are limited, there seems to be no chance to cope with that growth without significant initiatives such as the Single European Sky (SES) concept. It aims to reduce airspace fragmentation and thus to overcome current capacity issues as well as to improve air transportation's overall sustainability.

The impacts of delays shall be mentioned briefly for the areas of airlines, passengers and third parties in the following.

Notwithstanding the purpose of a journey (business or holiday trip) delays are an inconvenience to the majority of passengers. Increasing inconvenience among customers can be decisive for declining image values of airlines and may have negative effects on their market share. Furthermore, opportunity costs arise even for passengers in case of delays. Since the loss of use, e.g. by a missed business meeting, differ from the loss of use by late start into holidays, opportunity costs need to be monetarily judged differently depending on the purpose of journey. Independently of this, efficiency decreases with every delay minute since resources are not used optimally.

Following figure 2 gives an overview about the economic effects of air traffic delay. The x-axis is the quantity demanded/offered and the y-axis the price of the goods. As already mentioned, this figure shows the total delay costs to airlines as well as other parties such as passengers or the environment.

As shown in this figure, the equilibrium represented by Q_E and P_E is the market equilibrium based on demand and supply. Any prices below or above this equilibrium will not hold on the market due to economic reasons.

In case of delays (regardless of the actual causes) external costs are imposed on the air traffic system. To the traveler additional costs in the form of schedule change as well as opportunity costs are entailed.

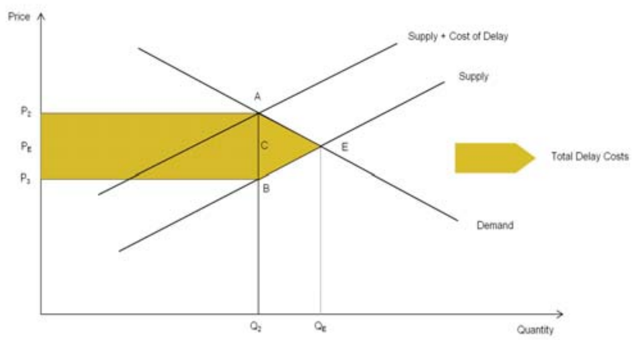

Figure 2 Economic effects of air traffic delay

Source: According to [25]

To the airline additional costs in the form of higher fuel or cabin crew wages are imposed. Theses costs are shown by the connection between A and B (line C).

Consequently a new supply curve can be set by parallel shift of the old supply curve. As a result a new equilibrium Q_2P_2 has been defined.

The effects on airlines as well as consumers can be described as follows:

As $Q_2P_2 > Q_EP_E$ consumers suffer from higher ticket prices and airlines from lower fares that can be obtained on the market. In detail, additional costs to airlines are equal to the rectangle P_3BCP_E plus the triangle BEC. Costs to consumers can be defined as the rectangle P_ECAP_2 plus the triangle CEA.

Thus total delay costs on airlines and consumers are equal to the rectangle P_3BAP_2 plus the triangle BEA. These welfare decreasing effects exceed by far the "positive" effects of ground delays that passengers are encouraged to consume more goods when filling the time gap to boarding which lead to higher sales in the non-aviation business [12].

Further considerations, such as any analogies to taxes that are imposed on the air traffic market and the question if delay costs are "lost" or if there is any return to the governmental authorities, are no matter to be discussed in this paper.

3. Airline Cost Classification

A common approach to airline cost classification can be achieved by using functional categories such as operating and non-operating costs [14]. Non-operating costs are fixed with output and account more than 50 % of total airlines costs (respective amount of non-operating costs depends i.e. on airlines expenditures or assets).

Focus in this paper is laid on operating costs because non-operating costs are not directly related to airline's air services (and therefore, independent of changes in delay level), but to any financial activities.

Total operating costs (TOC) can be furthermore subdivided into direct operating (DOC) and indirect operating costs (IOC). IOCs are rather passenger-related (i.e. passenger services, catering) and contain sales-dependent costs such as expenses for e.g. promotion [13].

DOCs largely depend on the flight operations and represent the largest proportion of airlines operating expenses [2].

