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Costs of Delay and Default Flight Level

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***Abstract*—This article deals with study of costs which every single aircraft operator has to pay for its delay against schedule or for non-flying in default flight level. These costs are defined, analysed afterwards and calculated accordingly.**

Keywords-strategic, tactical, reactionary costs, delay, flight level

I. Introduction

Today's air traffic is about 26 000 aircraft movements/day over Europe region and is going to rise. It is predicted that this amount will double till 2020. European ATM costs €2-3 billion more than other world's ATM therefore our aim is reduce the difference as much as possible, moreover fulfil the future demands.[1] That is why Single European Sky project was born. Researches have been established into several stages, e.g. airspace design, new technologies, procedures, optimizing the ATM network. This thesis focuses on the ATM network performance by collecting, analysing and predicting data.

The first part of this article aims at delay costs. Since the beginning the assumption suffered from the limited view on the problem because only fuel costs were considered. However thanks to researches, studies and collecting delay data from aircraft operators it has been found out that fuel costs are a small part of total costs and we have to focus on other factors such as passenger costs.

The second part focuses on costs which are caused by changing the default flight level.

II. COSTS OF DELAY

A. *Strategic costs (Schedule padding)*

Costs which are fixed into the operational design of the network at the strategic level, based on contingencies for dealing with delays at the tactical level. Such contingencies (e.g. schedule buffers) represent an opportunity cost for the airline, as, if delays were known in advance to be reduced, these resources could be put to better use, or dispensed with to save capital.[2] Strategic costs are calculated days, weeks even months in advance by adding a buffer into schedule to absorb delays. From this point they are difficult to forecast and consequently it is difficult to show real costs caused by contingencies so that real saving are hidden to the aircraft operator. Usually the financial losses are a consequence of lack of predictability.

B. *Tactical costs (Delay against schedule)*

If no buffer is added into schedule, the tactical costs will increase significantly as well as reactionary costs. We have to keep in mind that the primary delay affects not only the original aircraft on subsequent legs (rotational reactionary effect) but also other aircraft (non-rotational reactionary effect) and the ratio between these delays is 88:12 which means 88% of flights was delayed by rotational reactionary delay and 12% of flight was delayed by non-rotational reactionary delay.[3]

C. *Network reactionary costs*

All delays which may be directly attributed to an initial, causal or 'primary' delay, will burden the causal aircraft, and/or others. These may decrease throughout the network until the end of the same operational day. Either all, or part, of particular flight delay durations subsequent to the primary delay may be assigned as 'reactionary' in origin.[4]

Costs are divided into 3 phases due to the difference in fuel burn in each stage; these are at-gate, taxi and en-route.

As an example, figure 1 shows the calculation of 15 minutes delay of B737-800 in 2010. We notice that during at-gate phase it is assumed that engines are shut down hence no fuel is being burnt so passenger costs dominate in this phase, whilst fuel costs dominate during en-route phase. Also there is almost double difference between at-gate costs and en-route costs so it is more effective to delay the aircraft on the ground than in the air.

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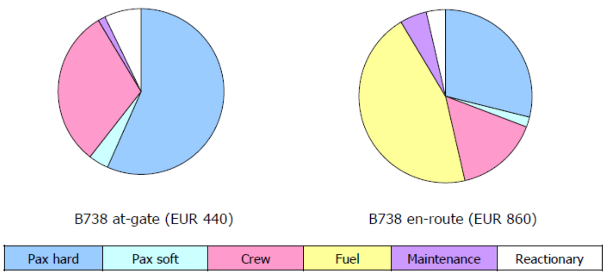

Figure 1. Costs in 2010 Euros. Delay weights use 2009 ATFM data

Pax hard cost means costs for rebooking, compensation or care while the flight is delayed, on the other hand soft cost is cost due to revenue loss such as passenger having a flexible ticket and taking competitor's on-time flight instead of a delayed flight.

