Development of Common Modelling Guidelines

D3.1

COMPAIR

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COMPAIR

COMPETITION FOR AIR TRAFFIC MANAGEMENT

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Abstract

The purpose of this document is to develop a set of common modelling guidelines to ensure that differences between modelling outcomes are driven by institutional designs studied and not by differences in model inputs. Guidelines address the model inputs: modelling horizon, the assumptions underlying the models and the potential sources for input data.

1 Table of Contents

2 Executive summary

This deliverable details the basic assumptions that the three modelling groups (TML, Nommon and HUJI) have agreed upon with respect to their future research for the COMPAIR project. We intend to draw conclusions about the potential impact of introducing competition to varying degrees (from benchmarking to unbundling to tendering arrangements) on the Air Traffic Control market in Europe in 2035 and 2050. We will analyse the choices of five different stakeholders to varying degrees of accuracy, namely the ATC en-route and terminal providers, airlines, airports, passengers and regulators. The Performance Review Reports and ATM Master Plan ([20] 2015) will provide the basis for most of the information. This will be supplemented by additional information from airline company reports, the DDR2 and CODA databases, the Eurocontrol Cost-Benefit Analysis Guidelines and other sources where necessary and agreed upon between the parties.

1. Introduction

1.1 Goal of COMPAIR

Since 2004, the Single European Sky (SES) initiative has aimed to re-structure the European airspace as a function of air traffic flows, create additional capacity and increase the overall efficiency of the Air Traffic Management (ATM) system, in order to cope with sustained air traffic growth under safe, cost-efficient and environmentally friendly conditions. The political objective of the SES is to achieve a future European ATM system which can, relative to 2005 performance, enable a three-fold increase in ATM capacity; improve the safety performance by a factor of 10; enable a 10% reduction in the effects flights have on the environment; and provide ATM services to airspace users at a cost of at least 50% less. Today's progress towards these objectives is perceived as slow: the steps taken towards enhanced collaboration between various air navigation service providers (ANSPs) are sometimes considered ineffective, the implementation of functional airspace blocks (FABs) to defragment the European landscape of national ANSPs and enable economies of scale has had limited success [11], and the Research and Innovation (R&I) cycle is long ([3] Baumgartner and Finger, 2014; [10] Fox, 2016; [16] Neroth, 2013). In this context, the question of how to provide the appropriate organisational structures, institutions and incentives for new operational concepts and technologies to yield the expected results stands high on the policy agenda.

The introduction of competition has been proposed as a means to provide improved incentives for the realisation of the high-level objectives of the SES[1], through the speed up of the innovation cycle and the fostering of more efficient operations. On the other hand, competition does not prevent every market failure (e.g., may fail to account for negative externalities) and, depending on market conditions, liberalisation can also have undesired outcomes, such as the emergence of oligopolies or monopolies. The goal of COMPAIR is to study how to introduce competitive incentives in ATM so as

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[1] http://www.sesarju.eu/discover-sesar/history/background-ses

to best contribute to achieving the European high-level policy objectives for aviation. The project objectives are:

1. Propose a set of new institutional market designs for the introduction of competition in the European ATM sector.
2. Define a framework allowing a comprehensive assessment of the impact of different institutional market designs.
3. Develop a variety of economic and network simulation models enabling the assessment of the proposed approaches.
4. Assess the feasibility and acceptability of the proposed institutional changes for various market actors.
5. Propose a vision for the implementation of the most desirable institutional structures.

This deliverable focuses on the third objective. Specifically, the purpose of the deliverable is to develop common guidelines to be used in order to ensure consistency between various model approaches. The intention is to increased comparability across modelling approaches to be developed in deliverables 3.2 and 4.

1.2 Acronyms and terminology

The same or similar performance areas have been referred to in the literature by different names. In this document we aim to establish a common understanding of a set of relevant concepts. The concepts and terminology used intend to be as consistent as possible with those used by the ICAO Performance Framework ([14] ICAO, 2008), the SES Performance Scheme ([9] EU 2013) and the SESAR Performance Framework ([19] SESAR JU, 2015a).