Most important cost items contributing to direct operating expenses are:

- Fuel Costs
- Flight and Cabin Crew Allowances
- Maintenance Costs

In contrast to US Department of Transportation (US DOT) [24] or International Civil Aviation Organization (ICAO) [16] categorization, landing fees can also be considered as direct operating costs because flights can not be operated without starting or landing at an airport [7].

4. Calculations

There are different methods for assigning airlines delay costs. In this paper the cost items which already have been mentioned in chapter 3 are taken into account. Further operating or non-operating cost elements are not discussed as their amount is either not influenced by the (un-)-punctuality level (i.e. marketing expenses) or negligible (changes in the amount of route/airport charges due to delays) [6].

Due to the fact that delay costs vary (amongst others) according to the equipment used, different aircraft types are defined to estimate additional expenses.

Therefore a B737-500 is selected as a typical representative for medium jets and a B747-400 for heavy jets[1].

4.1 Fuel Costs

Fuel costs of airlines mainly depend on fuel consumption and fuel prices on the market. Since aviation fuel (Jet A-1) is closely linked to oil prices, the impact of climbing oil prices in past years needs to be considered when calculating fuel costs. Between 2001 and 2008 oil price rose more than 330 % and reached a peak of more than $ 120 per barrel in 2008. In order to keep the values up to date the following calculation is based on an average oil price of $ 60 per barrel in the year 2009.

[1] Classification of aircraft to the wake turbulence categories according to [15]

Fuel burn data provided by [6] offers a reliable basis to determine different fuel consumption according to the different flight phases (APU, stationary ground, taxi, en-route and approach) and different aircraft equipment used (B737 and B747). Fuel costs per minute for both aircraft considered are given by the following Figure 3.

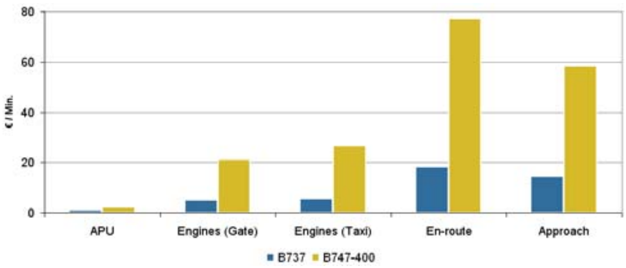

Figure 3 Fuel costs per minute

Airlines may benefit from cost-savings achieved by synergies established in alliances and fuel hedging practices. Especially hedging activities are carried out by most European network airlines in order to achieve advantages in investment opportunities [18, 4].

4.2 Flight and Cabin Crew Allowances

Marginal crew cost contribution to airlines allowances is another important factor that needs to be examined. Payment mechanisms depend on a wide range on parameters beginning with the base country, economical development, social security contributions or any types of operations [7]. Most important cost drivers are the different payment mechanisms, size of aircraft flown and legal restrictions concerning number and composition of cabin crew and labor time. The regulation (EC) No 1899\2006 of the European Parliament defines the minimum number of cabin crew as follows [10][2]:

"An operator shall ensure that the minimum of cabin crew is the greater of one cabin crew member for every 50, or fraction of 50, passenger seats installed on the same deck of the aeroplane […]"

As mentioned in this regulatory framework the amount of aircraft seats is decisive for the minimum allowed number of cabin crew members. Estimating marginal crew costs the following assumptions are made in this paper:

First of all the EU regulation No 1899\2006 (see above) has been applied. Furthermore a total number of 347 seats in a three-class configuration represents the basis for calculation. This number complies with the average number of seats of airlines looked at (e.g. German Lufthansa, United Airlines et al). In order to provide a higher service level in business and first class, more crew members than required on law are assumed. The number of seats as well as the number of crew members (including one senior flight attendant for medium haul flights and two senior flight attendants for long haul flights) corresponds with most both European and US network carrier seating plans and therefore offer a valid basis for the following examinations. Apart from the size of crew per aircraft, wages for both cabin crew and flight crew members are another point of interest. According to own examinations salaries increase by the size of the equipment used. Therefore, higher marginal flight crew costs are taken into account for a B747 than for a B737. For both aircraft types a flight crew of one pilot in command and one first officer is assumed. In order to provide reliable results, values used in this part were both derived by detailed examination done by [22] and own examinations of payment mechanisms of German airlines.

