DATASET2050

“Data driven approach for a Seamless Efficient Travelling in 2050”

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Deliverable 4.1

“Current Supply Profile”

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Abstract

The purpose of this document, Deliverable 4.1, is to describe the Current Supply Profile for its further use in different threads by the DATASET2050 Horizon 2020 coordination and support action.

This deliverable comprises the work conducted in order to define and list the door-to-door mobility supply components, as described in task 4.1. It presents the baseline supply situation with respect to current door-to-door trips within Europe, including an assessment, identification and mode of the mobility services currently available in Europe (airport access/egress times, airport processes times etc.) All the above will allow the DATASET2050 project partners to determine the time required to undertake the current processes involved from leaving the place of origin (the "Door") to the point of arrival at the airport (the "Kerb"), from the Kerb to the moment the passenger has had their boarding card scanned immediately prior to embarkation (the "Gate"). The same approach is used for the Gate-to-Gate processes (including connecting flights and the transfer process), and finally Gate-to-Kerb and Kerb-to-Door. The inherent asymmetries of what are, in principle, symmetric processes have been assessed (e.g.: Door-to-Kerb vs. Kerb-to-Door).

D4.1 directly feeds the supply side of the mobility model that will be run in WP5 of DATASET2050.

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1 Introduction

1.1 Introduction to DATASET2050

DATASET2050, "DATA-driven Approach for Seamless Efficient Travelling in 2050", is a Coordination and Support Action (CSA) funded by the European Commission, under H2020 Call MG.1.7-2014 "Support to European Aviation Research and Innovation Policy", Grant Agreement no: 640353. It is coordinated by Innaxis, with EUROCONTROL, the University of Westminster and Bauhaus Luftfahrt as partners. DATASET2050 was launched in December 2014 for 36 Months. The key highlights of DATASET2050 are the following:

- The objective of DATASET2050 is to provide insights into the European door-to-door travel paradigm for the current, 2035 and 2050 transport scenarios, through a data-driven methodology;
- DATASET2050 puts the passenger at the centre, paving the way for a seamless, efficient door-to-door travelling experience. Its main focus is to analyse how the European transport supply profile (capacity, connections, business models, regulations, intermodality, processes, infrastructure) adapts to the demand profile (customers, demographics, passenger expectations, requirements);
- DATASET2050 addresses the main transport mobility goal stated in the EC's FlightPath2050 (EC, 2011): in 2050, 90% of travellers within Europe will be able to complete their journey, door-to-door within 4 hours. Through application of statistical analyses, multi-modal mobility modelling and predictive analytics, DATASET2050 will compute the current status and future prediction of air transport mobility across Europe;
- The analyses will enable the identification of transport bottlenecks in the current scenario and across different future scenarios. These findings will serve as a basis for the development of intermodal transport concepts; identifying possible solutions for current and predicted shortcomings. The insights gained will highlight research needs and requirements towards the four hour door-to-door goal formulated by ACARE. Due to the multi-dimensionality of the problem, DATASET2050 will use visualisation techniques, to ease understanding of the results;
- DATASET2050 partners are supported by an Advisory Board, made up of key European transport stakeholders;
- The dissemination and communication plans ensure efficient circulation of results among key European transport policy makers and stakeholders. The plans also incorporate their valuable input and perspectives, obtained during the project workshops.

1.2 WP4 and deliverables 4.1 and 4.2 in context

The European Commission convened a group of key stakeholders from European aviation to develop a vision for the EU's aviation system and industry in 2050 as a driver for European research and innovation in the field. These goals were set out in Flightpath 2050: the European vision for aviation and Air Transportation in 2050, published in 2011. A key component of the vision is customer centricity, which aims to progressively change the current 'payload' paradigm towards seamless and efficient door-to-door mobility where customer experience is paramount and where air transport is at the heart of an integrated, seamless, diffused intermodal system, capable of transporting travellers and their baggage from door-to-door, safely, affordably, quickly, smoothly and predictably.

The objective of WP4 is to enable a model to be built for the current and future European supply for these journeys. WP5 (fed by WP3 and WP4) will ultimately assess the capability of the EU transport system's interconnectivity, models and processes to identify infrastructural limitations and/or bottlenecks that impede the ability of customers to accomplish their mobility needs in an efficient and timely manner. WP4 runs in parallel to WP3, the first covering the mobility supply side, the second covering the equivalent demand.

The mobility supply side (WP4) will be modelled and assessed in terms of supply-side metrics on mobility, which must meet certain requirements:

- The supply metrics need to be quantitative, and based/calculated on existing datasets and facts for the current mobility paradigm;
- They have to offer enough granularity to assess the supply situation in Europe across different geographical regions and airports;
- The metrics should cover all the different phases of the door-to-door paradigm:
  - Door-to-Kerb: multi-modal, public/private transport;
  - Kerb-to-Gate: includes airport processes, check-in, baggage drop-off, security, immigration and boarding, as well as the initial movement from arrival at the airport to the terminal door;
  - Gate-to-Gate: covers boarding, off-block, taxiing-out, take-off, climbout-cruise-approach, landing, taxiing-in, on-block and disembarkation. This is the "air side" of the process, but it also includes all flight connections and the transfer processes involved in these.
  - Gate-to-Kerb: from arrival at the destination terminal building through luggage reclaim, immigration and customs, to the point of departure from the airport;
  - Kerb-to-Door: multi-modal, public/private transport.
- The metrics should allow later analysis that helps to understand the limitations and bottlenecks, providing information on the phases of flight that are more limiting;
- Finally, the metrics should reflect real requirements coming from operational stakeholders: further usability of these metrics is crucial.

In contrast with the list of requirements, the reality is that some of the datasets about the supply side referred to in D2.1 do not offer enough resolution or coverage to measure the entire passenger mobility in Europe through simple observation. The door-to-door process is complex and involves many different stakeholders who might not collect data on their processes, might not open their dataset up to the public due to its commercial value, might not share their data due to legal/technical constraints, or might store the data in disconnected silos. These data-access challenges are common when assessing the performance of any complex system with a large number of stakeholders and elements involved. Therefore, to allow the assessment of the mobility supply side in Europe in a way that supports policy making, an overall data-driven model needs to be provided, as explained in the current deliverable.

1.3 D4.1 structure

After this Introduction there is a discussion of supply side processes and archetypes in Section 2.

The following three sections cover the door-to-door process. For the sake of simplicity, the processes between points that only differ in their order (e.g. door-to-kerb and kerb-to-door) have been analysed and documented in the same sections of the current document. This way, the inherent similarities and differences are easily listed, avoiding overlapping and duplications. These sections are as follows:

- Door-to-Kerb and Kerb-to-Door are covered in Section 3;
- Kerb-to-Gate and Gate-to-Kerb are covered in Section 4;
- Gate-to-Gate is covered in Section 5.

Finally, Section 6 presents the conclusions.

2 Supply side processes and scope

Following the same approach as that used in the model (D2.2) and in the demand side (D3.1), the door-to-door mobility supply side has been split into the following sub-processes:

- Door-to-Kerb (D2K): Airport access, or simply "access". Door-to-kerb is the portion of the trip in which the passenger moves from the door of the building of their origin (home, office, hotel or any other building unrelated to the trip) to the airport. The airport kerb is understood to be the last position of the means of transport chosen to get to the airport: e.g. metro station exit, car parking space, airport taxi stop;
- Kerb-to-Gate (K2G): The kerb-to-gate process begins when the passenger reaches the "kerb" of the airport (concluding their previous door-to-kerb process) and ends when the passenger passing through the boarding gate door;
- Gate-to-Gate (G2G): The gate-to-gate process covers the time spent by passengers in-between the following events:
    - Crossing the boarding gate of the departure airport (the initial departure airport in the case of a journey with flight connections);
    - Crossing the entry gate of the final arrival airport. This includes when the arrival airport is not the original destination (e.g. leg cancellation, flight re-routing, etc.).

  Flight connections are included in the gate-to-gate process, restricting gate-to-kerb for the very final destination airport.
- Gate-to-Kerb (G2K): This is the phase in which passengers move from the last arrival gate to the "kerb" of the same airport. The kerb is defined as the place where the passenger takes their first egress mode of transport (e.g. train station, long-term car park, car-hire office);
- Kerb-to-Door (K2D): Airport egress or simply "egress". Kerb-to-door is the process in the journey in which the passenger moves from the last airport's "kerb" to the "door" of the building of their destination (home, office, hotel or any other building unrelated to the trip).

Airports are the air mobility supply elements that ultimately define which and where the "kerbs" and the "gates" are. The unique size, geometry, complexity, location, land and air connections are the variables that definitively establish the times spent reaching the kerb and gates. As there are certain technical limits in the door-to-door model computation, the total number of airports covered will be 200. In other words: metrics will be provided for passengers flying to and from any of the top 200 airports of the EU+EFTA[1] countries (see Figure 1). These correspond to the 200 airports with the highest traffic volumes, and in total cover almost 95% of the internal traffic in Europe (2014 Traffic). These 200 airports are given in Table 38 in Appendix 1.

[1] EU+EFTA means the current EU-28 member states plus the four European Free Trade Association countries

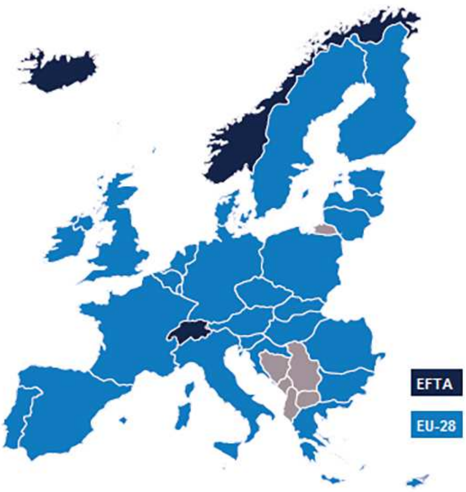


Figure 1: EU-28 and EFTA Countries

Source: adapted from EFTA (2014)

Despite these 200 airports' being the airports that will be assessed in terms of door-to-door metrics, other airports outside EU+EFTA are considered for different reasons:

- From the point of view of congestion: flights either arriving at or departing from these 32 EFTA countries should also be included in some parts of the model, in order to take the "internal" EU congestion they cause into account. For instance, London to Dubai flights cause gate-to-gate congestion in the system when overflying central Europe. Another example, in kerb-to-gate processes, could be Frankfurt to Istanbul passengers who are part of the queuing lines in Frankfurt and lengthening the queues for the kerb-to-gate passengers from Frankfurt to other EU+EFTA destinations.
- The second reason is that we know what the European Union currently is. However, it is almost impossible to predict how the "European Union" will evolve in the medium-to-long term timeframe, due to the socio-political changes of the surrounding countries, added to potential changes in current EU members.

For both reasons, the total list of 200 airports is not exclusive, and can be expanded to the full ECAC area - 44 countries and 600+ airports (see Figure 2) or even further (all worldwide airports sharing origin or destination with a flight arriving in or departing from the ECAC area).

Figure 2: ECAC Area

A list of all 604 ECAC airports is given in Table 39 in Appendix 2.

3 Door to kerb and kerb to door

A passenger's journey to and from an airport is open to myriad options. As already described and documented in Deliverable 2.2, there is an endless list of possibilities that range from walking, to taking a fast train from a city 500km away from the airport. The available options depend on the location of the airport and its proximity, for example, to an intercity rail line, as much as on the passenger's personal choice. They can also depend on the local culture; long-distance coach travel is commonplace in countries like the UK, for instance, whereas it has only very recently become legal within France (i.e. between two French cities) where the railway had previously enjoyed a monopoly. Obviously, access to an intercity rail or coach network greatly increases the catchment area of an airport: there's an over-night coach service from Edinburgh to London Heathrow (some 640km)!

The cost of surface access, combined with the cost of car-parking if a private car is used, will be a factor in the choice of the surface access mode used as much as the time taken. This could depend on the type of journey (business vs. leisure/VFR[2]) being undertaken. The choices taken are not independent - someone who drives to the airport will drive back after their return trip. Similarly, if the outward kerb-to-door journey was by hire car, it is most likely that the return door-to-kerb trip will be by hire car.

Surface access to an airport (door-to-kerb) may be characterised into four principal means of transport, as shown in the following figure:

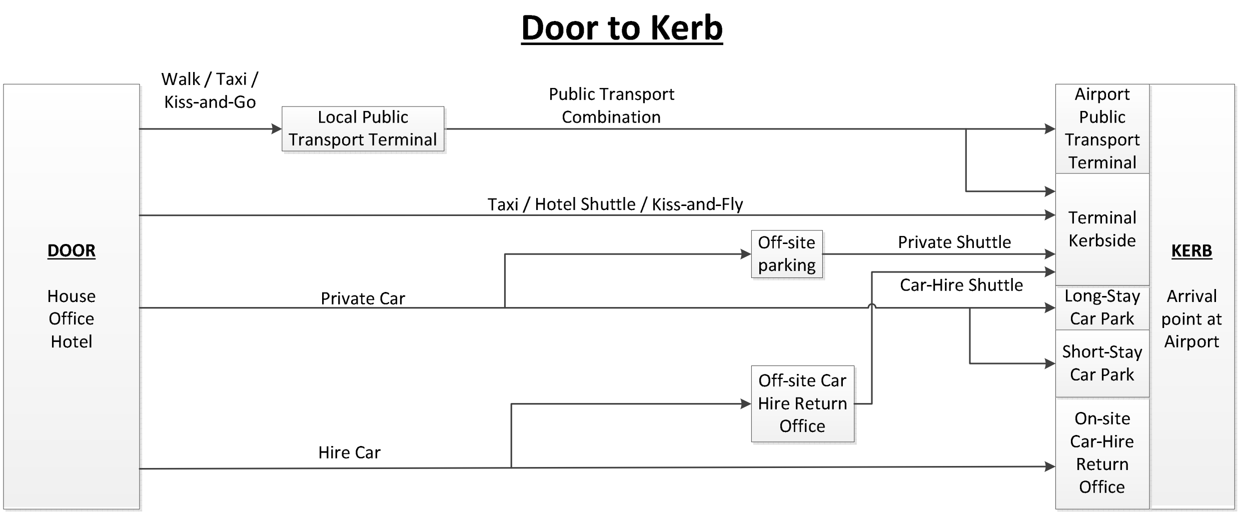


Figure 3: Door-to-kerb process

The kerb is the place where the method of getting to the airport stops at the airport. This may be at the required terminal - the door of the terminal for access by taxi, a shuttle stop at the terminal for access and egress by hotel and car-hire shuttles, designated stops for airport transport, short-stay car-parks, etc. or may be some distance from that terminal - long-stay car parks, car-hire office etc. (The kerb for Kiss-and-Fly is, of course, as close as the driver could possibly get to the terminal door, irrespective of the number of other passengers and road users inconvenienced.)

Note that some airports now offer valet parking which is equivalent to driving a private car to the terminal kerbside (not shown on the above diagram).

"Public Transport Combination" is any succession of public transport services (bus, coach, train, underground, tram) on the understanding that once a passenger has joined the public transport network, they stay on that network until reaching their destination stop/station/terminus.

[2] Visiting Friends and Relatives

There is a strong case for saying that there is no logical difference between an off-site car-hire office and an on-site one (that's not at the terminal door), or between a private off-site car park and a long-stay car park. In fact, some airports' long-stay car parks are off-site anyway.