1.2.1 Acronyms

Acronym	Definition
ANSP	Air Navigation Service Provider
ARES	Airspace Reservation / Restriction
ATCO	Air Traffic Controller
ATM	Air Traffic Management
BIC	Best In Class
CODA	Central Office for Delay Analysis
EC	European Commission
FAB	Functional Airspace Block
GAT	General Air Traffic
ICAO	International Civil Aviation Organization
KPA	Key Performance Area
KPI	Key Performance Indicator
MUAC	Maastricht Upper Area Control Centre
NSA	National Supervisory Authorities
PRB	Performance Review Board
PRC	Performance Review Commission
PRR	Performance Review Reports
R&I	Research & Innovation
RWY	Runway
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme

1.3 Structure of the document

The document is organised as follows:

- Section 1 describes the scope and objectives of the deliverable. It also defines the key concepts used in the rest of the document.
- Section 2 outlines and details guidelines to be used with respect to each of the five main stakeholders: regulators, air traffic control providers, airports, airlines and passengers.
- Section 3 describes the data sources from which all three modelling approaches will draw their relevant parameters.

2. Guidelines

2.1 Modelling Horizon

The timeframe for this study will be 2035 to 2050, SESAR's target year to attain the vision of air traffic control as indicated by the 2015 European Air Traffic Management (ATM) Master Plan [20]. This Single European Sky (SES) vision, of "high-performance aviation for Europe," is to be achieved through the first three of four phases outlined towards a fully integrated European Network in 2050.

Given the ever evolving world we do note that results will be more reliable on the shorter term than in the longer term. This is not only related to the assumptions we use (e.g. with respect to demand), but to the general framework: Will we still have airlines? Will we still use the fuels that we know today? Will there be pilots? Etc.

2.2 Assumptions

This section will outline the assumptions regarding the major stakeholders involved in COMPAIR: regulatory bodies, SJU and the Deployment Manager, air traffic control providers, airports, airlines, and passengers.

2.2.1 Regulatory Bodies

The European Commission (EC) launched the Single European Skies (SES) initiative, whose goal is to improve the management of European airspace. In an attempt to promote defragmentation of the European airspace, the legislative SES package of 2004 introduced the Functional Airspace Block (FAB), which combines state boundaries. The second SES legislative package (SES II) proposed nine specific FABs and required them to be implemented by 2012. Although all the FABs have been formally established, as of February 2016, the European Commission has called for the need for further progress [10].

In addition to promoting the efficiency of the European airspace, cost regulation was addressed by SES II. Specifically, SES II introduced price-cap regulation with respect to ANSPs, to be determined on a five year cycle. The price caps are set by the Performance Review Board (PRB) and are based on negotiations with the Member States after data is collected on an annual basis, in order to reduce information asymmetries.

Eurocontrol is an inter-governmental body representing 41 states including the 28 belonging to the European Union. Eurocontrol's primary roles are in four areas:

- **Network Manager** which extends the role of the former Central Flow Management Unit and now proactively manages the entire ATM Network in close liaison with the air navigation service providers, airspace users, the military and airports. Eurocontrol was appointed to this role in July 2011 for a period of 8 years. This role is expected to undergo a second tender process in 2019.
- The **Central Route Charges Office** handles the billing, collection and redistribution of aviation charges from the airlines on behalf of all the air navigations service providers. In addition, Eurocontrol charges an additional 0.3% to cover administrative and network manager costs.
- The **Maastricht Upper Area Control Centre (MUAC)** provides upper airspace air traffic control services for the Netherlands, Belgium, Luxembourg and northern Germany. Unlike other ANSPs, whose charges are paid by the airlines directly through the CRCO charging process, MUAC is paid by the ANSPs that it serves, namely LVNL, BelgoControl, GLCCA and DFS.
- The **Performance Review Body** (PRB) of the Single European Sky initiative, which Eurocontrol was appointed to undertake in 2010 for a period of seven years. The PRB provides information to the Performance Review Commission (PRC), including an annual benchmarking process utilized to determine the ANSP price-cap regulation.

At the national level, regulation is provided by the National Supervisory Authorities (NSAs). The primary focus of NSAs is to oversee the national Air Navigation Service Providers (ANSPs) in terms of systems, rules and procedures. We note that safety is beyond the scope of this study, and will thus not be included. It is assumed that all scenarios comply with safety regulation.