Finally total marginal crew costs (flight crew and cabin crew) of approx. \$ 10 per minute for B737 and approx. \$ 20 per minute for B747 for ground and airborne delays can be derived. Reasons for this deviation can be seen in the already mentioned different crew size as well as seniority-based payments.

4.3 Maintenance Costs

Maintenance costs basically depend on the following cost components:

- Labor
- Materials
- Third Party
- Burden

[18] analyzed that total direct costs reach up to 60-70 % of maintenance costs. Consequently 30-40 % can be allocated to the burden costs. Representing the fixed costs, these cost elements do not vary respectively to the delay level. In order to determine airlines´ marginal delay costs, fixed costs can be excluded from the following calculation method.

The following calculation method basically focuses on these parameters:

- Block hours per year
- Variable cost elements of maintenance costs

[2] Equivalent regulations are given by Federal Aviation Administration (FAA) for the United States of America [11]

At first focus is laid on the operating hours per year. Due to the fact that the amount of block hours depends on the airlines aircraft mix, in-depth analysis were arranged to obtain reliable information. It is assumed that every aircraft is available 365 days a year. Aircraft groundings due to economic crises or aircraft losses as a result of accidents are not taken into account. As this paper tends to determine the benefit from reducing delay depending on the specific flight phase in which it occurs, "operating minutes" implying total flight, gate and taxi minutes of an aircraft per year need to be defined. According to own data (see the following chapter 5), it can be assessed that wide bodies (here: Boeing B747) are airborne for about 13.4 hours per day. Relating to a whole year the percentage is about 56 % of total operating minutes. Remaining 44 % can be allocated to gate (approx. 29 %) and taxi (approx. 15 %) depending on specific airline procedures, airport layouts or aircraft operations.

In the next step, specific "load minutes" are calculated. They offer an overview about how the most important aircraft components (airframe and engines) are exposed on the ground and in the air. Due to difficult mechanical loads in the particular flight phases, weighting factors ("0", "0.5","1") are set to underline the difference in additional delay costs when a delay occurs on the ground or in the air.

According to this approach aircraft engines are assumed to be exposed only during taxi and in-flight. Numbers "1" and "0.5" represent the degree of exposure, e.g. full technical load is represented by "1", while standing at the gate is assumed to have no effect ("0").

Apart from the block hours, delay dependent maintenance costs are the second important parameter that needs to be calculated. As already mentioned, variable delay costs are calculated by subtracting fixed cost components from total annual maintenance costs. According to [23] delay dependent maintenance costs can be assigned as follows:

65 % can be allocated for maintaining the airframe and 35 % for the engines. Monetary weighting factors are set in order to calculate the different additional delay costs (analog to flight phase dependent weighting).

On basis of this method, marginal maintenance costs of about $ 8 per minute can be calculated for a B747. Costs for both taxiing to/from runway (approx. $ 2.46) and standing at the gate (approx. $ 1.04) are certainly lower.

In case of the medium aircraft type Boeing B737 temporary weighting factors are changed due to different aircraft turnings compared to long range jets. Mid-range jets like the B737 usually have more takeoffs/landings per day and spend more time on the ground than long range jets consequently. According to own analyses of airlines operating at leading European airports only 1,73 takeoffs and landings per day are performed by long range aircraft whereas typical mid-range aircraft have 4,2 takeoffs and landings per day in average. The following Figure 4 gives an overview about the calculated marginal costs for the relevant flight phases.

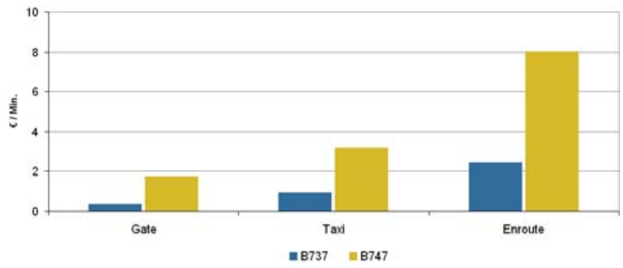

Figure 4 Marginal maintenance costs per minute

5. Evaluating the benefit for airlines

In this chapter focus will be laid on analyzing the potential benefit of airlines by reducing delays. Therefore an approach of the procedures and the underlying database will be given in the following chapter 5.1.