Egress (or kerb-to-door) may be characterised as the "inverse" of this:

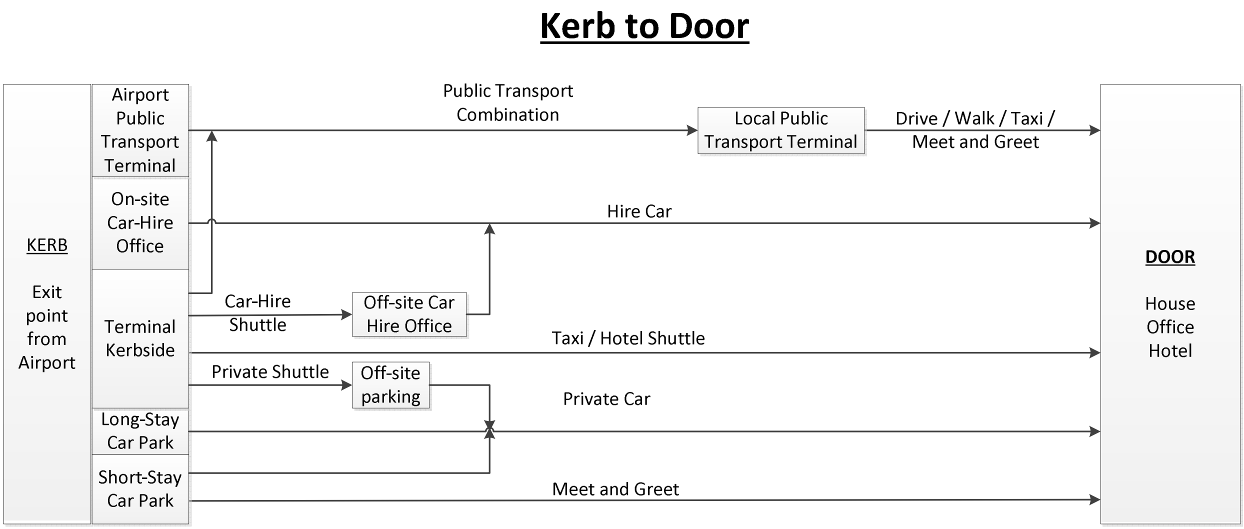


Figure 4: Kerb-to-door process

The process is not however the exact inverse for a number of reasons provoked by asymmetries both in demand and supply:

- Passengers might be more likely to hurry in door-to-kerb processes since they are bound by their flight's departure time which does not apply in the reverse process. Usually kerb-to-door processes are less demanding and more flexible, as passengers are arriving at their destination, especially on inbound flights.
- However, passengers' cost elasticity and comfort requirements may change depending on the stage of the trip [Pels et al., 2003; Loo, 2008, Tsamboulas and Nikoleris, 2008]. For example: both inbound and outbound kerb-to-door processes are performed after the (long, tiring) trip. The value of time [Plötner, 2010] and willingness to finish the trip as quickly as possible increases once the flight/business meeting/tourism experience is accomplished. So, in this context of cost elasticity, comfort and fatigue, passengers are more likely to choose faster (and more expensive) means in those processes.
- The availability of some means of transport is not always the same in door-to-kerb and kerb-to-door processes. For example, public transport might not be as frequent or as desirable in the evening as in the morning.
- Queuing times of some means of transport may differ in door-to-kerb and kerb-to-door processes: queues at airport taxi stop may take more time than simply taking a free taxi on the street, for example.
- For access, the "Kiss-and-Fly" option takes the passenger to the terminal kerb, whereas for egress (kerb-to-door), the Meet-and-Greet option is now mostly obliged to involve the greeter's car's being parked in a short-term car park.
- The Car Hire option is generally used in egress on the outward leg and access on the return leg. Some car-hire offices are located directly at the terminal, so in this case the "shuttle" between the car-hire office and the kerb would be replaced by a "walk".

This section documents information available on D2K and K2D processes for airports within the scope. The choice of approach used in the mobility supply side of the DATASET2050 model has also been documented.

3.1 Airport connections and Airport archetypes: Some examples

The objective of this section is to have a holistic door-to-kerb and kerb-to-door perspective. The main aim is understanding and quantifying how the door-kerb supply side works in the EU. Are there buses connecting LHR with the city centre? How long does a taxi ride take from neighbourhoods surrounding Madrid to Barajas Airport? Which train lines stop at Frankfurt airport? Is there Uber in Paris? Is Warsaw airport connected with Poznan? The reality is that each airport is different and the means of transport available (and usage percentages among them) can vary considerably - an airport may or may not have a train station, a metro link, etc.

The DATASET2050 model needs information about what the "doors" (e.g. houses, hotels, offices) are and how much time it takes to go from the "door" to the airport "kerb" (and vice-versa) as input. This includes first locating trip starting points, quantifying the number of travellers, identifying the means of transport chosen and finally estimating the time spent getting to/from the airport. While the demand side (the passengers) deals with the demography, cost elasticity and behavioural mobility aspects that were studied in WP3, the supply side aspects (airports, means of transport available, times spent etc.) are covered in current deliverable.

In this section the availability of different means of transport has been individually documented and studied at several different airports. Additionally references to some full reports on this topic by UK CAA, French DGAC and German ADV have been added. The raw data displayed has been useful for supporting, calibrating, validating and enhancing the approach described in Section 3.3.

Table 40 in Appendix 3 gives the surface options available for the top 10 airports in the region of Europe within the CSA scope. These are the major European air transport hubs, used between them by around 30% of EU flights and hence deserving individual and detailed analysis. If other airports serve these cities, these are mentioned in the table.

The remaining European airports are all small to medium size. These have been either analysed individually when data are available or directly merged into airport archetypes.

Table 41 gives the same for a selection of 5 smaller airports. The rationale for this is that sometimes individual airport data - especially for those airports ranked 100 to 200 (all of them with less than 0.12% of EU traffic) - are not available and/or not accurate and as such would risk reaching meaningless and insignificant results in the context of the full door-do-door metrics.

The airports classified into archetypes have been divided into:

- **Medium-size regional airports:** those in the top 10-100 with no individual data and no seasonal component
- **Large to Medium-size summer-seasonal airports:** those in the top 10-100 with no individual data but with a seasonal component
- **Small regional airports:** those in the top 100-200 with no individual data and no seasonal component
- **Small-size summer-season airports:** those in the top 100-200 with no individual data but with a seasonal component.

3.1.1 Some examples (UK CAA, French DGAC, German ADV)

For the sake of completion, some full reports and analysis on how the access/egress process is done have been reviewed. Despite only giving results for specific areas/airports, they have been useful for calibrating and validating the data obtained by other means.

UK

The UK CAA has analysed this topic in great detail, with some 30 specific modes of transport available to respondents, for 11 English airports (5 London and 6 provincial). Although the cost of obtaining these complete data is beyond the available budget for this project, the publicly-available summary report (CAA, 2014) provides the following:

Table 1: Surface access modes to UK airports

	Gatwick	Heathrow	London City	Luton	Stansted	Birmingham	Doncaster	East Midlands	Leeds Bradford	Liverpool	Manchester
Private %	58.3	58.6	52.9	70.9	48.5	76.5	90.8	92.4	88.5	79.3	83.5
Public %	41.4	41.1	46.3	28.8	49.6	22.7	9.0	7.4	11.3	20.4	16.2
Other %	0.2	0.3	0.8	0.3	1.9	0.9	0.2	0.3	0.1	0.3	0.2
Terminating passengers (000's)	34,994	46,991	3,533	10,186	18,855	8,976	714	4,374	2,879	3,752	20,830

These results are based on a departure survey only. The assumption, for weighting purposes, is that arriving and departing passengers share the same modal characteristics.

Heathrow has performed its own study and has included the following data in its 5-year Public-Transport plan (Heathrow, 2015):

Table 2: Heathrow surface access modes

Transport	Usage	Comments
Private Car	26.4%	
Hire Care	2.8%	
Taxi/Minicab	29.4%	
Bus/Coach	12.7%	41.1% Public transport (18.4m journeys)
Metro	18.3%	
Rail	10.1%	
Other	0.3%	

Unfortunately, these data are said to include approximately 13,000 staff working at the airport (13,000 x 2 x ~240 working days = ~6.24m journeys) as well as passengers. However, if 41.1% of journeys = 18.4m, 100% = 44.8m c.f. 47m passengers terminating at Heathrow stated in the CAA survey above. The Heathrow public transport plan also states that "[O]ver 220,000 coaches leav[e] Heathrow every year". However, "more than 25% of our coach passengers" are non-airport traffic (i.e. they use the terminal as a ground-transport hub).

France

The French DGAC has also studied surface access in their 2014-2015 airport passenger survey (DGAC, 2015), covering 15 airports. Unfortunately, these data have been aggregated over all 15 airports. The result of 33,655 responses by non-transfer passengers to the question of how people arrived at the airport is given here:

Table 3: French airport surface access modes

Transport	Usage	
Kiss-and-Fly	28%	43% Dropped off at kerb by another person
Taxi	17%	
Personal car	14%	15% in car parked at airport car park
With another passenger (in their personal car)	1%	
Hire car	4%	
Hotel or other Shuttle	4%	
Local public transport	28%	
Intercity train	5%	
Other	2%	

These data are wildly different in structure from the Heathrow data. Heathrow combines Kiss-and-Fly with Personal Car and they only have one entry for Bus/Coach although Bus is Local Public Transport (as is Metro) and Coach is Long Distance Public Transport (as is Intercity Train). However, Inter-France coach lines did not exist in France before 2015. The only train connection to Heathrow is local - Heathrow Express or Heathrow Connect to London Paddington.

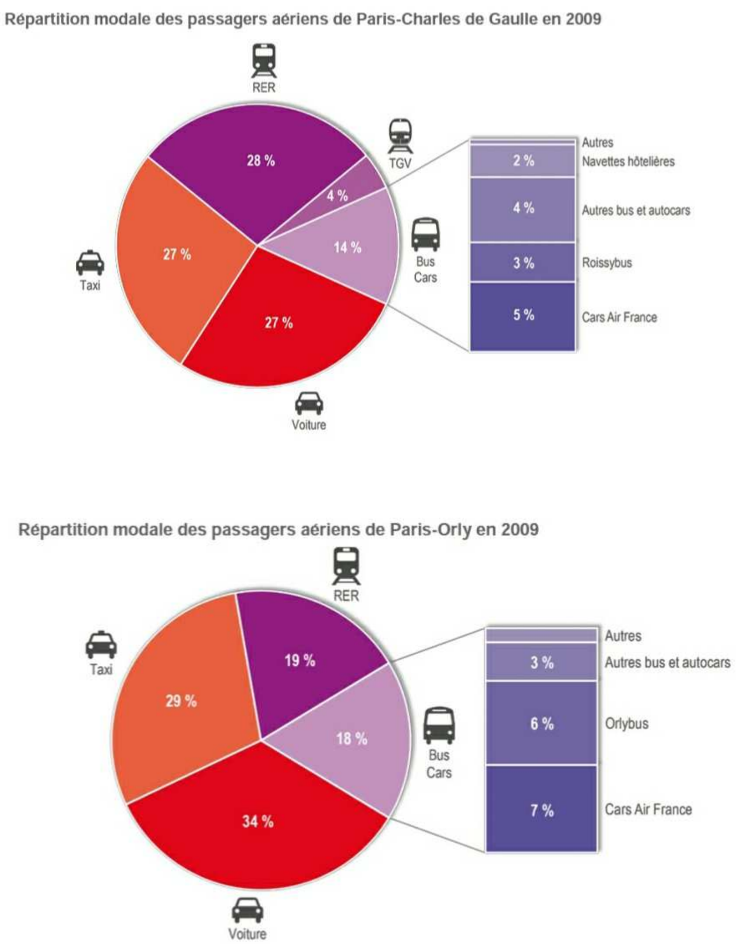


Figure 5: Share of Paris airport surface access modes

Specifically for Paris CDG and Orly, a study by the Institut d'Aménagement et d'Urbanisme-Île de France (IAU-IDF, 2016(1&2)) provides the diagrams of mode share at these two airports repeated in Figure 5 and the following diagrams in Figure 6 showing the average journey times to Paris from these airports by the different modes, together with their average cost. (The "Navigo" ticket shows that these are incorporated into the Paris transport ticketing system.)

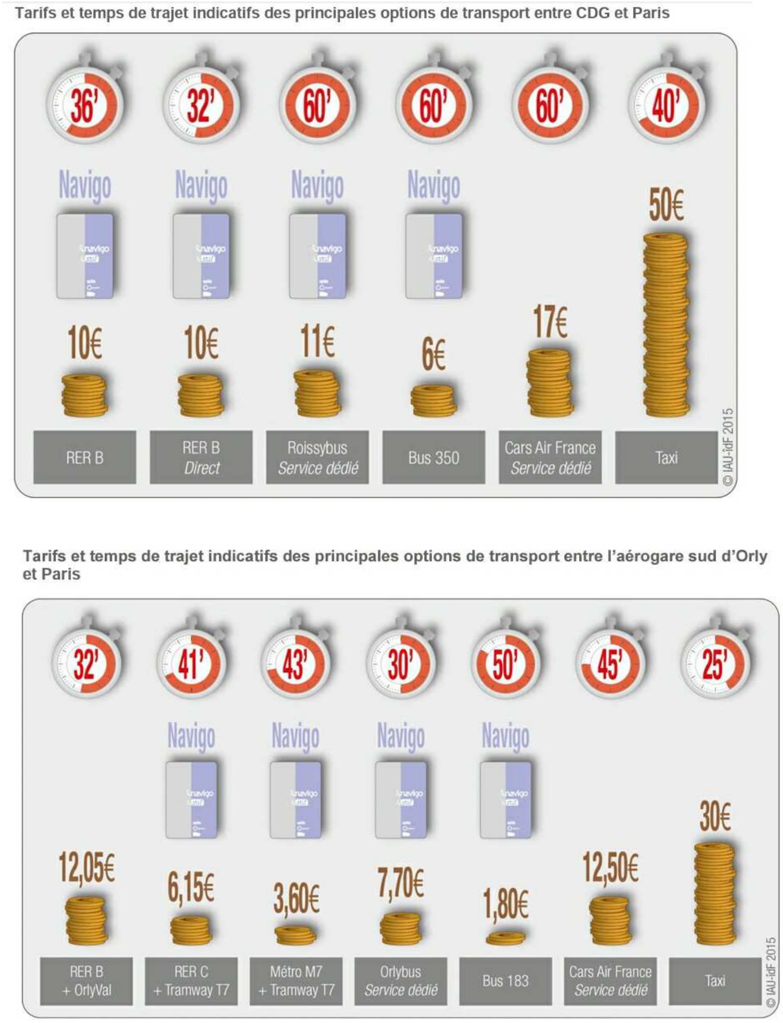


Figure 6: Journey times and costs of different surface access options between the centre of Paris and CDG/Orly airports

It should be noted here that in French, "car" or "autocar" means "coach", whereas "voiture" means private car; "RER" is the rapid suburban train network - there is no underground/metro connection to either airport; "Navettes Hôtelières" are hotel shuttles.

Germany

The German Airports Group (ADV) also performs passenger surveys. The latest "Airport Travel Survey 2015" (ADV, 2015) includes summary data on the modes of transport used by (all) passengers to access one of the 22 airports in the study:

Table 4: Surface access mode share for 22 German airports

Transport	Usage
Private car (including kiss-and-fly)	44%
Taxi	21%
Metro/U-Bahn	16%
Bus (including coach)	8%
Rail	6%
Rental Car and Other	5%

The "2008 Airport Travel Survey" (ADV, 2008) quoted in "Airport Accessibility in Europe" (Grimme et al., 2010) breaks this down further:

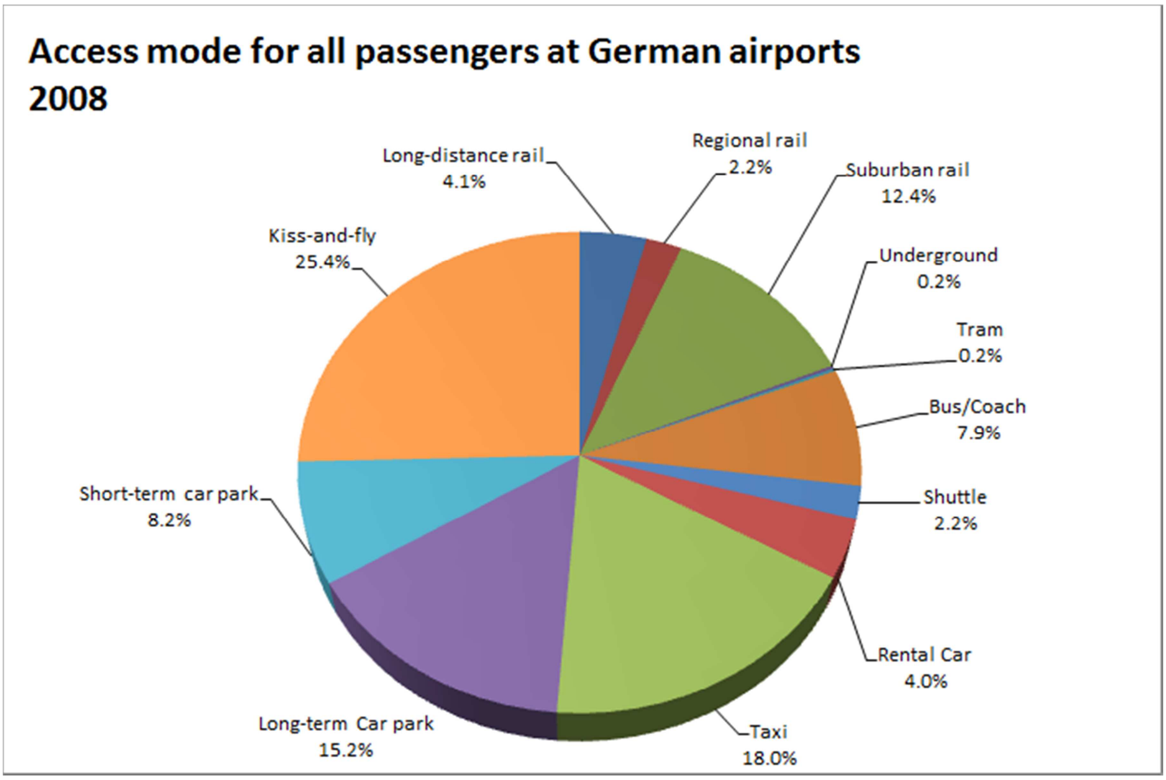


Figure 7: Surface access mode share for German airports

(Grimme et al., 2010) also presents the percentage share of travellers from certain urban areas using long-distance trains, again taken from (ADV, 2008). The journey times from the table of major airport access methods above are repeated here for information.