The total cost of ATFM delay in 2010 was €1 250 million (all causes considered), 92% of flights did not incur ATFM delay, the average cost of delayed flight was €1 660, the average value calculated as a division of total ATFM delay cost and total ATFM minutes is €81/min.[5]

III. DEFAULT FLIGHT LEVEL

The most efficient flight level for every aircraft considering fuel consumption is an optimal flight level, however, only occasionally ATC allows the airplane to fly in optimal flight level and it is done only if there is a spare traffic in the airspace e.g. at night. The airplane flies in its non-economical flight level most of the time. But what if the flight level is changing during the whole flight? Theoretically the heavier the airplane is, the more fuel it consumes. The more fuel the airplane consumes during the flight, the higher the optimal flight level is. If we want to fly as economically as possible, we will continually increase our flight level. Unfortunately it is not possible during normal day-to-day operation. Let's focus on the usual case.

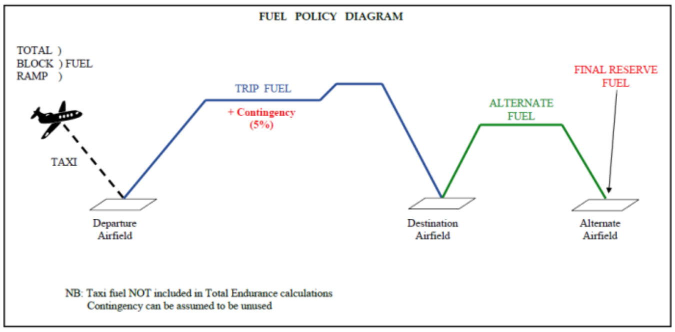

Figure 2. EASA Fuel policy

Figure 2 shows how much fuel you have to consider for a flight and what the minimum for a flight is, this is known as a Fuel policy by EASA.

IV. COSTS' ANALYSIS AND ESTIMATION

A. *Effects of delay*

Figure 3 shows how the aircraft operator manages the delay effects.

1) Strategic, gate-to-gate level

Based on statistical consideration from the previous season aircraft operator sets up the individual legs including buffers large enough to absorb delay caused by contingencies and small enough not to block the resources.

2) Strategic, network level

Then taking acount the individual requirements of each leg a network schedule is set up. As the white arrow shows the process must be repeated constantly in order to optimize the schedule.

3) Tactical, gate-to-gate level

If the strategic delay was counted properly, the primary delay caused at the day of operation would be absorbed by buffers and would not lead to other delay normally.

4) Tactical, network level

However due to contingencies in this case ATFM restrictions reactionary delays has been created. Buffers are not designed to absorb other delay than primary and therefore we have to take in account that the aircraft doesn't recover from the first delay of the day.

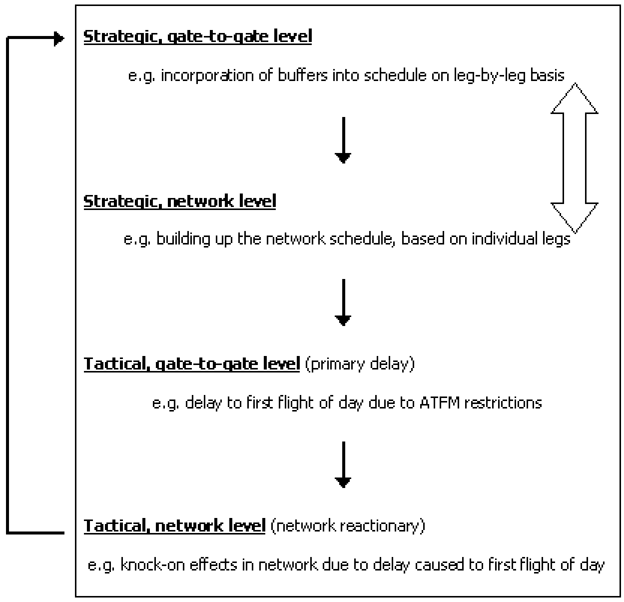

Figure 3. Hierarchy of delay level costs

B. *Primary and reactionary delay comparison*

Primary and secondary causes vary according to airport and area. Regular division of delay causes and 2011/2012 statistics are shown in figure 4.