In the subsequent chapter 5.2 the results will be presented and discussed.

5.1 Explanation of the procedure and the database

As already mentioned in the introduction, the European hub airports London Heathrow, Munich and Rome Fiumicino have been selected for the following calculations.

Figure 5 offers an overview about the key parameters of these airports.

	LHR	MUC	FCO
total dep. in 2009	233.000	197.000	162.000
Ø dep. / day (April - August 2010)	636	531	474
Ø percentage of heavy jets (dep.)	31.0	7.9	8.4

Figure 5 Key parameters for calculation

The total number of departures in 2009 is given to distinguish the different dimensions among the hubs. According to [9] London Heathrow was ranked number two (behind Paris Charles de Gaulle (CDG)) in Europe with approx. 233.000 departures in 2009. Munich and Rome were listed number six und seven.

Rows two and three of Figure 5 offer up-to-date flight data. These were gained from the FlightStats platform which delivers worldwide flight on-time performance information [6].

The period of data collection extended over several months from the beginning of May to mid-August 2010.

The unprecedented Eyjafjallajökull[3] ash crisis (most severe from 15th to 22nd April 2010) was not taken into account as regular flight operations should be considered.

Most relevant data attained are for example:

- Equipment_ actual
- Number of departures _actual
- Number of arrivals _actual
- Operating airline/codeshare partners

The need of these data can be explained by describing the procedure of the calculation method which is shown graphically in the following Figure 6.

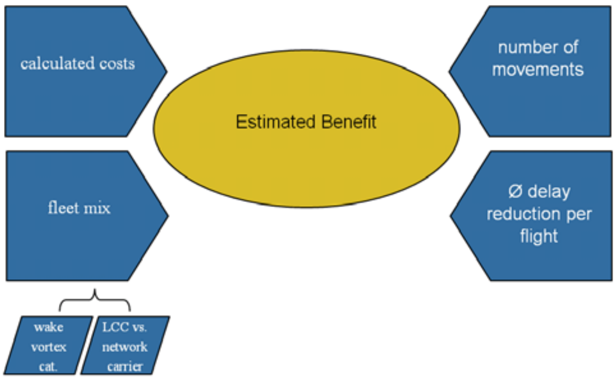

Figure 6 Explanation of the procedure

Considering the fleet mix, it is essential to look at the wake vortex category as well as the proportion of Low Cost Carrier (LCC) (e.g. Ryanair, EasyJet) to network carriers (German Lufthansa, All Nippon Airways). Without any differentiation in heavy, medium or light jets, unrealistic unit costs per minute would have to be adopted.

Counting the number of arrivals and departures, the total average number of movements per day at one specific airport can be assigned.

Furthermore the percentage of LCC at the selected hub airports has to be determined as LCC implement several strategies in order to cut costs [7].

The percentage of LCC as well as the ratio of the leading carrier of the total movements is shown in the following Figure 7.

It can be witnessed that the percentage of LCC at London Heathrow is negligible whilst almost 20 % LCC at Rome is an uncommon high value for hub airports. In general network carriers are largely attached to hub airports whereas secondary/regional airports are more attractive to LCC due to idle capacities and lower airport charges [1, 20].

	LHR	MUC	FCO
leading carrier	BA	LH	AZ
percentage leading carrier of total movements	42	38.5	35.7
percentage of LCC	~ 1.4	~ 5.9	~ 19.6

Figure 7 Ratio of LCC to network carrier

In consequence delay costs per minute are considerably lower than those of network airlines[4]. Thus a differently minted cost reduction potential can be suggested depending on this mentioned proportion.

In case of in-depth analysis, as done in chapter 4, in addition with explicit actual equipment data, more adequate results could be achieved. As there are too many different aircraft types at hub airports explicit analysis of marginal delay costs can not be carried out for every one.

Thus the two aircraft types looked at in chapter 4 are assumed to be representative aircraft for the respective wake vortex category.