Table 5: Long-distance train access to Frankfurt airport

Urban Area	Share of passengers using long-distance trains	Distance to Frankfurt airport (km)	Average train time to airport (h)	Average train speed (km/h)	Drive time without traffic (h)	Published flight time (h)	Drive/ Train time ratio
Cologne	68%	180	0:52	207.69	1:38		1.88
Dusseldorf	70%	220	1:22	160.98	2:02		1.49
Stuttgart	50%	205	1:52	109.82	1:49		0.97
Dortmund	57%	225	2:16	99.26	2:04		0.91
Nuremburg	44%	225	2:24	93.75	2:07		0.88
Hannover	68%	350	3:05	113.51	3:10		1.03
Leipzig	82%	385	3:30	110.00	3:18	0:55	0.94
Munich	66%	390	3:50	101.74	3:35	1:00	0.93
Hamburg	83%	495	4:03	122.22	4:18	1:10	1.06
Berlin	36%	545	4:30	121.11	4:45	0:55	1.06
Bremen	57%	445	4:31	98.52	4:03	1:00	0.90

Grimme considers that "Especially on longer distances, the train is preferred by travellers in comparison to the car". This could be because passengers can take connecting flights from a nearer airport. However, the following figure shows that, from the above German data, there is no significant relation between the proportions of train travellers and the distance travelled. The same has been found for train journey time.

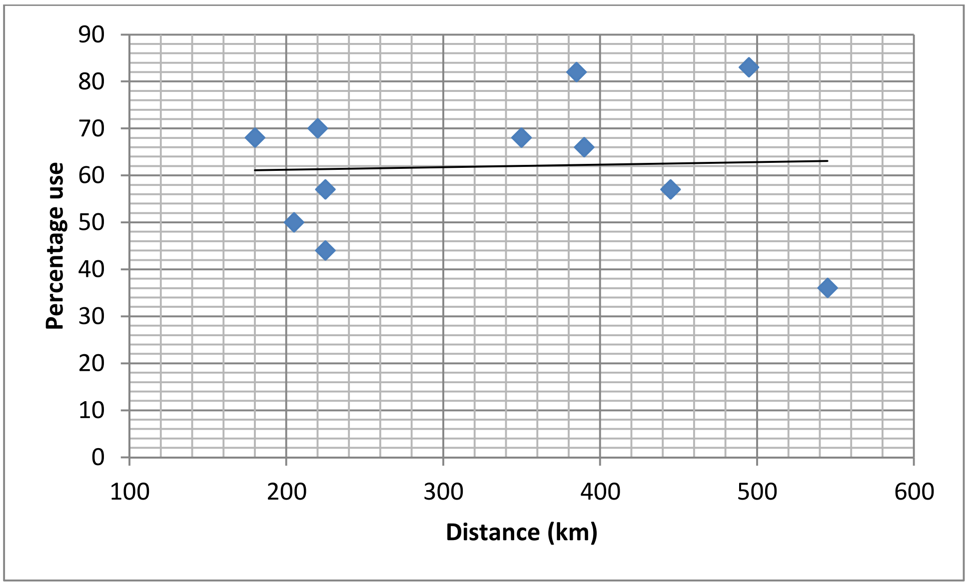


Figure 8: Comparison of percentage use of long-distance trains to Frankfurt airport to distance travelled

A slight relationship can be seen between the ratio of drive time to train time and the propensity to take the train, although the spread of data when drive-time and train time are near equivalent makes the trend line highly unreliable:

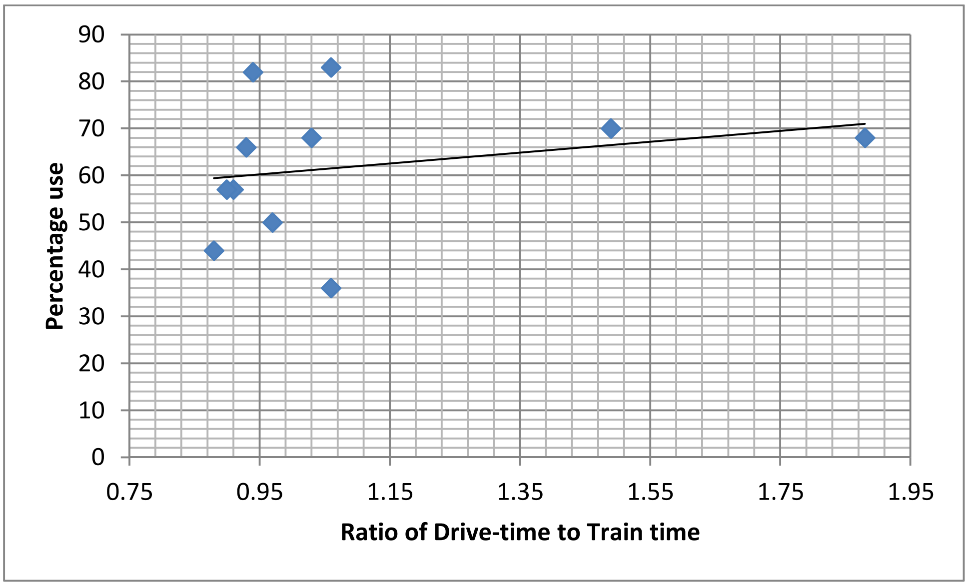


Figure 9: Comparison of percentage use of long-distance trains to Frankfurt airport vs. drive-time:train-time ratio

These data must, however, be taken in the context of only 4.1% of passengers at German airports using long-distance rail for access - though no specific value is given for Frankfurt. Again, no distinction is made between passengers flying to European destinations and those flying further afield.

Ireland

Surveys have also been undertaken at smaller airports.

Table 6: Surface access mode share at Dublin airport

Mode at Dublin	Usage	
Kiss-and-fly	21.15%	Total car 40%
Parked car	12.89%	
Rental car	5.11%	
Undefined car	0.87%	
Dublin Bus	5.27%	Total Bus/Coach 33%
Other bus/coach	23.71%	
Shuttle	3.95%	
Taxi	24.48%	
Other	2.55%	

In 2011, the Irish National Transport Authority undertook a survey of passengers departing from Dublin airport [NTA, 2011]. Among the information available in the report on this survey are the mode of travel and reason for this mode, as shown in Table 6 and Figure 10.

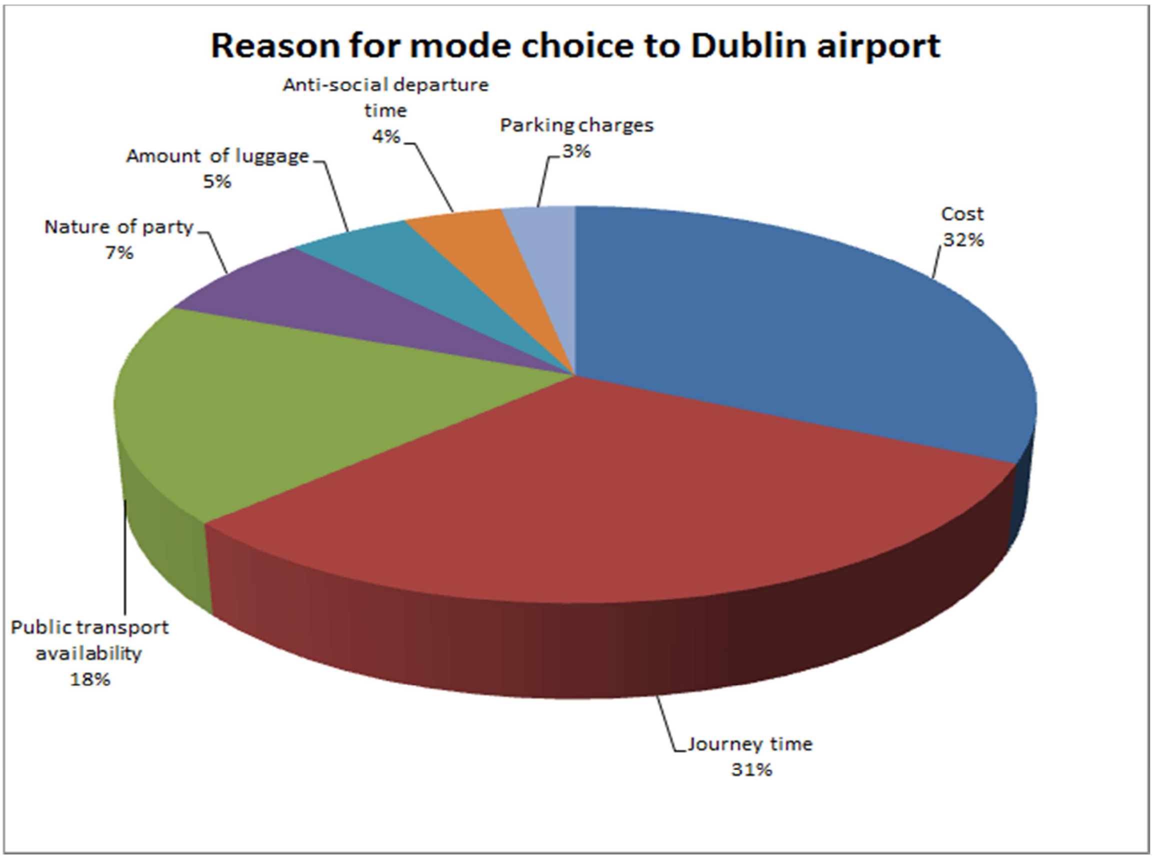


Figure 10: Reason for surface access mode choice at Dublin airport

Of those who parked a car, their car parks of choice were as follows:

Table 7: Car park choice at Dublin airport

Car park	Usage
Long-term	44%
Short-term	25%
Private off-site	17%
Hotel	7%
Other	7%

The stated journey time to the airport given in Table 8 coincides well with the origins of passenger given in Table 9.

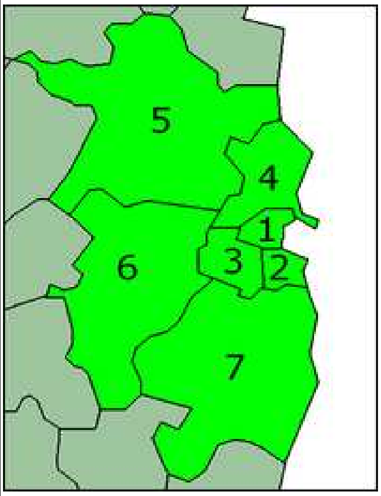
Table 8: Stated journey time to Dublin airport

Journey time	Usage
<= 30 mins	46%
30-60 mins	28%
60-90 mins	8%
90-120 mins	6%
>120 mins	12%

Table 9: Dublin airport passenger origins

Origin	%age
Dublin City	43%
Rest of Dublin County	26%
Rest of Greater Dublin Area	10%
Outside Greater Dublin Area	22%

Furthermore, 24% of passengers came from the central area of Dublin City. These areas can be seen on the map below [from Wikipedia: Greater Dublin Area]



Greater Dublin Area

1. Dublin city
2. Dún Laoghaire–Rathdown
3. South Dublin
4. Fingal
5. Meath
6. Kildare
7. Wicklow

Dublin County = 1,2,3 & 4

Figure 11: The Greater Dublin area

Once again, there is no information relating passenger journey time to destination (intra or extra Europe). 33% of passengers carried no (checked-in?) luggage.

3.2 Catchment areas and Airports feeders

There are two possible approaches when trying to link airports and the locations that each passenger is coming from:

- The first option is the **"catchment area"** concept: airport catchment areas are geographical regions, one per airport. In principle all the potential passengers from that area (inhabitants, tourists, business travellers, etc.) would use that airport when taking a flight. There are some issues (especially for cities with several airports) but these can generally be solved. Using this approach the starting point of the trip (the "door") is known, so catchment areas automatically establish the airport and its "kerb".
- The second option is the complementary one: **"airport feeders".** Here the departure airport is fixed, and where each passenger is coming from is inferred from this: the locations ("doors") feeding the airport ("kerb") are discovered.

There are pros and cons to both approaches. Both of them are documented in the present section for the sake of completeness and they give rise to two possibilities for calculating of access/egress times. The rationale of the choice of the preferred option is given at the end of the current section.

3.2.1 Catchment areas

Catchment areas are the geographical locations from which an airport attracts potential travellers. These travellers would usually use this airport's services as part of any potential door-to-door travel. As already outlined in deliverable D2.2, catchment areas ultimately depend on "balancing" mobility demands (demography, tourism, business activity, passenger profiling, cost elasticity) and mobility supply (means of transport available per area, duration, frequency).

The boundaries of catchment areas are more or less clear for those regions with a single (international) airport. Catchment areas can be simply defined based on the distance to the airport. The distance (to be strict: time-based distance) is measured in terms of travel time spent in the door-to-kerb process, which ultimately depends on the mode of transport chosen.

However, some major European cities are served by several airports (e.g. London: Heathrow, Gatwick, Luton, Stansted, City), hence, the simplified catchment area concept cannot be applied directly. For these cases, a generalised catchment area approach should be used, taking into account several variables (distance, time, cost, comfort). The catchment areas are found by calculating the minimum norm of the vector for each case. For instance, Luton may be preferred by low-cost tourists flying easyJet but who live in south-east London neighbourhoods (physically closer to Gatwick).

Table 10: Populations (millions) within different minutes of drive time from given airports

Airport	30	60	90	120	180
Madrid Barajas	5.8	7.0		7.8	
Barcelona El Prat	4.2	5.7		7.3	
Munich		4.1		11.2	26.0
Lisbon				>5.0	
Nice	1.0			>8.0	
Warsaw					13.0
Budapest		3.0	4.3	6.0	13.0

A similar case is experienced by those travellers who, despite being within the catchment area of "Airport1", ultimately choose "Airport2". This could be the case where the final destination cannot be reached by a direct flight from "Airport1", but there are direct flights available from "Airport2". Some travellers may prefer to extend the door-to-kerb phase in order to have a shorter gate-to-gate phase, especially if this avoids connecting flights.

Example catchment areas, in terms of population (millions) within 30, 60, 90 and 120 minute car journeys are given in Table 10 (compiled by the authors from airport web sites).