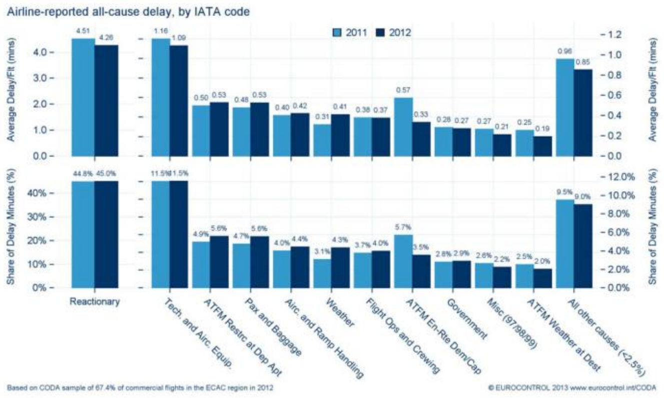

Figure 4. Primary and reactionary all-cause delay in 2011 and 2012, by causes

V. 2013 DELAY STATISTICS

TABLE I. Average delay due to air traffic flow in year 2013[6]

AIRPORT NAME	AIRPORT ID	DAILY AVG TRAFFIC (Dep+Arr)	% DEP REGULATED TRAFFIC	AVG DELAY PER DEP REGULATED FLIGHT	% EARLY DEP TRAFFIC OUTSIDE STW	% DEP TRAFFIC INSIDE STW	% LATE DEP TRAFFIC OUTSIDE STW
BIRMINGHAM	EGBB	251	10.2 %	12.9 min	16.8 %	77.6 %	5.6 %
OTOPENI-INTL.	LROP	240	9 %	10.2 min	5.1 %	90.8 %	4.1 %
FERIHEGY-BUDAPEST	LHBP	229	11.3 %	11.3 min	3 %	93.4 %	3.6 %
VENEZIA TESSERA	LIPZ	222	13 %	10 min	7.5 %	89.3 %	3.2 %
STAVANGER/SOLA	ENZV	216	6 %	12.5 min	1.4 %	96.1 %	2.5 %
GLASGOW	EGPF	213	7.3 %	14.7 min	5.6 %	89.4 %	5 %
LONDON/CITY	EGLC	202	7.2 %	12.8 min	9 %	87.4 %	3.6 %
BALE-MULHOUSE	LFSB	199	11.5 %	11.5 min	8.2 %	85.2 %	6.6 %
IZMIR-ADNAN-MENDERES	LTBJ	196	4.5 %	8.7 min	18.8 %	69.8 %	11.4 %
BERGAMO/ORIO ALSERIO	LIME	195	6.7 %	10.1 min	4.4 %	92.5 %	3.1 %
ABERDEEN	EGPD	194	5.4 %	16.9 min	8.5 %	86.6 %	4.9 %
ALICANTE	LEAL	186	18.8 %	11.9 min	2.2 %	95.4 %	2.5 %
RIGA INTL	EVRA	184	5.9 %	10 min	5.1 %	87.9 %	7 %
EAST MIDLANDS	EGNX	181	7.2 %	12.1 min	14.2 %	81.1 %	4.7 %
BOLOGNA	LIPE	178	10.3 %	12.4 min	5.7 %	92.6 %	1.7 %
HANNOVER LANGENHAGEN	EDDV	175	12.2 %	10.7 min	2.3 %	93.1 %	4.6 %
SCHOENEFELD-BERLIN	EDDB	173	10.7 %	10.9 min	5.4 %	89.9 %	4.7 %
GOTEBORG/LANDVETTER	ESGG	166	10.6 %	11.9 min	7.1 %	91.1 %	1.8 %
PORTO	LPPR	163	9.6 %	11.6 min	5.7 %	88.7 %	5.6 %
LEIPZIG/HALLE	EDDP	163	6 %	11.4 min	1.9 %	95.7 %	2.4 %
LUXEMBOURG	ELLX	158	12.4 %	12.5 min	10.6 %	83.1 %	6.3 %
BRISTOL/LULSGATE	EGGD	159	10.2 %	13.8 min	21.6 %	75.2 %	3.1 %
TRONDHEIM/VAERNES	ENVA	155	5.7 %	13.5 min	1.9 %	95.7 %	2.4 %
BORDEAUX-MERIGNAC	LFBD	155	6.7 %	12.6 min	7 %	87.7 %	5.2 %
NAPOLI CAPODICHINO	LIRN	153	6.2 %	11.2 min	3.6 %	94.6 %	1.8 %
CATANIA FONTANAROSSA	LICC	152	3.7 %	12 min	9.8 %	84.2 %	5.9 %
TENERIFE SUR	GCTS	74	13.4 %	11.7 min	5.3 %	86.5 %	8.2 %
PARIS LE BOURGET	LFPB	147	7.7 %	17.1 min	3.3 %	89.1 %	7.6 %
IBIZA	LEIB	147	14.5 %	13.7 min	1.8 %	95.9 %	2.3 %
NUERNBERG	EDDN	142	12 %	12.6 min	6 %	92.2 %	1.9 %
ROMA CIAMPINO	LIRA	141	6.6 %	10.1 min	9.6 %	79.7 %	10.8 %
NANTES	LFRS	138	8.1 %	14.2 min	11.7 %	85.7 %	2.6 %
CHARLEROI/BRUSSELS SOUTH	EBCI	137	8.6 %	11.9 min	4.2 %	88.9 %	7 %
STOCKHOLM-BROMMA	ESSB	137	1.3 %	9.8 min	2.4 %	89 %	8.5 %
VALENCIA	LEVC	134	10.7 %	11.5 min	1.2 %	97.4 %	1.5 %
IRAKLION/NIKOS KAZANTZAKIS	LGIR	128	7.9 %	12.9 min	9.1 %	77.3 %	13.6 %
NEWCASTLE	EGNT	128	11.5 %	12.4 min	4.6 %	90 %	5.4 %
TENERIFE NORTE	GCXO	63	4.9 %	11.3 min	3.2 %	94 %	2.9 %
ARRECIFE LANZAROTE	GCRR	59	9.6 %	13.8 min	1.6 %	95.1 %	3.3 %
FARO	LPFR	118	11.6 %	13.6 min	9.5 %	88 %	2.5 %
THESSALONIKI/MAKEDONIA	LGTS	117	5.1 %	11.1 min	9.3 %	77.2 %	13.5 %
BILLUND	EKBI	115	11.2 %	11.9 min	4.2 %	91.7 %	4.1 %
PISA SAN GIUSTO	LIRP	113	8.7 %	10.7 min	11.9 %	78.8 %	9.4 %
JERSEY	EGJJ	113	1.8 %	21.1 min	2 %	95.5 %	2.5 %
GUERNSEY	EGJB	113	1.2 %	17.6 min	7.5 %	82 %	10.5 %
KRAKOW/BALICE	EPKK	112	10.5 %	11.9 min	4.8 %	87 %	8.2 %
PALERMO PUNTA RAISI	LICJ	112	3.9 %	12.4 min	3.7 %	93.8 %	2.5 %
LARNACA	LCLK	111	13.3 %	10.6 min	5.9 %	86.7 %	7.4 %
BODO	ENBO	110	1.4 %	18.2 min	2.5 %	94.7 %	2.8 %