2.2.2 Air Traffic Control Providers

The goal of air traffic control providers is to coordinate air travel, in a manner that is (1) safe and (2) minimizes delays. The domain of Air Traffic Management can be subdivided into en-route and terminal air traffic service provision. The majority of European ANSPs provide services to both the en route and terminal sectors, but there are exceptions where unbundling of en route and terminal air traffic services have occurred. MUAC, for example, is an international not-for-profit ANSP that provides solely en-route upper airspace service to four countries. As indicated in Deliverable D2.2, “Report on Institutional Design Options”, the ownership form of ANSPs varies over countries, from a department in the Ministry of Transport to 100% government-owned corporations to semi-public and semi-private firms (for-profit or not-for-profit). We will assume that the air traffic control providers aim to maximize profits. As a form of sensitivity analysis, we may also test their likely behaviour under revenue maximization, an objective that may be relevant when part of a government ministry.

2.2.3 Airports

Airports link travel between destinations, and are the location of the terminal air traffic control centres. Airport ownership may take on one of several forms. Though historically airports were publicly owned, in 1987 the UK privatised the London airports. As a result, other countries followed, and many of the European airports were completely privatised or a public-private ownership form was established.

As airports may be viewed in some regards as monopolists, regulation is often in place and may take one of the following forms: cost plus, price cap, yardstick competition, light-handed or standard anti-trust regulation. In addition, airports may be regulated under either a single till approach, whereby all airport revenues are limited, or a dual till approach, whereby aeronautical revenues are restricted and commercial activities are not. We will assume that airports are, at the very least, commercialised hence interested in minimizing their input costs, including the ATC provision costs.

In terms of air traffic control at airports, terminal control towers provide services from 13 kilometres around the airport to the gate, although remote control centres may be relevant for small airports thus avoiding the need for a tower at every location. A number of airports in the UK, Spain and Germany have tendered terminal air traffic services, including tower control. We will assume that airports are players solely in that they minimize ATC terminal costs which are then passed on to the airlines either directly or through the landing charges.

2.2.4 Airlines

Airlines are the key customers in the air traffic control framework. We will address the activity of commercial air transport solely and assume that military and general aviation is beyond the scope of this research. As with ATC providers, there is variation in ownership form of commercial airlines. While the vast majority of European airlines are privately owned and publicly traded, there are airlines that are semi-private, including TAP Portugal and Czech Airlines, and fully state-owned airlines, such as Air Croatia and LOT Polish Airlines.

There are various business models utilized by commercial airlines. The two major forms are hub-spoke airlines and low cost carriers. While there are additional hybrids of these, the focus of this project is to be on these two models based on the understanding that hub-spoke network carriers are more likely to use the slot-constrained airports across Europe, creating congestion and delays within the ATC sectors whilst low cost carriers, providing more than 30% of traffic [15] across Europe today are more likely to use point-to-point networks utilizing smaller, secondary airports ([6] Dobruszkes (2006) and [13] Gillen and Lall (2004).

The airlines are interested in minimizing their costs which are impacted by ATC charges and the level of congestion. Delays and congestion impact airlines directly by increasing their operating costs including labour and, if incurred en-route, excess fuel burn. In addition, passenger compensation is stipulated by the European Commission, whereby the airlines must compensate the passengers in case of delay. Specifically, food, communications and, if necessary, board must be provided to the passenger if the delay is over two hours. If the flight arrives over three hours later than scheduled, the passenger is entitled to monetary compensation between EUR 250-600, depending on the distance travelled. Additionally, if the delay is over five hours, passengers are entitled to demand a refund.

2.2.5 Passengers

Passengers may be modelled directly or indirectly in the various modelling approaches. If direct, the model would include a utility function involving willingness to pay and cost parameters. The model would then include airfares and frequencies decision variables, enabling the calibration of a market share model. The alternative would be to induce passengers indirectly, assuming a standard load factor and aircraft size thus estimating consumer surplus approximately. Furthermore, we note that passengers may be split according to their value of time, whereby business passengers' willingness to pay is higher than that of leisure passengers.