Some airports publish maps of their catchment areas. Those of the airports listed in Table 10 are given here:

Figure 12: Madrid and Barcelona 30, 60 and 120 minute drive time

Figure 13: Munich 60, 120 and 180 minute drive time

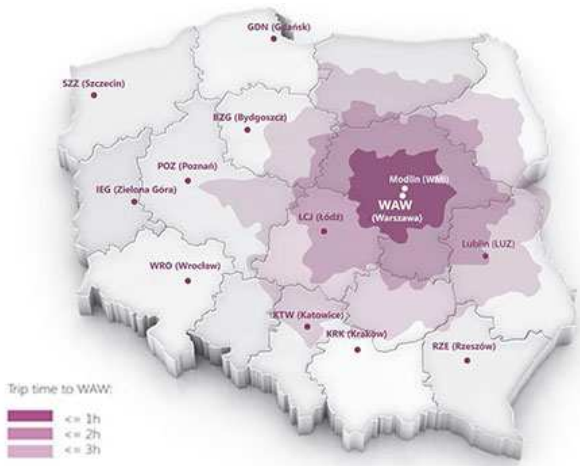


Figure 14: Warsaw 60, 120 and 180 minute drive time

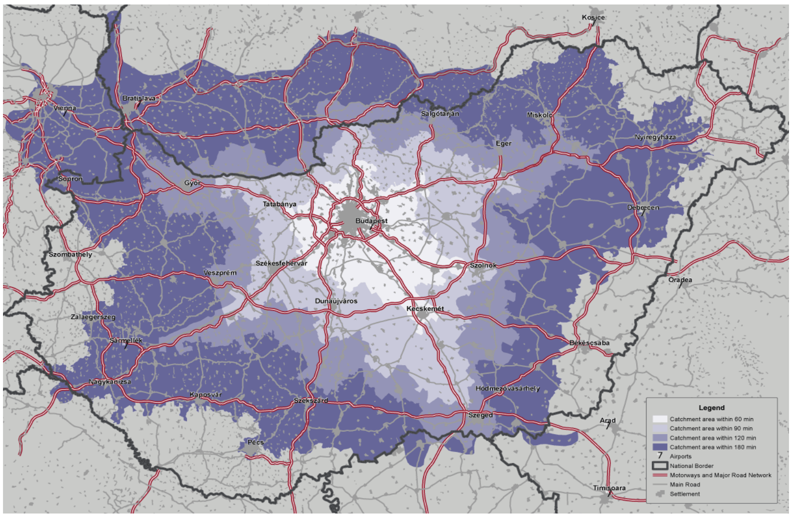


Figure 15: Budapest 60, 90 120 and 180 minute drive time

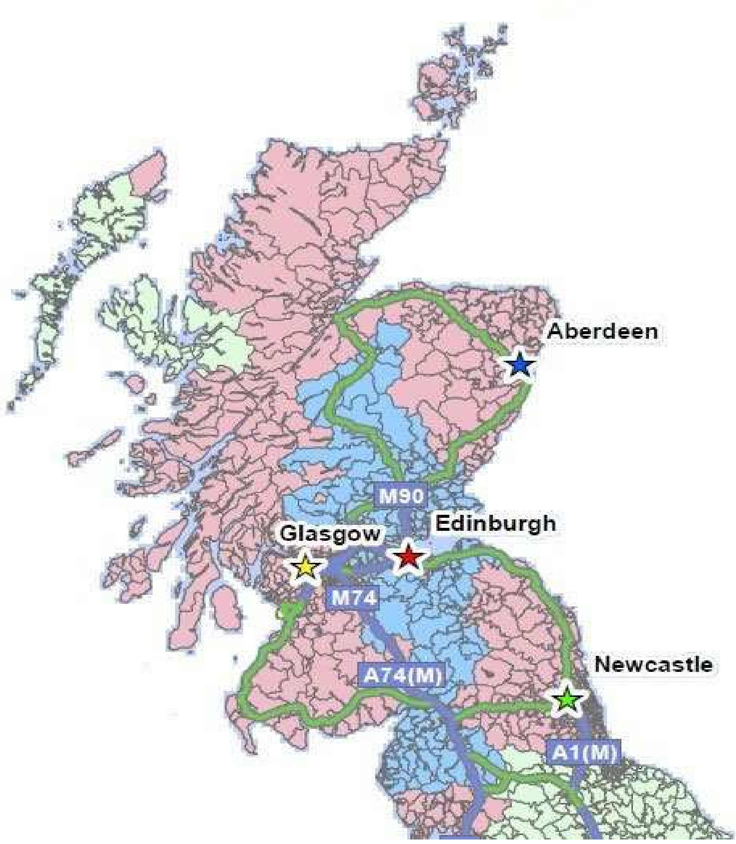


Figure 16: Catchment area of Edinburgh and other north-UK airports.

The blue region is the area closer to Edinburgh than other major airports in terms of driving time.

3.2.2 Airport feeders

The second option is the airport feeder approach: fixing the departure airport, and then identifying/calculating/forecasting where each traveller is coming from. It is important to not fall into the trap of focusing too strictly on the catchment area concept (even in the generalised catchment area version), as there are many cons associated, as described below.

Table 42 in Appendix 4 from (CAA 2014) shows the actual UK NUTS1 regions that passengers originating or departing from each of the 11 airports came from. The region local to the airport has been further broken down into the former English counties (not NUTS2). Table 11 summarises the percentage of airport passengers who come from the major county in their own (Home) region:

Table 11: Percentage of airport passengers who come from the major county in their "Home" region

Airport	Terminating Pax 000s	Home County/ counties	Home Region	% from Home County	% from Home Region
Heathrow	47,317	Greater London	South East	52.68	76.00
Gatwick	35,228	Greater London	South East	42.48	79.70
Manchester	20,938	Greater Manchester	North West	31.15	61.00
Stansted	19,096	Greater London	South East	52.91	60.90
Luton	10,237	Greater London	South East	35.22	51.60
Birmingham	9,029	West Midlands	West Midlands	38.96	66.10
East Midlands	4,441	Derby, Notts, Leics*	East Midlands	53.60	62.50
Liverpool	3,840	Merseyside	North West	42.11	78.98
London City	3,561	Greater London	South East	85.85	91.83
Leeds Bradford	2,970	West Yorkshire	Yorkshire & the Humber	52.79	86.10
Doncaster	722	South Yorkshire	Yorkshire & the Humber	30.47	73.50
			Minimum	30.47	51.60
			Maximum	85.85	91.83
			Average	47.11	71.66

The number of passengers, however, is probably not the best indicator of a catchment area. As can be seen from Figure 17, the number of airport accesses/egresses per head of population may be more explicit.

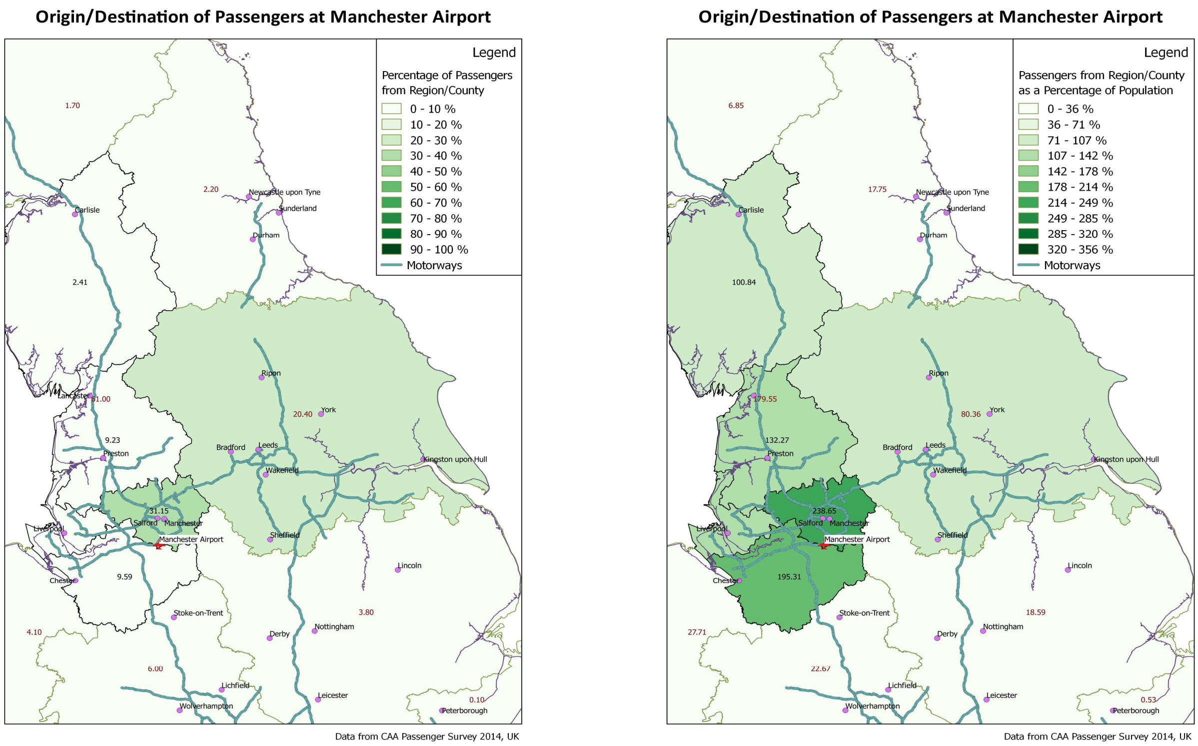


Figure 17: Airport passenger share by region and by percentage of population

It could be imagined that a larger airport would have a greater catchment area, and thus a lower proportion of passengers from its "home" zones, than a small, "local" one. As can be seen from the two figures below, this is not particularly borne out by the data.

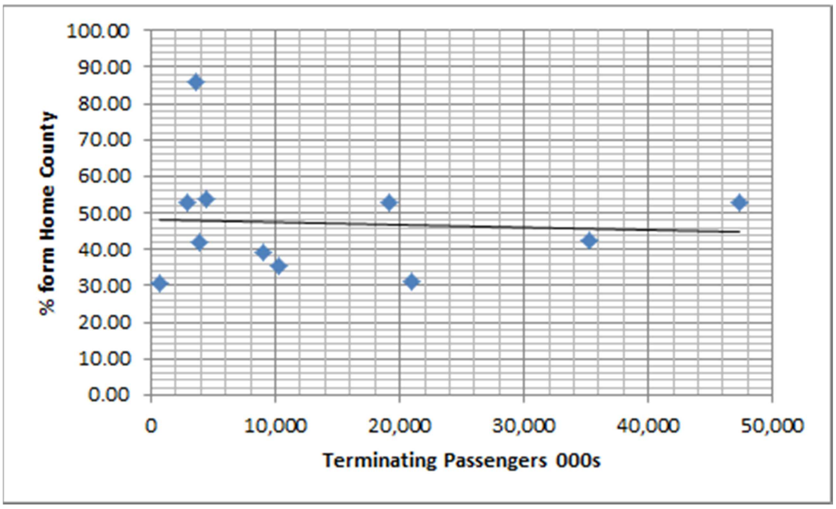


Figure 18: Percentage of terminating passengers from airport's home county

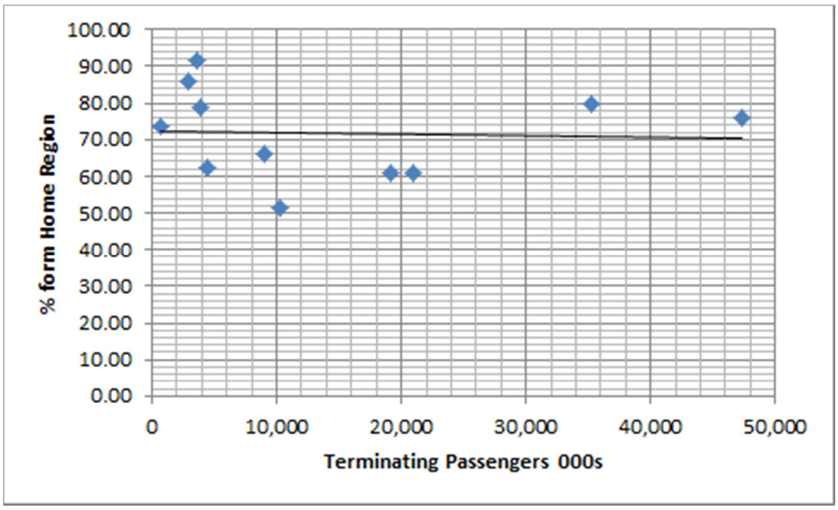


Figure 19: Percentage terminating passengers from airport's home region

In fact Gatwick Airport's Surface Access Plan (Gatwick 2011) explains why people choose that airport over others. Location and surface access is the reason for only 35% of passengers.

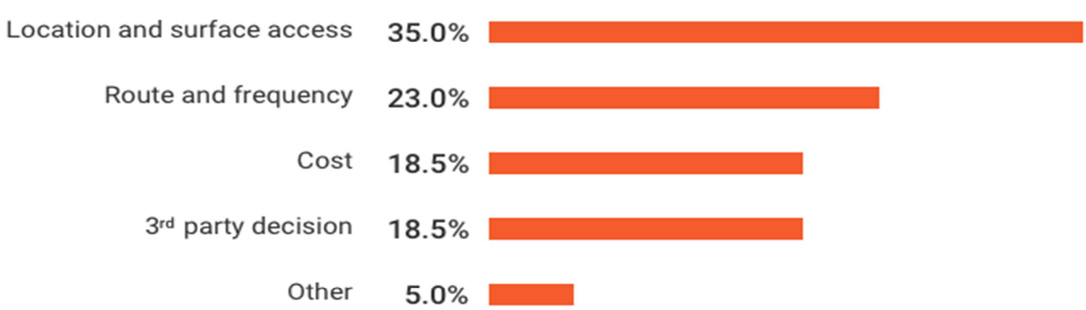


Figure 20: Factors affecting air passengers' choice of Gatwick airport

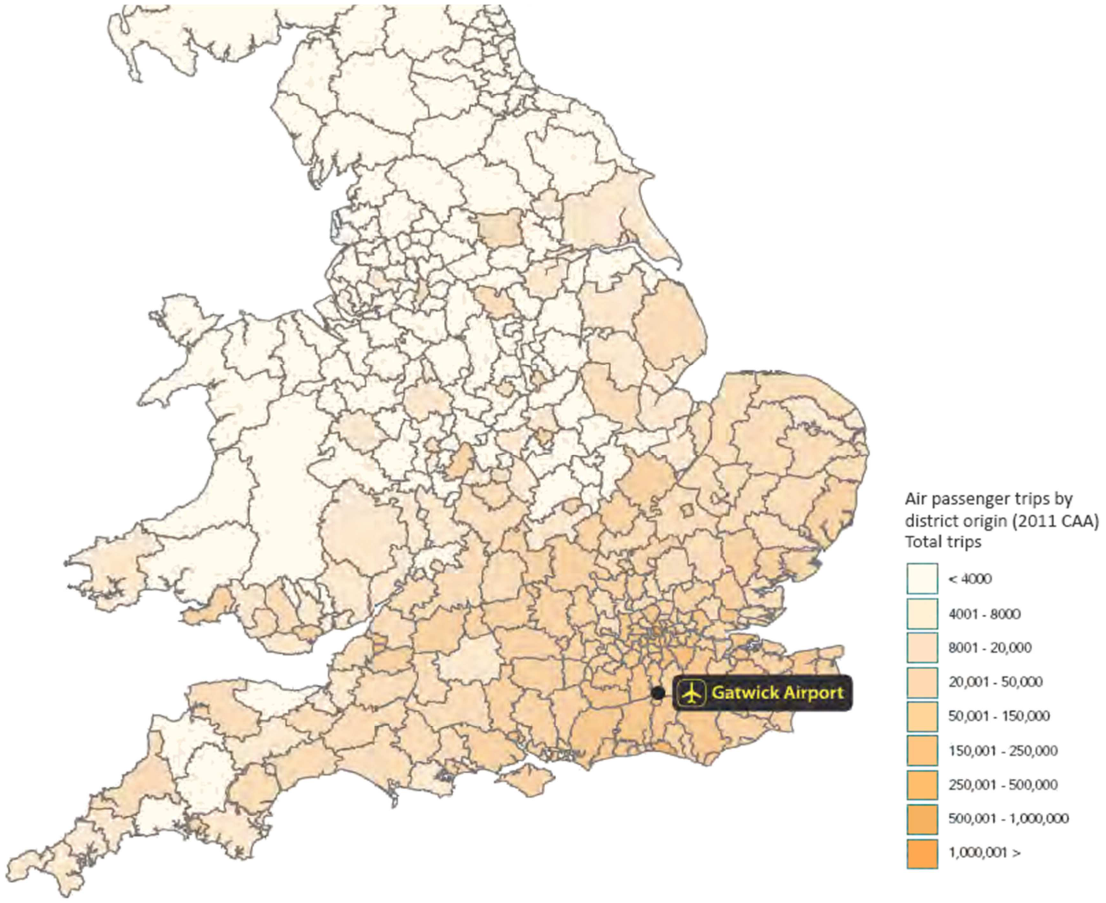


Figure 21: Origin of passengers at Gatwick Airport

Unfortunately, the available data (here from the UK CAA, but also from other sources) do not break the passengers using the airport down into European or International destinations. It is difficult to use the airport feeder method for determining the catchment area of passengers whose destination is in the scope of this project. The map in Figure 21 shows that passengers from the very south-west of England and west Wales fly from Gatwick. But how many of these are likely to spend hours getting to this airport for a short European trip, especially when there are services to many European destinations from Plymouth, Exeter, Cardiff, Bristol, Bournemouth and Southampton, which are closer than Gatwick?