For better idea how important problem is delay we show average delay statistics from chosen European airports, in table I. Table I. covers statistics for whole year 2013. Early departing traffic is traffic departing 5 minutes or more prior slot time, late departing traffic is traffic departing later than 10 minutes after original slot time. % of regulated traffic is percentage (compared with the ATC Activated Traffic count) of terminated flights affected by one or more regulations. Only the Regulated Flights for which an Actual Take-Off is known are used.

If we used early mentioned sum of 81 €/minute of delay costs we may estimate that according to numbers in figure 5 costs of delay originated by air traffic flow only in Prague Airport 2013 is more than 7,4 million EUR.

VI. CONCLUSION

Costs of delay cause a financial losses, therefore, prevention and recovery process have to be established. We usually focus on the tactical phase but the truth is that we should focus on the strategic phase, this planning can reduce delays. Despite of all known values we cannot avoid delay. However, we can soften the impact of delay by calculating the delay in advance – strategic delay, by adding buffer into schedule to absorb delay caused by contingency. Nevertheless there is a risk of blocking the aircraft and resource due to larger buffer than the situation needs which affect the airline profitability as well. The aircraft operator has to calculate and predict the schedule very properly but even in this case we are not able to avoid a coincidence. If the primary delay occurs earlier in the day, it will cause the greater reactionary delay. This is what the aircraft operator should do primarily. As it was mentioned at the beginning airline is not the only one, a huge work should be made also on the other side – ATM, route planners, airspace designers, airports – to make the flow smoother.

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[6] NM ATFCM Monthly Summary per Airport (Traffic Part) - December 2013

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