3 Sources of Input Data

In this section we include all relevant data to be utilized and the sources from which they are available. The most important data sources for this project include:

- The 2015 European ATM Master plan: https://www.atmmasterplan.eu/.
- The Eurocontrol 2015 Standard Inputs for Eurocontrol Cost Benefit Analysis, edition 7.0 https://www.eurocontrol.int/sites/default/files/publication/files/standard-input-for-eurocontrol-cost-benefit-analyses-2015.pdf

The regulatory costs are drawn from the Eurocontrol Annual Report which shows the following for 2014:

2014 budget at a glance

- € 505.8 million cost base, Parts I and IX – DATM, DG/DR, DPS, NMD, and financing
- € 15.5 million, Part II – CRCO
- € 147.2 million, Part III – MUAC
- € 668.5 million total nominal costs

3.1 Demand data

The Demand Data Repository (DDR2) of Eurocontrol provides information on European air traffic flow as well as estimates into the near future. In terms of historic traffic, DDR2 provides information regarding the number of filed flight paths and the 4D trajectory of flights for a particular day. Additionally, utilizing STATFOR as well as flight intention data, DDR2 provides traffic forecasts. The DDR2 website is http://www.eurocontrol.int/ddr. In terms of long term demand, traffic flow by 2035 is estimated to grow by 18-50%, as indicated by the ATM Master plan [20], depending on economic growth. Specifically, 11.2-14.4 million flights are predicted annually.

Figure 1a indicates expected traffic growth according to Eurocontrol from 2012 to 2035 and will provide the basis for estimated demand, and Figure 1b reflects forecasts for 2050 drawn from the Challenges of Growth Report published by Eurocontrol [8]. If passengers are also included in the analysis, we will refer to the PRIMES projections. Air transport is projected to be the highest growing of all passenger transport modes, going up by 133% between 2010 and 2050 (2.1% p.a.), mainly due to the large increase of international trips (e.g. to emerging economies in Asia). Higher potential for air traffic growth (3.1% p.a. for 2010-2050), including for international holiday trips, is expected in the EU12 member states due to their less mature markets and faster growing GDP per capita. Aviation activity in the EU15 would increase at a lower rate compared to EU12 due to weaker growth of GDP per capita and the available capacity at the airports. Overall, air transport is expected to increase its modal share by about 5 percentage points, from 8% in 2010 to 13% in 2050, and become the second most important passenger mode after road transport.

Figure 1a: Eurocontrol IFR Movement Estimates

	IFR Movements(000s)									Traffic Multiple 2035/ 2012
	2009	2010	2011	2012	2019	2020	2025	2030	2035	
A: Global Growth	9,413	9,493	9,784	9,548	12,045	12,485	14,139	15,749	17,338	**1.8**
C: Regulated Growth	.	.	.	.	11,169	11,411	12,561	13,520	14,356	**1.5**
C': Happy Localism	.	.	.	.	11,169	11,338	12,236	13,015	13,769	**1.4**
D: Fragmenting World	.	.	.	.	10,132	10,194	10,612	10,840	11,249	**1.2**

Founding Members

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Figure 1b: Challenges of Growth Scenarios

	IFR Movements (million)			Annual Growth			AAGR 2050/ 2012	Traffic Multiple 2050/ 2012
	2012	2035	2050	2012	2035/ 2012	2050/ 2035		
A: Global Growth	9.5	17.3	26.1	-2.4%	2.6%	2.8%	2.7%	2.7
C: Regulated Growth	-	14.4	18.6	-	1.8%	1.8%	1.8%	2.0
C': Happy Localism	-	13.8	17.7	-	1.6%	1.7%	1.6%	1.9
D: Fragmenting World	-	11.2	10.5	-	0.7%	-0.4%	0.3%	1.1

3.2 Air Traffic Control Data Sources

3.2.1 Financial Data

Past data will be taken from 2002-2014, as these are the years with published financial figures. Financial information will be taken from the ATM Cost Effectiveness (ACE) Benchmarking reports, published annually by the Performance Review Commission [17] of Eurocontrol: http://www.eurocontrol.int/prb/publications. Unless stated otherwise, all financial data will be PPPed into artificial euro currency for 2014[2].

3.2.2 ATC Capacity Data

Historical capacity data for ATC will be obtained from the Performance Review Reports (PRR) published by the PRC of Eurocontrol: http://www.eurocontrol.int/prb/publications. Data pertaining to technology implementation will be as defined by the European 2015 ATM Masterplan [20].

[2] According to the OECD, purchasing power parities (PPPs) are the rates of currency conversion that eliminate the differences in price levels between countries. Per capita volume indices based on PPP converted data reflect only differences in the volume of goods and services produced.