3.3 Access and egress process times

In parallel to what was explained in the previous section, there are two ways of calculating airports access and egress times (door-to-gate and gate-to-door metrics). This section explains both while including an assessment of London and Berlin case studies, including door-to-kerb patterns, duration, private car/public transport usage etc.

Table 12: Two approaches for analysing access/egress times

Approach	Starting element	Algorithm estimates	Access and egress time calculations	Case study
Catchment area	Passenger location	Departing airport	**Possibility A**: city-centred times	London airports
Airport feeders	Departing airport	Passenger location	**Possibility B**: airport-centred time	Berlin airport

The following two sub-sections present two varying methods of producing airport access/egress times, where the first is city-/passenger-focused ("catchment area" approach) and the latter airport-focused ("airport feeders" approach). The first one has been applied on London airports, and the latter to Berlin. Both possibilities are based on geolocation requests/queries and enable an estimation of airport access/egress times from any address to any airport's kerb (or vice-versa).

For both cases distances and travel durations for different transport modes can be retrieved:

1. driving - private cars, rental cars, Uber, limousine, kiss-and-fly;
2. public transport:
   - bus
   - train
   - tram
   - metro/underground
   - any combination of these
3. cycling;
4. walking.

3.3.1 Possibility A: City-centred airport access/egress times

City-centred travel distances and times to airports start with a defined city centre, a maximum range from the city centre, and a node distance. From the city centre outwards, the area within the maximum range from the city centre is filled with nodes - each separated by the defined node distance - from each of which the distance and time to predefined airports is retrieved. With this method, multiple airports can be assessed for a single city at the same time, with the possibility of later allocating potential travellers either by shortest distance or by shortest access/egress time. A few comments are necessary regarding the preliminary case study:

- It is population-centred. This is not fully realistic, since 50% of travellers (those on the return leg) do not start/end their trip in their home. Additionally, the model population density needs to be multiplied by "propensity to travel by air to another part of Europe". As this depends on the demand supply profile, an in-depth analysis is out of scope here, and will be further documented in D5.1. Hence, a population-centred approach was considered an interesting starting point for the door-to-kerb time calculations.
- The grid of nodes can be used to interpolate results and create city maps (as shown below). However, this requires an immense amount of data access, which is sometimes technically challenging and can also be expensive (if using the Google API for instance).

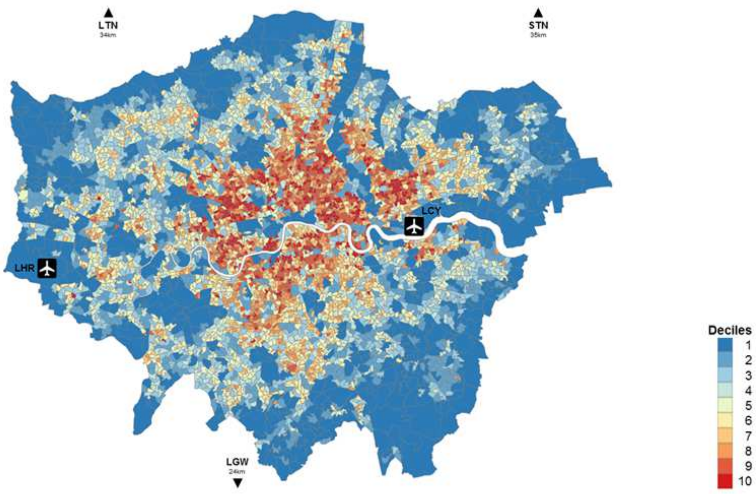


Figure 22: Greater London population density

Info: Population 8,538,689
Source: data.london.gov.uk/dataset/lsoa-atlas, Map created using QGIS

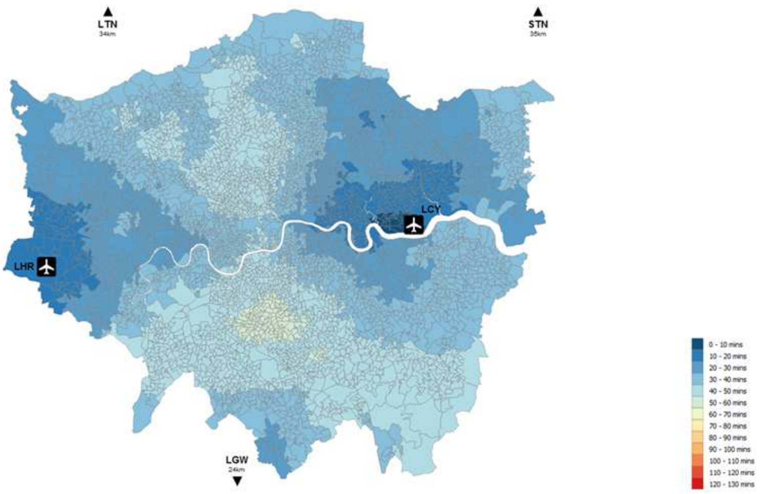


Figure 23: Greater London - airport access time duration by private car

Info: Map created via interpolation of 18,915 query points
Source: Trip durations via Google Maps Distance Matrix API, Map created using QGIS

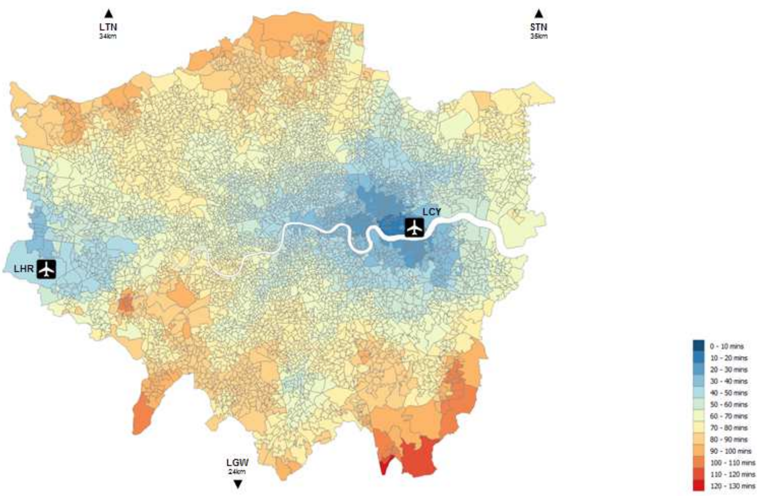


Figure 24: Greater London - airport access time duration by public transport

Info: Map created via interpolation of 18,852 query points
Source: Trip durations via Google Maps Distance Matrix API, Map created using QGIS

Average times through weighting population

Overlaying the retrieved travel duration maps with a population map allows travel duration to be weighted by population and to derive averages, such as:

- Average private car trip length 33.29 minutes (weighted by population).
- Average public transport trip length 61.95 minutes (weighted by population).

Average times by request time

For creating distance-independent benchmarks, the travel speed can be derived and plotted for each request time. Additionally, time of day or weekday averages can be derived (as shown in Figure 25).

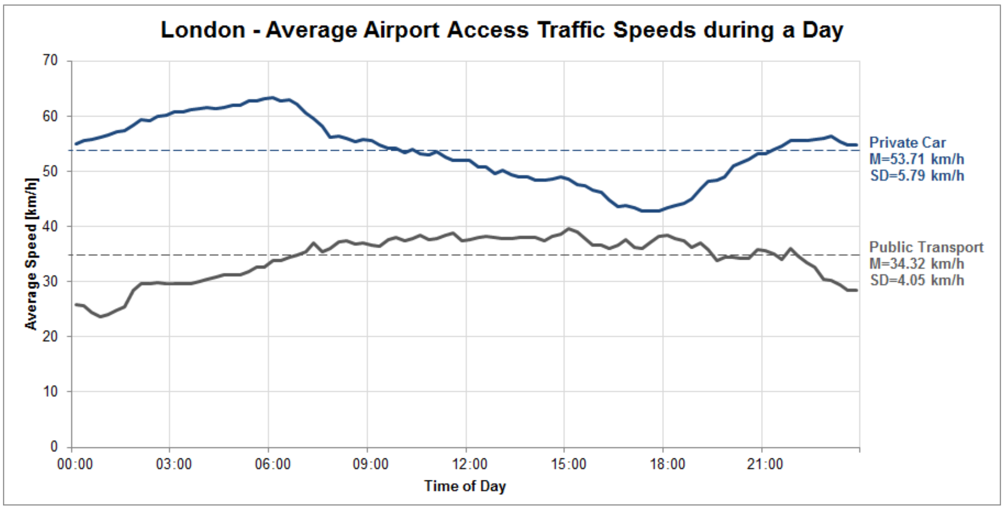


Figure 25: Speed pattern averaged over a day in London

A private car travels faster on average, yet suffers more from rush hour traffic (from 3pm - 8pm), than public transport does. At night, private car speeds are at their fastest, while public transport are at their slowest at the same time (possibly due to reduced number of offered connections).

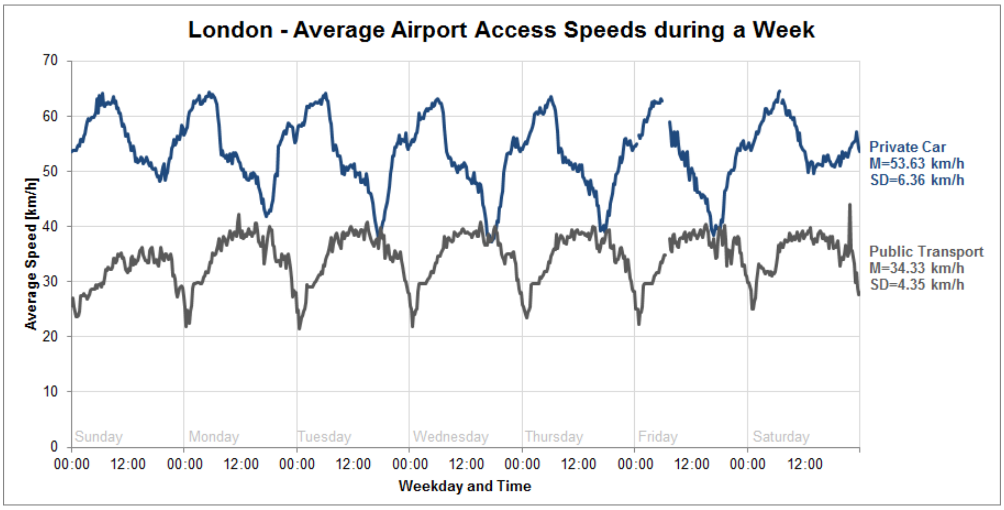


Figure 26: Speed pattern over a week in London

A private car travels faster on average, yet suffers more from rush hour (every weekday) traffic, than public transport does. At night, private car speeds are at their fastest, while those for public transport are at their slowest at the same time (possibly due to a reduced number of connections offered and reduced frequencies).

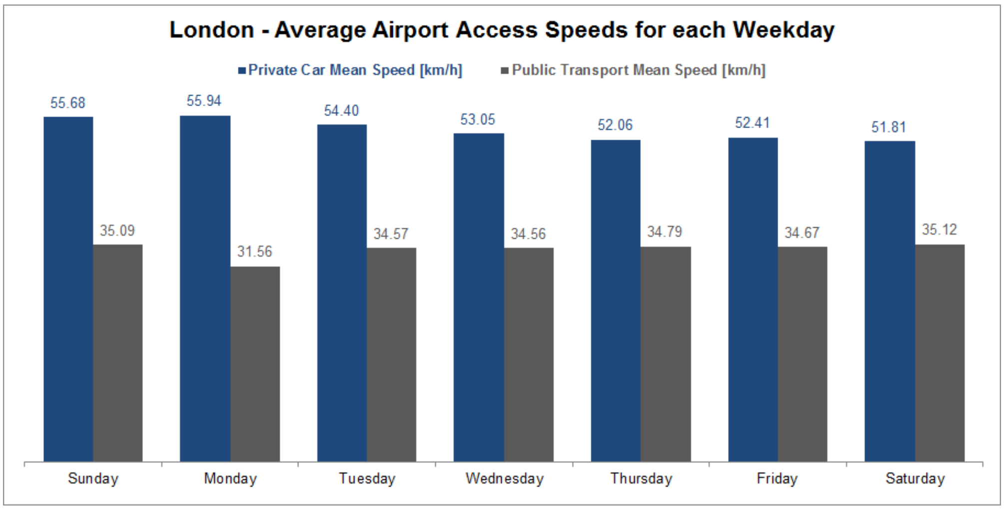


Figure 27: Average speeds per day in London by day of the week

Again, private car and public transport show contrary developments: while private car speeds slow during the week, public transport speeds increase.

Distance-Duration Regressions

Further, all Google requests can be plotted and enhanced with a regression line to create a distance-duration function with which to estimate average travel durations.

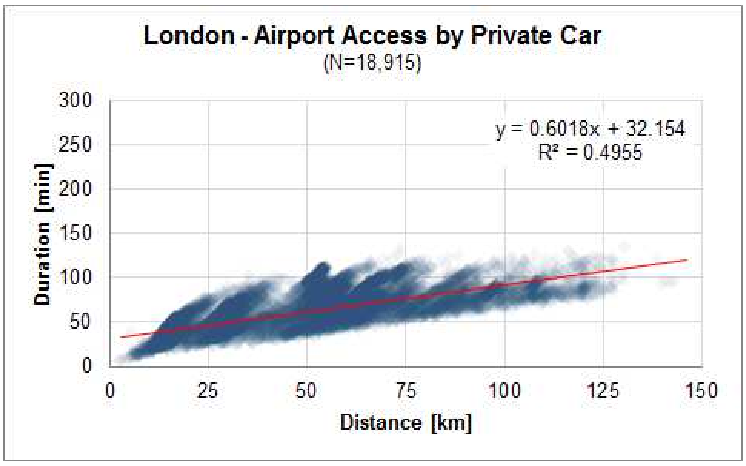


Figure 28: Airport access time for private car by distance

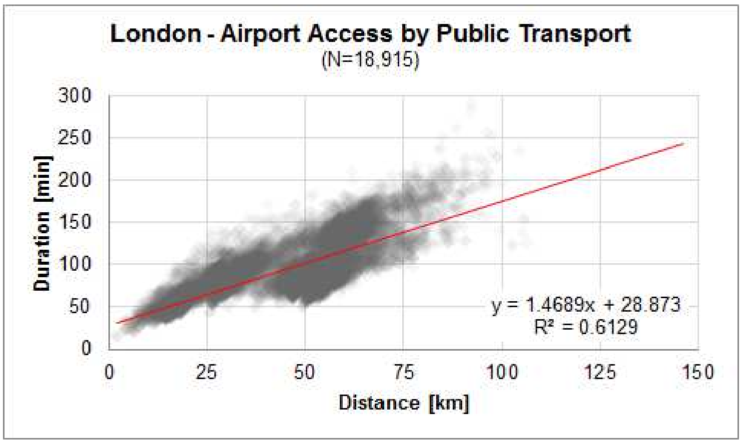


Figure 29: Airport access time for public transport by distance

The regression for public transport shows a better fit than for private car use. It should be noted that simple linear regression has been used, but that this is not valid for very short distances as it should obviously pass through the origin.