Costs determined for B737 are assumed to be realistic average costs for typical medium jets. Costs for B747 are

[3] Eyjafjallajökull is one of the smaller glaciers of Iceland, which covers a volcano that has erupted twice in April 2010.

[4] The specific practices how to cut costs are no matter to be discussed in this paper.

taken as the upper limit for heavy jets[5]. This procedure can be justified by extensive analysis of marginal delay costs of different aircraft types done by [6]. This work shows that the fuel consumption, which is the most important component of operating costs of a B737, is comparable to the one of other medium jets such as A319/A320. As the amount of seats is also similar, comparable marginal crew costs in case of delays can be assumed[6].

Apart from these parameters it is necessary for the following consideration to define an “interval” in which the “average delay reduction per movement” due to current or future measures can be expected. This procedure offers considerably more meaningful values than the definition of one concrete number since this is aggravated by the variety of factors influencing punctuality in air traffic. [3] has shown that every taxi process can be lowered by optimized ground guidance control (A-SMGCS) by 24 seconds on average. Besides examinations dealing with the principle of Collaborative Decision Making (CDM) (see [8]) prove that additional ground time of an aircraft can be reduced by a value up to approx. 60 seconds by implementation of this system.

These scientific examinations offer a valid basis for the definition of the interval above. Therefore values of approx. 24 seconds as well as 60 seconds are considered as lower and upper temporary barrier for the potential cost reduction. It is assured by this procedure that the given interval of the potential delay reduction is based on a realistic and furthermore scientifically verifiable basis.

5.2 Results

Based on the values given in Figure 5 and considering the procedure pictured in Figure 6, the following benefit can be estimated (see Figure 8).

The highlighted area represents the interval with the temporary boundaries mentioned above.

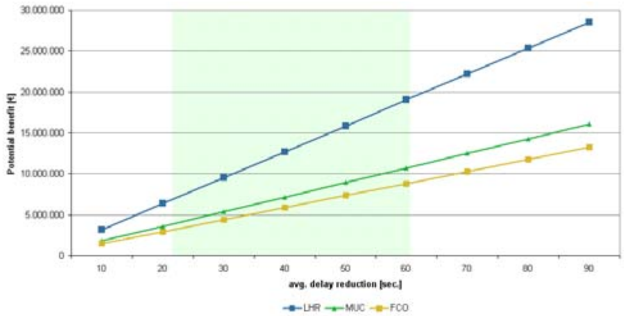

Figure 8 Estimation of potential benefit

Depending on the reduction of the average delay, benefits up to almost 20 Million Euros per year can be estimated for London Heathrow[7]. Values for Munich and Rome Fiumicino are considerably lower in comparison with those of London. One decisive reason is surely the lower number of movements as well as the strongly divergent fleet mix.

Despite a slightly higher percentage of heavy jets in Rome Fiumicino, the estimated benefit is lower than in Munich. This can be explained with the lower quota of LCC (~ 5.9 % vs. ~ 19.6 %) and the lower number of total movements.

If further operating and non-operating costs such as passenger costs, capacity-induced schedule delay or indirect economic impacts were taken into account, the potential cost reduction could be increased even further.

6. Conclusion and Outlook

This paper aimed to analyze the cost structure of airlines in order to determine additional operating costs in case of delays in the air traffic system. On the basis of information gained by scientific sources as well as own examinations changes in operating costs are estimated.

Having selected three main European hub airports, an interval of potential cost reduction could be evaluated on basis of airport-specific data such fleet mix, percentage of LCC vs. network carrier and total number of movements.

This paper therefore may function as a kind of impulse to sensitize ATM-Stakeholders to the amount of potential cost reduction. Such considerations are of great importance, especially in times of economic recession and increasing consolidation trends in air traffic market since airlines make large effort to cut costs in order to remain competitive in the global market.

[5] Marginal delay costs for the new A380 are not considered in this paper.

[6] According to German Lufthansa’s seat map there is a difference of 21 seats comparing B737-500 and A319 and a difference of 5 seats comparing B737-300 and A319 respectively [17].

[7] The benefit estimated in this paper is based on the definition of the values explained in chapter 4.3.

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