3.2.3 Geographic Data

Data regarding geographical distances will be obtained from the Great Circle Mapper, at http://www.gcmap.com/, while historic flight paths will be taken from DDR2, as indicated above.

3.3 Airline Data

Data regarding the financial aspects of airline activity of private airlines will be provided by the airlines' financial reports. These reports are to be obtained either from the airline website directly or from Thompson Reuters[3]. Costs resulting from delays will be obtained from the University of Westminster 2014 report "European Airline Delay Cost Reference Values" published on the [7] Eurocontrol website.

3.4 Airport data

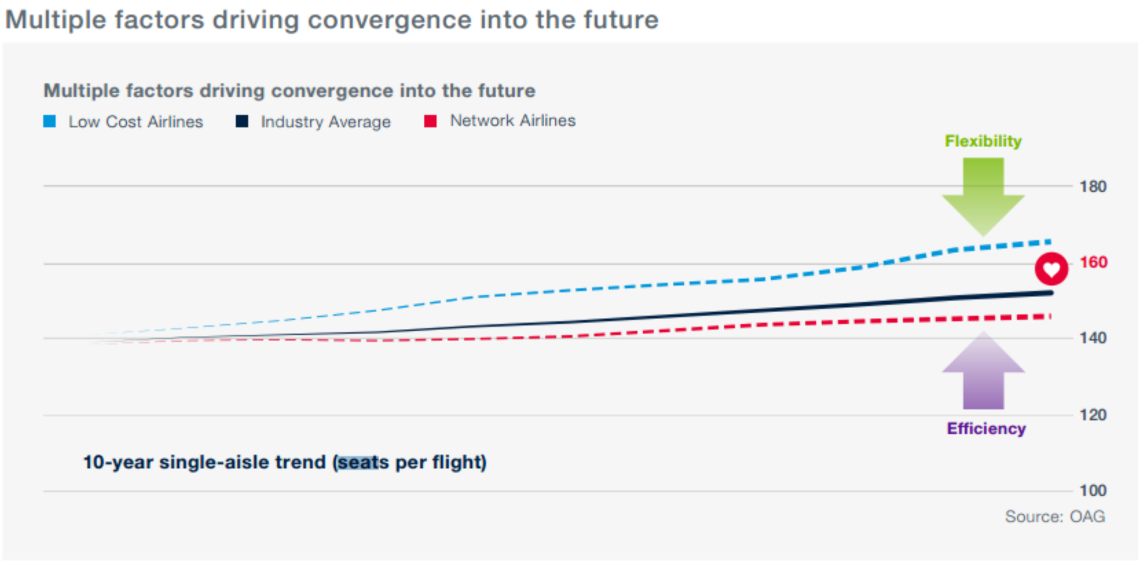
Given the assumptions with respect to airports, we will only need the en-route costs involved with terminal control. This implies that any changes in ATC costs will be fully passed on the airline customers. This assumption is reasonable if the airports are working in a competitive environment, which is true for the major international gateways but may be less accurate for the smaller spoke airports ([21] Starkie (2002)). However, as described by [12] Gillen (2011) airports are two-sided platforms serving both airlines and passengers hence profit maximizing prices depend on the elasticities of demand by customers on both sides of the platform, the nature and magnitude of the indirect network effects between the two groups of customers and the marginal costs for both sides. One of the arguments drawing from this line of reasoning, together with the privatization of the airline sector and subsequent rise of low cost carriers, is that even spoke airports are under pressure due to the change in balance within the aviation supply chain. Finally, we will assume that the airport charges to airlines are regulated where necessary, such that were the terminal ATC costs to decrease, the regulated prices will also be expected to decrease accordingly.

[3] This database is available from the Hebrew University library.