3.3.2 Possibility B: Airport-centred airport access/egress times

The steps required are pretty much the same, with the exception that the centre of the analysis is one specific airport. Thus each airport is analysed on its own and with nodes distributed around the airport (instead of the adjacent city centre). The objective here is determining the potential "door" locations, once the "kerb" is fixed. This method can also be used with a reduced number of data requests (though no mapping is then possible in this option).

Maps such as the following (source: https://apps.route360.net) of Berlin Tegel airport can be created, with each colour representing the time required to travel between Berlin and each specific location. The following diagrams show the locations/time required while using different means of transport. Note that these diagrams are given to different scales.

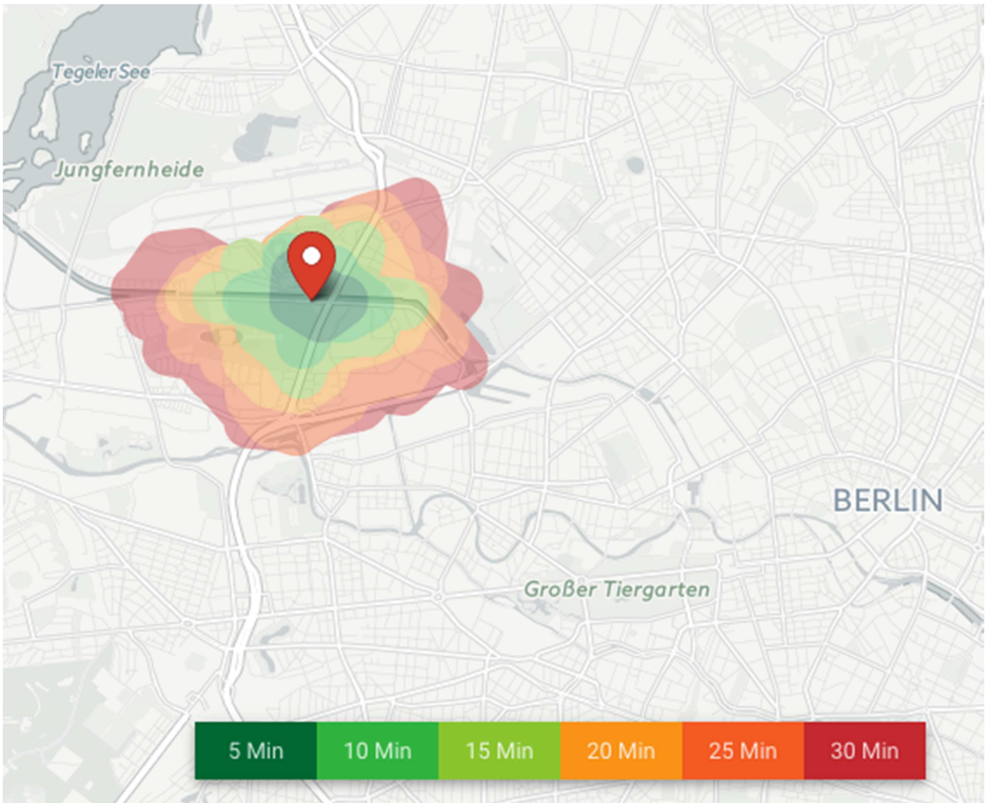


Figure 30: Berlin Tegel walking access-egress times

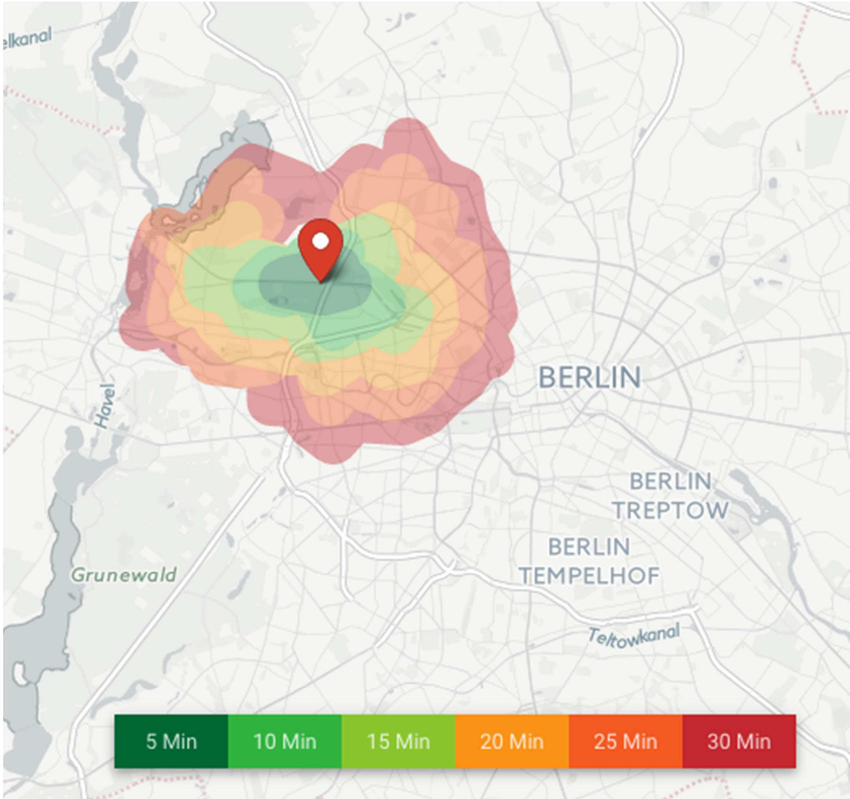


Figure 31: Berlin Tegel bicycle access-egress times

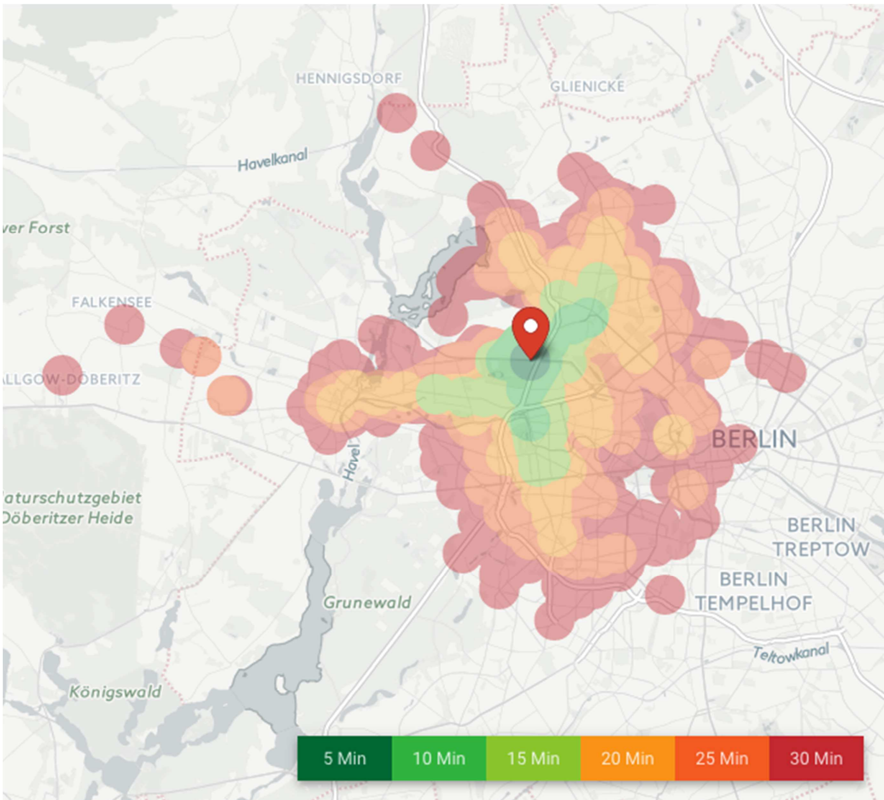


Figure 32: Berlin Tegel public transport access-egress times

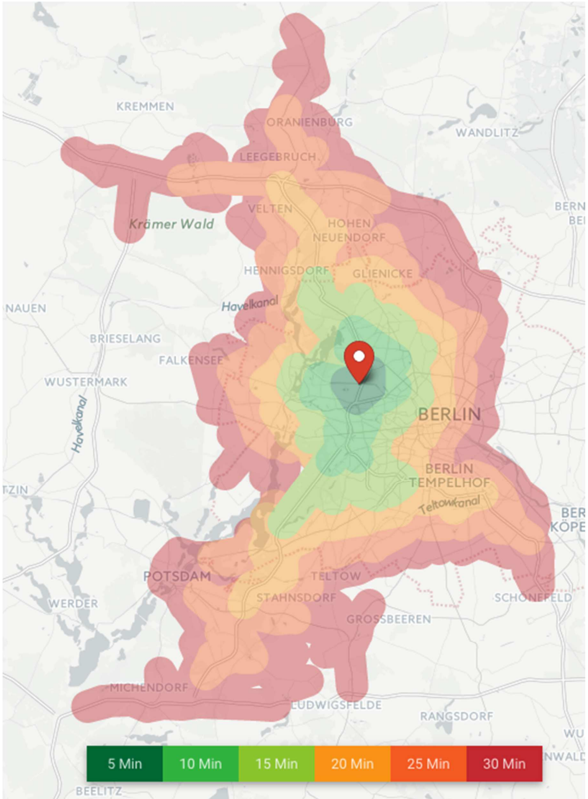


Figure 33: Berlin Tegel car access-egress times

It is interesting to note that in the case of Berlin, it is almost as fast, and sometimes faster, to go to the airport by bicycle as it is by public transport!

3.4 Access/Egress Times using the Google Maps API

3.4.1 Methodology

Travel times have been gathered using the Google Maps Distance Matrix API (Google 2016) for 22 European airports (see Figure 34). For each airport, circular grids with different great circle distances (5, 10, 25, 50, 75, 100, 200, and 300 km) to the airport have been defined, each with 12 sampling points equally distributed along the circular grid (see Figure 35). Each sampling point was used as the origin of a route to the airport and as the destination of a route from the airport - to simulate airport access and egress times respectively. Further, each sampling point was analysed in both travel directions for two different travel modes (driving: private car/taxi, public transport: bus, tram, metro, rail, etc.), for three weekdays (Monday, Wednesday, Friday), and five times of day (09:00, 12:00, 15:00, 18:00, 21:00). Travel times have been gathered for all combinations of airport, travel direction, travel mode, weekday, and time of day.

Figure 34: Location of the 22 airports analysed

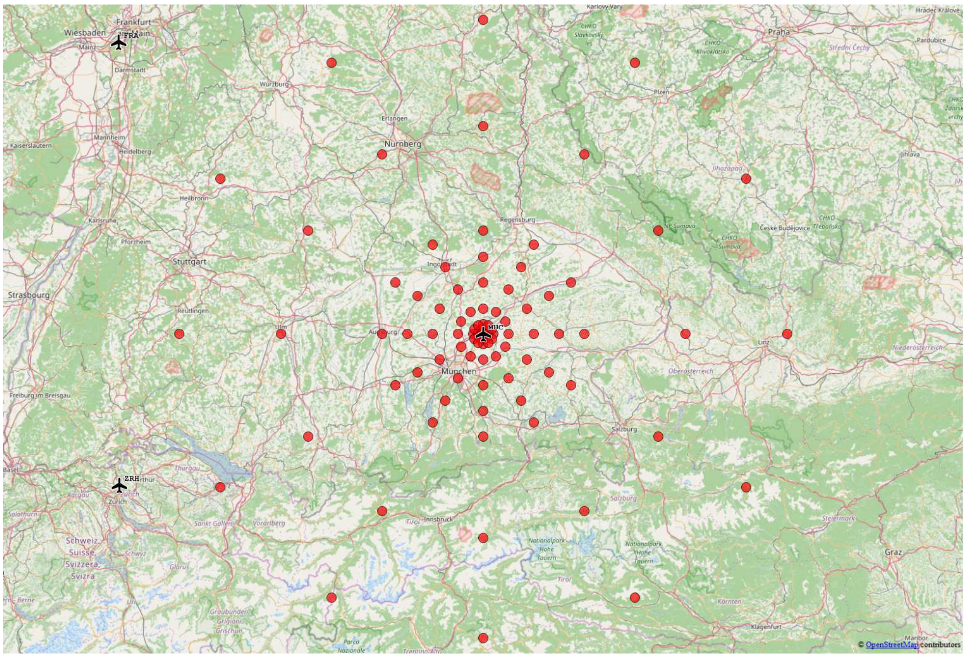


Figure 35: Sampling points (red) around Munich airport

In addition to the GPS coordinates of the origin and destination, the Google Maps Distance Matrix requests can be adjusted by adding parameters for travel date, time, and mode. Requests were sent automatically via a specifically-developed Python script to Google and all responses were gathered and aggregated. Data cleaning was undertaken to exclude faulty responses (e.g. if no route could be found or if the route included ferry travel as in Figure 36). It must be stressed that the results are heavily reliant on whether or not Google's street and timetable information' is complete and up-to-date.

Figure 36: Excluded sampling point (distanced 100 km from PMI) due to ferry usage

3.4.2 Results

Differentiation by Travel Mode

Across all 22 airports analysed, the driving speed has a sample mean (μ) of 67km/h and standard deviation **(**σ) of 22km/h, while public transport (PT) speed averages μ=28km/h, σ=16km/h) (see Table 43). A significant difference in travel speed can be observed between the two travel modes, as illustrated in Figure 37. (Note that "transit" is used for "public transport" in this and following figures). It should however be noted that, especially for public transport times, results vary greatly for each city based on that city's infrastructure and the availability of schedule data (very high σ relative to μ). Based on this differentiation, all of the following analyses will be considered separately for driving and public transport.

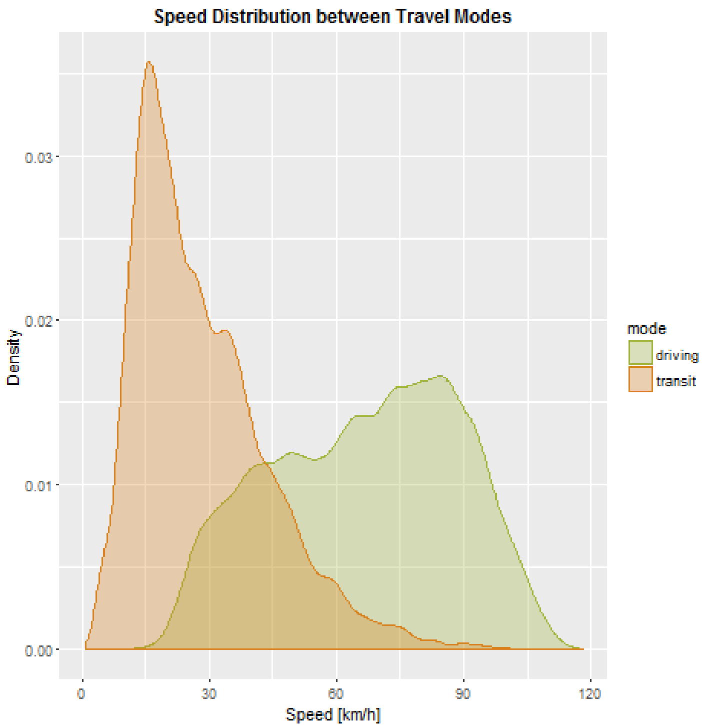


Figure 37: Density plot of travel speed [km/h] for both travel modes

As Figure 38 illustrates, the difference in speeds when differentiating between travel direction (i.e. airport access or egress), instead of travel mode (i.e. driving or public transport), is less marked. Still, with average speeds of μ=68km/h, σ=22km/h for airport driving access and μ=28km/h, σ=16km/h for airport public transport access, access speeds for both travel modes are higher than for airport egress - $\mu_{driving,egress}$=66km/h, $\sigma_{driving,egress}$=22km/h); $\mu_{pt,egress}$=28km/h, $\sigma_{pt,egress}$=16km/h (see Table 48). The difference between airport access and egress speeds is greater for driving than for public transport (see Table 15 and Figure 39 for illustration).