3.5 Passenger Data

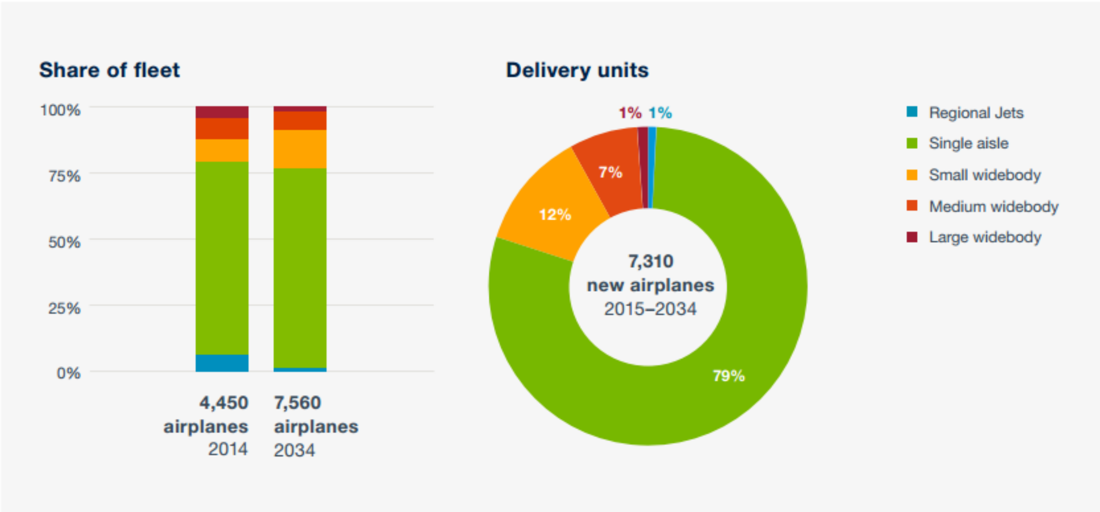
Passenger data to be used is that regarding passengers' value of time. This value is to be obtained from the "Eurocontrol 2015 Standard Inputs for Eurocontrol Cost Benefit Analysis, edition 7.0". According to this report, business passengers' value of time is approximately €42 per hour of delay. Leisure passengers range from €13 to €21, hence we propose to use the average of €17. Based on data from the Boeing Market Outlook 2015-2034, we propose to assume an average aircraft size of 152 seats for flights within Europe today and 160 by 2035 and 297 seats per flight on intercontinental routes which is expected to rise, so we could assume 300 seats by 2035. Assuming an 80% load factor, this means that on average there are 128 passengers on an average narrow-body aircraft within European routes and 240 passengers on inter-continental routes using wide-body aircraft. Finally, we propose to apply an assumption that 30% of revenues draw from business and first class passengers (according to Dr. Brian Pearce, Chief Economist of IATA). This will be relevant for the network rather than low cost carriers.

Figure 2: Seat estimate for narrow-body aircraft in 2034



Source: Boeing Market Outlook 2014-2034

Figure 3: European aircraft fleet estimates for 2034



Source: Boeing Market Outlook 2014-2034

3.6 Additional Data

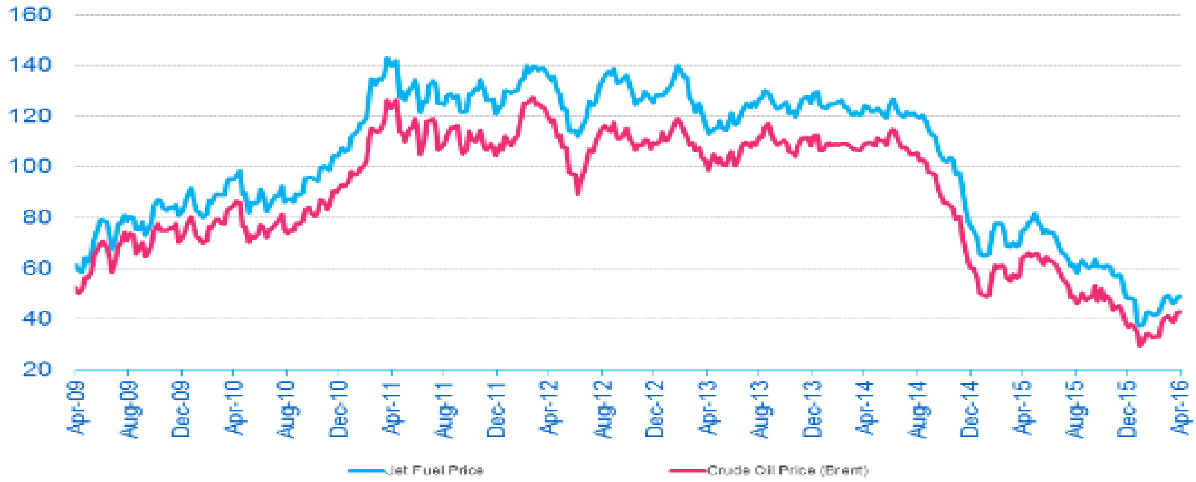
This section refers to fuel cost estimates, environmental cost estimates and delay data respectively.