Figure 38: Density plot of travel speed [km/h] for both travel directions

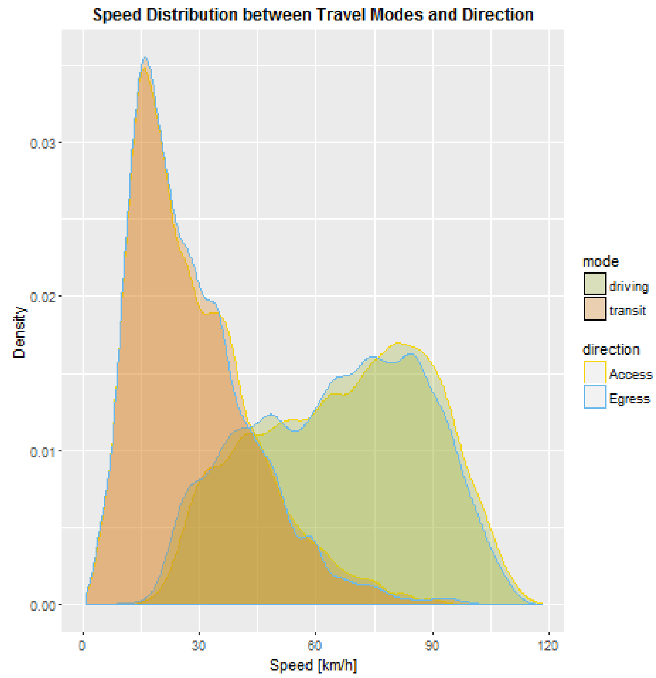


Figure 39: Density plot of travel speed [km/h] for both travel modes and directions

Differentiation by Time of Day

Across all airports and weekdays, the time of day shows an impact on average travel speeds for both travel modes. While average driving speeds increase towards the evening (i.e. 21:00) after the - presumably - 6pm rush hour, average public transport speeds decrease from 15:00 onwards. The decrease in average public transport speed towards later times of day may be caused by a reduction in connecting public transport services towards the evening.

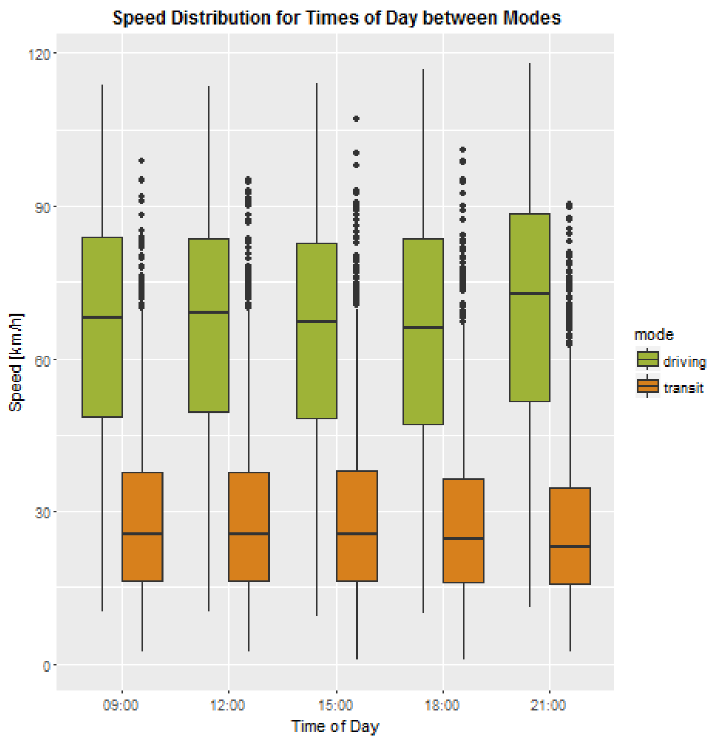


Figure 40: Speed distribution for times of day, differentiated by travel mode

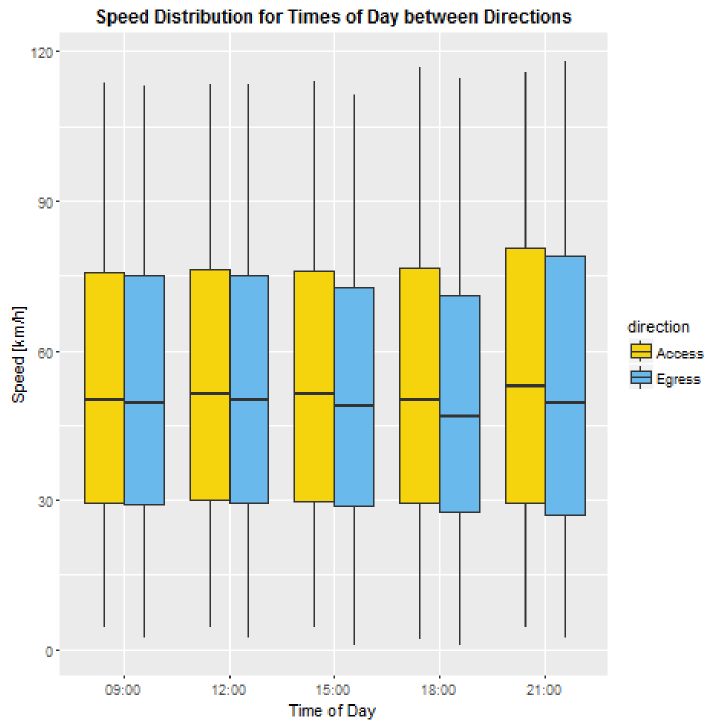


Figure 41: Speed distribution for times of day, differentiated by travel direction

An impact of time of day can also be observed when differentiating between travel directions and follows a similar pattern to the distribution when differentiating between travel modes. However, the difference between airport access and egress speeds seems to increase later in the day.

Differentiation by Weekday

Comparing average speeds grouped by weekday shows nearly no difference - leading to the conclusion that driving and public transport speeds do not vary significantly for the observed weekdays (Monday, Wednesday, Friday). The same holds true when differentiating by travel direction: no significant impact of a chosen weekday on travel speeds can be observed.

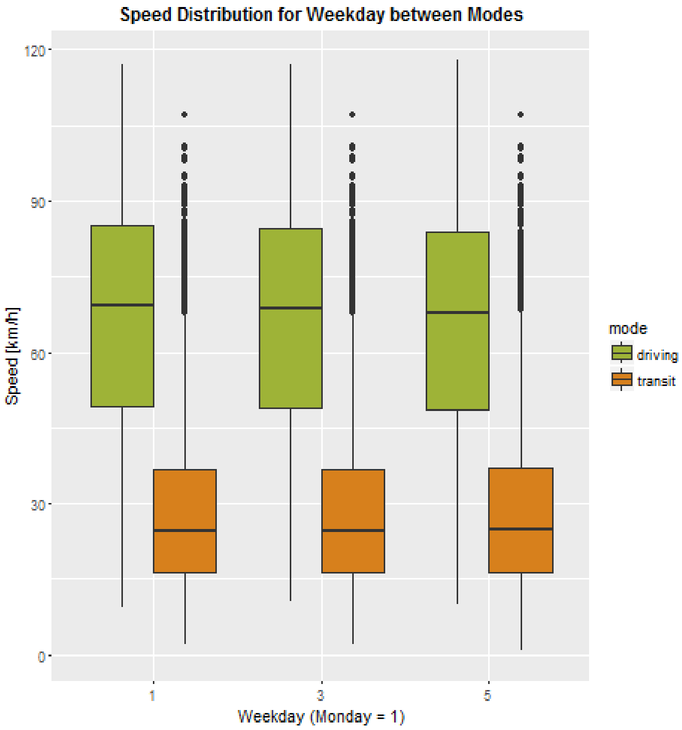


Figure 42: Speed distribution for weekday, differentiated by travel mode

Table 13: Average speeds per weekday and travel mode

Weekday	Mode	Mean Speed (km/h)	σ (km/h)
Monday	driving	67	22
Wednesday	driving	67	22
Friday	driving	66	22
Monday	public transport	28	16
Wednesday	public transport	28	16
Friday	public transport	28	16

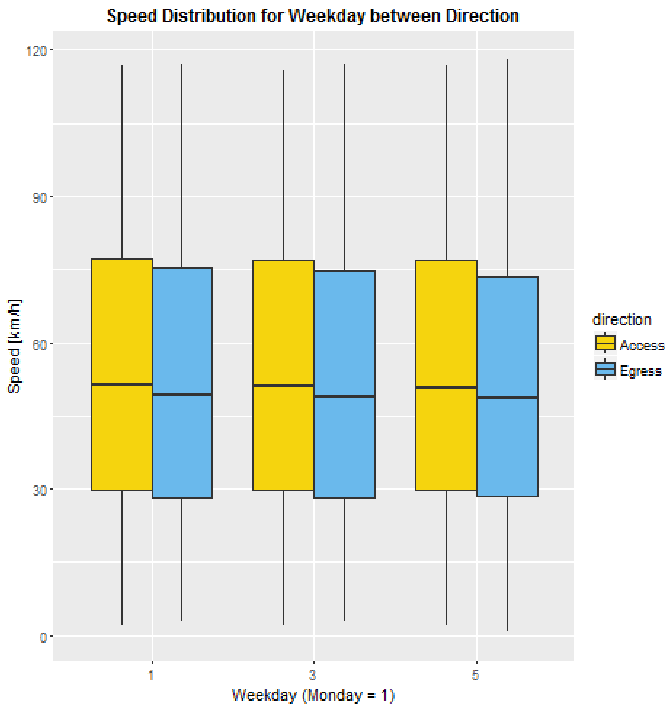


Figure 43: Speed distribution for weekday, differentiated by travel direction

Table 14: Average speeds per weekday and travel direction

Weekday	Direction	Mean Speed (km/h)	σ (km/h)
Monday	access	53	28
Wednesday	access	53	27
Friday	access	53	27
Monday	egress	52	27
Wednesday	egress	52	27
Friday	egress	51	27

Figure 42 and Figure 43 show the small differences in average speeds between the various observed weekdays.

As these differences are so small, Table 15 and Table 16 have been provided show their underlying data.

Differentiation by Geography

While the impact of weekdays is relatively low, travel orientation (i.e. the heading with which a passenger approaches or leaves an airport) and travel distance seem to have greater impact.

Figure 44 illustrates the average travel speed (regardless of travel direction (i.e. access or egress)) grouped per heading (in degree segments with the airport being the centre point), per airport and travel mode (driving: green, public transport: orange). Coastal cities are especially prone to a high variance in average travel speeds based on the incoming/outgoing heading. Barcelona (BCN) for example shows a clear distinction between north-west-bound traffic (land-inward) and south-east-bound traffic (land-outward).

Figure 45 plots the average travel speeds per travel mode and travel distance. Even though speed is a derivative of the underlying distance and duration, it varies along changing travel distances, with shorter distances showing lower average speeds than longer ones. The development, however, is not linear and average travel speeds start to stagnate after their maximum speed has been reached.

It is important to note that travel distance varies greatly from the direct, great-circle distance between an origin and a destination. Table 20 shows the average factors by which the great circle distance of two points must be adjusted (i.e. multiplied) to estimate an average travel distance.

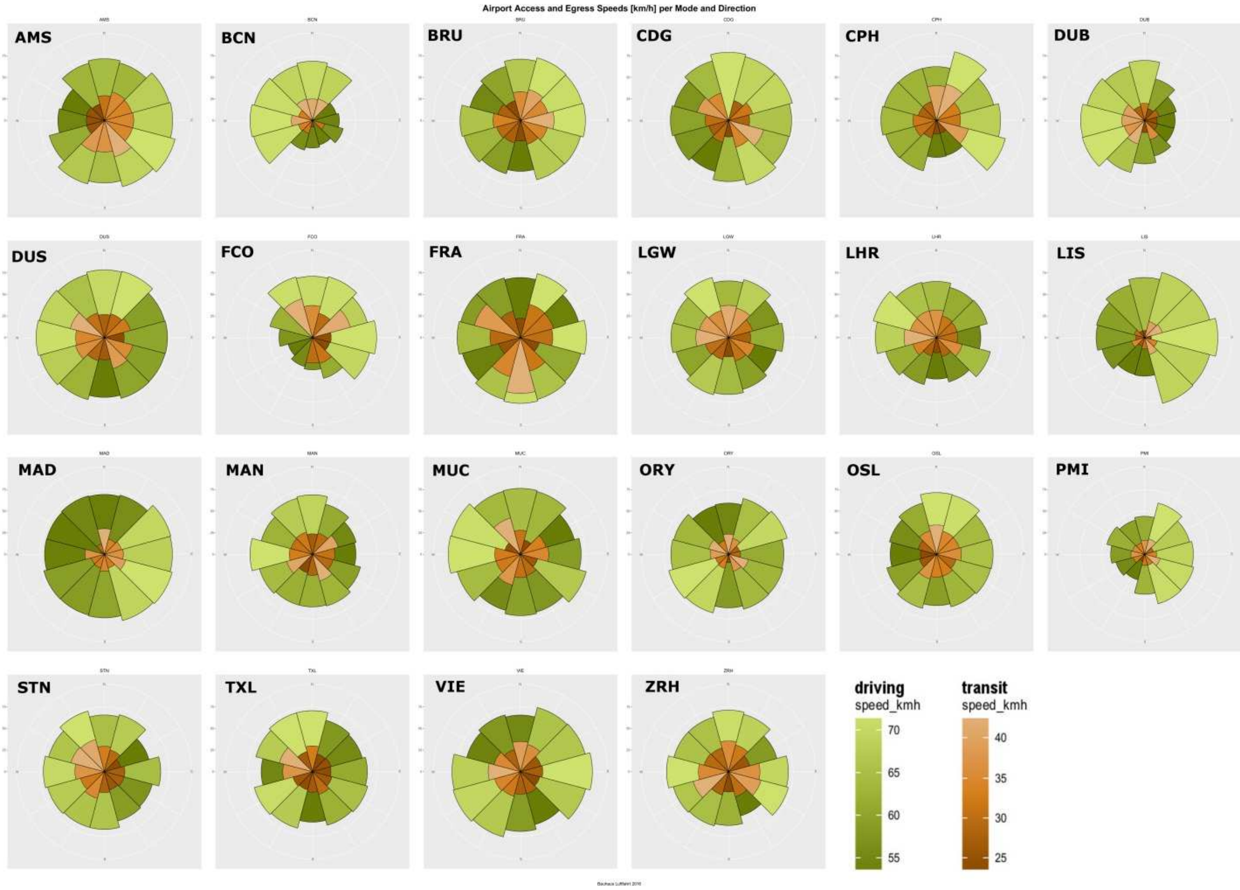


Figure 44: Average speeds (km/h) per heading from/to each airport for driving (green) and public transport (orange)

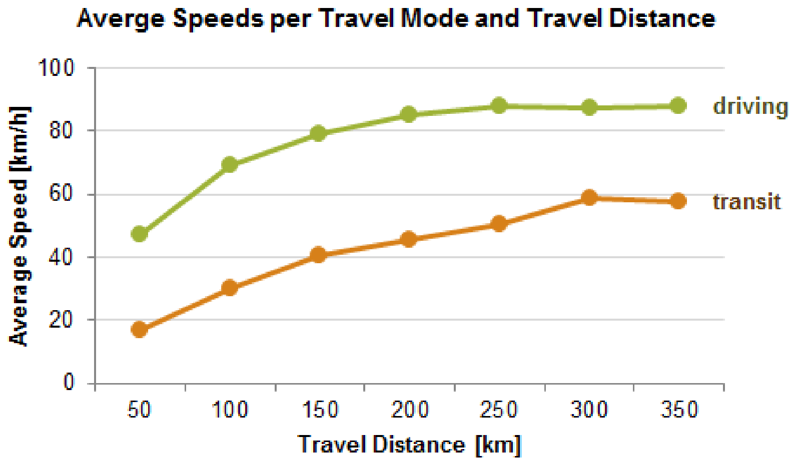


Figure 45: Average speeds (km/h) per travel mode and travel distance

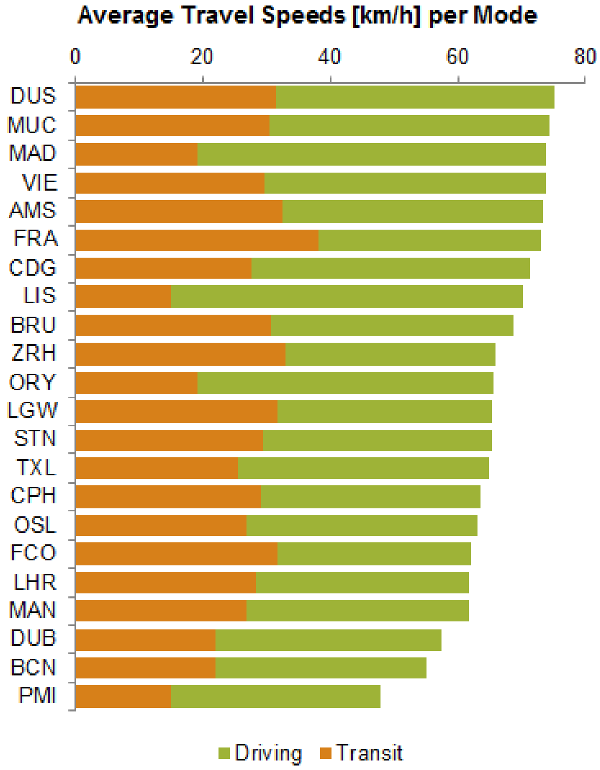


Figure 46: Average travel speeds per travel mode, descending order by driving speed