3.6.1 Fuel

Based on the "Standard Inputs for Eurocontrol Cost Benefit Analysis," the cost of fuel is estimated to be 0.7 €/kilo (equivalent to €116 per barrel). This is based on 2014 data from the IATA website, which provides jet fuel prices analysis for various regions. Sensitivity analyses for this input will need to be undertaken given the fact that the cost may vary substantially by 2035 to 2050 and has ranged from 10 to 40% of the airline operating input prices over the last five years. We suggest testing €40 to €100 a barrel as the potential jet fuel oil price in 2035 according to [1] Aguilera et al. (2009). We will also utilize the PRIMES projections[4] for this purpose.

[4] https://ec.europa.eu/energy/en/news/reference-scenario-energy

Figure 4: Jet fuel and crude oil prices ($/barrel) from 2009 to 2016



Source: Platts, Oanda

3.6.2 Environmental Data

COMPAIR models may attempt to evaluate any changes from the equilibria outcomes in 2035 and 2050 with respect to the value of CO^2 emissions in general, noise charges at airports and additional pollutants using the Ricardo-AEA handbook [18] developed for DG-MOVE: http://ec.europa.eu/transport/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf

3.6.3 Delay Data

Delays are a major economic expense in air transport. According to the 2011 report from the University of Westminster, in collaboration with the Performance Review Unit, the total network cost of ATFM delays across Europe amounted to €1.25 billion in 2010 alone.

Figure 5: European ATFM delay cost estimates in € 2010 (University of Westminster)

Factor	Cost
Network total cost of ATFM delay (all causes)	**1 250 million**
Average cost of delay of an ATFM delayed aircraft	**1 660**
Network average cost of ATFM delay, per minute	**81**

Thus, delay data are an important measure of the quality of the ATC service. Delay data is provided by the Central Office for Delay Analysis ([4] CODA) within Eurocontrol. CODA collects data from a wide variety of sources, and provides past delay information, with regards to delay level (with respect to time), and reason for delay, based on IATA delay codes, specified in the following report:

CODA delay categories: http://www.eurocontrol.int/sites/default/files/content/documents/official-documents/facts-and-figures/coda-reports/iata_delay_sub_code_list_ahm731.pdf

We plan to consider delays categorised as 81 and 82 as being caused by en-route ATC capacity issues and 83, 88 and 89 as being caused by terminal ATC problems, as described in Figure 6.

Figure 6: CODA classifications for delay causes

AIR TRAFFIC FLOW MANAGEMENT RESTRICTIONS

81 (AT)	ATFM due to ATC EN-ROUTE DEMAND/CAPACITY, standard demand/capacity problems
82 (AX)	ATFM due to ATC STAFF/EQUIPMENT EN-ROUTE, reduced capacity caused by industrial action or staff shortage, equipment failure, military exercise or extraordinary demand due to capacity reduction in neighbouring area
83 (AE)	ATFM due to RESTRICTION AT DESTINATION AIRPORT, airport and/or runway closed due to obstruction, industrial action, staff shortage, political unrest, noise abatement, night curfew, special flights
84 (AW)	ATFM due to WEATHER AT DESTINATION

AIRPORT AND GOVERNMENTAL AUTHORITIES

85 (AS)	MANDATORY SECURITY
86 (AG)	IMMIGRATION, CUSTOMS, HEALTH
87 (AF)	AIRPORT FACILITIES, parking stands, ramp congestion, lighting, buildings, gate limitations, etc.
88 (AD)	RESTRICTIONS AT AIRPORT OF DESTINATION, airport and/or runway closed due to obstruction, industrial action, staff shortage, political unrest, noise abatement, night curfew, special flights
89 (AM)	RESTRICTIONS AT AIRPORT OF DEPARTURE WITH OR WITHOUT ATFM RESTRICTIONS, including Air Traffic Services, start-up and pushback, airport and/or runway closed due to obstruction or weather[1], industrial action, staff shortage, political unrest, noise abatement, night curfew, special flights

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