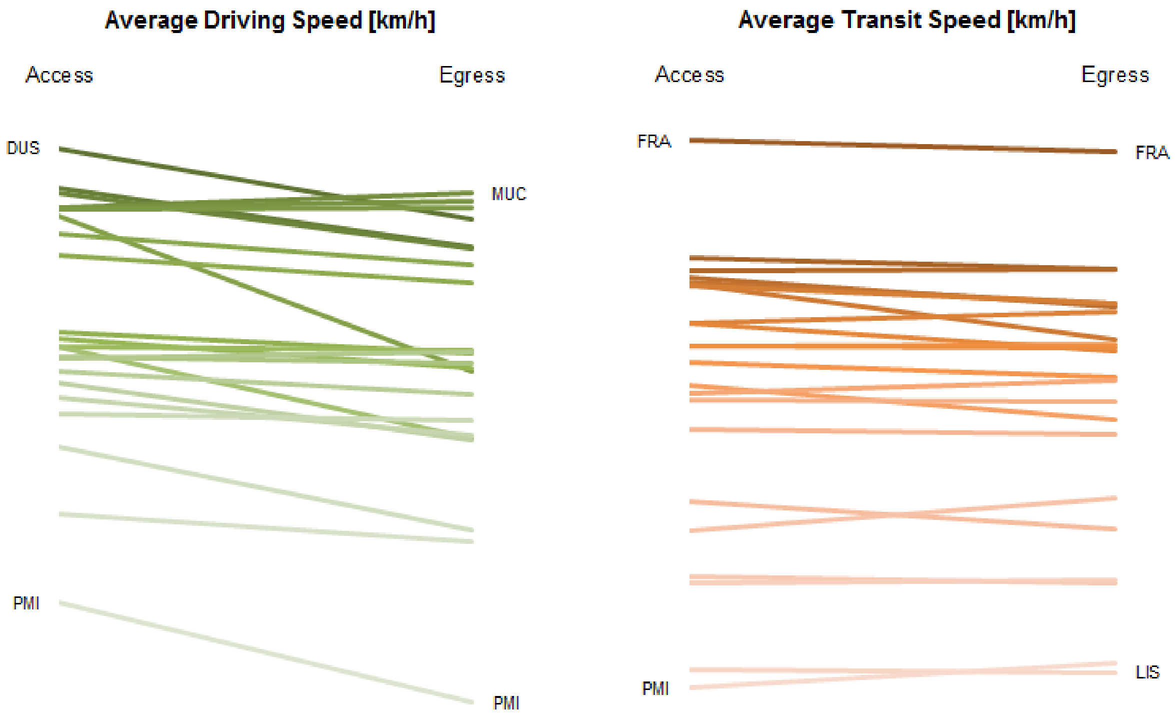


Figure 47: Visualisation of differences between access and egress times per airport for driving and public transport ("transit")

3.4.3 Data Tables

Average Speed Tables

Appendix 5 provides tables of the mean speeds in km/h and standard deviation (StD) for both driving and public transport travel modes and for each airport by:

- travel mode (Table 43)
- travel distance in multiples of 50 km (Table 44 and Table 45)
- time of day (Table 46 and Table 47)
- travel direction - access and egress (Table 48)
- day of the week - Monday, Wednesday, and Friday (Table 49)
- cardinal direction - North, East, South, and West (Table 50 and Table 51)

Travel Speed Factors

Based on these speed tables, the average travel speed per travel mode can be adjusted with the following factors to take various travel properties (e.g. travel direction and time) into consideration:

Table 15: Average speed adjustment factors per travel direction

Travel Mode	Access	Egress
Driving	1.02	0.98
Public transport	1.01	0.99

Table 16: Average speed adjustment factors per weekday

Travel Mode	Monday	Wednesday	Friday
Driving	1.01	1.00	0.99
Public transport	1.00	1.00	1.00

Table 17: Average speed adjustment factors per time of day

Travel Mode	09:00	12:00	15:00	18:00	21:00
Driving	0.99	1.00	0.98	0.98	1.05
Public transport	1.02	1.03	1.03	0.99	0.94

Table 18: Average speed adjustment factors per cardinal direction (clustered by compass points)

Travel Mode	North	East	South	West
Driving	1.03	1.01	0.95	1.01
Public transport	1.04	0.98	0.94	1.04

Table 19: Average speed adjustment factors per travel distance (clustered)

Travel Mode	50	100	150	200	250	300	350
Driving	0.71	1.04	1.18	1.28	1.32	1.31	1.31
Public transport	0.60	1.06	1.43	1.61	1.78	2.09	2.05

Table 20: Average speed adjustment factors from great circle distance to actual travel distance

Travel Mode	Great-Circle-Distance-to-Travel-Distance
Driving	1.63
Public transport	2.07

3.4.4 Recommendations

For incorporating airport access and egress times into a passenger travel model based on the above information, it is recommended to look at both travel modes separately within the model to be developed in WP5. While both modes' average speeds can be used as a base case, $\mu \pm \sigma$ can be used for best/worst cases respectively. Depending on the desired level of granularity, it is recommended to include the following parameters in this prioritised order:

- Travel distance (see Table 19)
- Time of day (see Table 17)
- Travel direction (see Table 15)
- Weekday (see Table 16)

While travel orientation (see Table 18) has great impact on travel speed, it is only recommended to be included in a model if each airport is assessed individually with its own adjustment factors per cardinal direction.

Finally, if - for a potential passenger trip - only origin and destination are known, their great circle distance should be adjusted (see Table 20) to reflect the difference between the great circle distance and the actual travelled route distance.

3.5 Regulatory role regarding airport access

3.5.1 Overview

The regulatory context regarding airport access is complex because it can involve regulations related to airport development, surface transport operations and planning controls. In countries where there is more of an integrated approach to transport provision, or when all transport modes are the responsibility of the same government body, this may simplify the situation. Often airports will be required to provide detailed information (and possibly targets) about future surface access proposals in their airport master plans or equivalent planning documents, whilst the individual surface modes will normally be subject to the regulations specific to that mode. Examples are provided for UK, Germany and France to illustrate these points. The regulatory context regarding airport access will be developed further in Deliverable 4.2.

3.5.2 Situation in the UK

Originally the airport surface access strategies were required to reflect the conclusions of the *Air Transport White Paper* (Department for Transport, 2003) and airport master plan development proposals. The White Paper (ibid.) established the following objectives: since 1999, airports in England and Wales with more than 1000 passenger-carrying air transport movements per year have been required to establish an Airport Transport Forum (ATF) and prepare an Airport Surface Access Strategy (ASAS). It is the responsibility of the airport operator to develop proposals in line with the ASAS and to secure corresponding funding. The ASAS should establish short and long-term targets for reducing the proportion of journeys to the airport by car, and increasing that from public transport. This includes passengers and airport workers.

- *Ensuring easy and reliable access for passengers, which minimises environmental, congestion and other local impacts, is a key factor in considering any proposal for new airport capacity. All such proposals must be accompanied by clear proposals on surface access which meet these criteria.*
- *Increasing the proportion of passengers who get to airports by public transport can help reduce road congestion and air pollution. We expect airport operators to share this objective, and to demonstrate how they will achieve it in putting forward their proposals for developing new capacity.*
- *Airports are part of our national transport infrastructure, and need to be planned and developed in that context. The Strategic Rail Authority and (for strategic roads within England) the*

Highways Agency will take full account of likely future airport development, and regional and local transport strategies should do the same.

- *The Government expects developers to pay the costs of up-grading or enhancing road, rail or other transport networks or services where these are needed to cope with additional passengers travelling to and from expanded or growing airports. Where the scheme has a wider range of beneficiaries, the Government, along with the devolved administrations, the Strategic Rail Authority, the Highways Agency and local authorities, will consider the need for additional public funding through their investment programmes on a case-by-case basis. Prospective developers should consult those bodies at an early stage in formulating their proposals.*

The UK Department of Transport subsequently commissioned research on the White Paper, aiming to better understand stakeholder perceptions of its strategic framework (Ipsos MORI/Institute for Transport Studies, 2010). This review also explored the influence of the airport master plans on airport development processes and the effectiveness of the ASASs. The report concluded:

> *There were mixed reactions to surface access targets and commitments where these were included within master plans. In particular, there was a lack of consensus across local planning authority respondents around the viability of including these objectives within master plans. The lack of agreement across these respondents was evident as some reported surface access targets and commitments to be overly ambitious, whilst others considered them to be overly conservative*.

The report stated that the master plans sometimes proposed rather limited investment in public transport services, noting that

> *The fact that linking an airport to other local transport networks is not directly within an operator's control was seen as an additional tension which made surface access a difficult issue to cover adequately within airport master plans.*

In 2013 the UK Government published its Aviation Policy Framework (APF) (Department for Transport, 2013) which replaced the 2003 White Paper. The APF commits to supporting the integration of airports in the wider transport network, improving airport surface access and recommends that airports should continue to use ATFs and ASASs. Taking into account the 2010 review, it states that:

> *There is currently a range of mechanisms for airports to engage with key stakeholders in the local area and beyond, including airport consultative committees (ACCs), airport master plans, airport transport forums (ATFs) and airport surface access strategies (ASASs). Responses to the consultation confirmed that there were many examples of good practice across the country where local stakeholders are working well together. Overall, existing mechanisms were seen as useful, but local community groups in particular felt there was room for improvement.*

These improvements relate to improving the quality of information produced, increasing the breadth of representation, avoiding duplication with the ACC and reducing the consultation burden. The APF states that the ASASs should be combined with the master plans to ensure a joined-up approach and easier access to information. It suggests that the membership of the ATF should include the following: local transport providers (e.g. bus, rail, coach, car hire); local authorities; passenger representatives; freight industry representatives; local businesses; representatives from the ACCs; representatives of airport users; representatives of airport employees; and bodies representing interests of walkers, cyclists and disabled people in the area. The ATF should meet at least twice a year, being funded by the airport operator.

A study of 11 ASASs in their early years (Humphreys and Ison, 2003) showed that the number of members of the ATFs ranged from 12 to 71 although this may have been changed slightly in line with the APF recommendations.

The APF lists the suggested content of the ASASs:

- *analysis of existing surface access arrangements;*

- *targets for increasing the proportion of journeys made to the airport by public transport by passengers and employees; cycling and walking. There should be short- and long-term targets;*
- *consideration of whether freight road traffic can be reduced;*
- *consideration of how low carbon alternatives could be employed;*
- *short-term actions and longer-term proposals and policy measures to deliver on targets such as:*
    - *proposed infrastructure developments e.g. light rail;*
    - *car/taxi sharing schemes*
    - *improved information provision on public transport, cycling and walking options;*
    - *car park management; and*
    - *through-ticketing schemes;*
    - *indication of the cost of any proposals;*
    - *performance indicators for delivering on targets;*
    - *monitoring and assessment strategies (internal and external);*
    - *green transport incentive schemes for employees.*

Table 21: Members of the Airport Transport Forums

Airport	Air-Lines	Local Authority	Train Op Company (TOCs)	Bus Operators	Coach Operators	Cycling Group	Environ-mental Org.	Airport Employees	Chamber of Commerce	Freight Industry	Regional Develop-ment Agency	Infrastruct-ure Providers	Highway Authority	Local Business	DETR	ATF members
Heathrow	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			64
Gatwick	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓		52
Manchester	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		49
Stansted	✓	✓	✓	✓	✓			✓	✓			✓	✓	✓	✓	71
Birmingham	✓	✓	✓	✓	✓	✓		✓	✓			✓	✓		✓	38
Luton	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	47
Newcastle		✓	✓	✓	✓	✓		✓			✓	✓	✓		✓	31
Bristol		✓	✓	✓				✓			✓	✓				12
Liverpool		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		28
Leeds/Brad		✓		✓		✓	✓	✓	✓		✓	✓				23
Sheffield		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	20

A detailed recent analysis of 10 ASASs (Ison at al. 2014) identified five common aspects of the plans: environmental footprints, employee access, passenger access, car parking and constrained location/land use issues. The policy measures were both short term (e.g. Improved public transport bus services—frequencies and route provision; improved public transport marketing and information—airport website details; car parking charges) and long term (development of rail links; development of ground transport interchanges). Currently the UK is fairly unique in adopting such ASAS and Heathrow was shown to be the only airport out of the top 10 airports of the world by passenger numbers to have a separate plan. A rare example outside of Europe is the major Australian airports that have recently been required to produce separate surface access plans for the first five years of a master plan's 20-year life span, primarily to prepare the airports for forecast growth of traffic.

Ison et al. (2014) agreed that one of the shortcomings of the ASASs was that, in spite of discussions within the ATF, many targets are ultimately outside the airport operators' control, for example the provision of improved bus services, unless some incentive is offered by the airport. Other criticisms have been that the ASASs vary considerably in terms of the chosen metrics and targets, the methodologies used and the degree of detail which raises questions about their effectiveness (Humphreys and Ison, 2002; Humphreys at el., 2005). Jacobs (2016) questioned the suitability of having a primary target related to public transport mode share since issues related to the interpretation of this metric meant that the impact of such targets was difficult to determine. It suggested that perhaps targets should be related specifically to actual impacts rather than behavioural specifics, for example by relating them to total daily or peak traffic generation (measured in number of vehicles) travelling to and from an airport.

The House of Commons Transport Committee (2016) in reviewing the ASASs stated:

> *There is too little scrutiny of individual strategies and plans which is akin to letting airports set and mark their homework themselves. We recommend that the Government consult on the institutional and governance arrangements needed to ensure airport operators are setting meaningful targets and being held to account for their performance.*

ASASs seem likely to remain a key feature of surface access planning in the UK for the future. With the trends towards airport commercialisation and privatisation remaining, more European countries may feel the need to adopt similar policies in order to co-ordinate the views of diverse stakeholders. Even at airports where surface access is entirely the responsibility of the public sector, they could potentially benefit from the greater degree of coordination which comes with the ATFs, although the variation in institutional and planning regimes would influence the extent to which similar policies could be effectively replicated in other countries. More sharing of best practice which has been largely lacking in the UK to date would be helpful.

However, whilst it is generally agreed that the ASASs have been useful at the regional or local level, it has been frequently argued that a more nationally integrated and coherent approach is needed, with not merely transferring responsibility to the individual airports (House of Commons Transport Committee, 2016; Airport Operators Association - AOA, 2015). The AOA (2015) stated that to create a more integrated transport policy the government should:

- *Assess the level of public transport infrastructure connecting UK airports and identify where there are gaps in present and future demand …*

and

- *Ensure rail capacity assessments and Highways Agency route studies include airport access and compare passenger growth assessments and their impact on transport infrastructure ...*

In 2015 the National Infrastructure Commission was set up by the government as an independent body to provide unbiased analysis of long-term infrastructure (including transport) needs. This has the potential to look at national transport networks and airport planning, and so it may help towards providing a more co-ordinated approach but its impact is too early to assess. The government is also expected to issue a National Policy Statement (NPS) for Aviation (once decisions concerning airport capacity in London and the South East have been made) which should help to clarify how planning decisions will be made in relation to surface access improvements, particularly at the large airports. NPSs include the government's objectives for the development of nationally significant infrastructure in a particular sector. (A road and rail 'National Networks' NPS was designated in 2015).

Another regulatory issue relates to the market structure for surface access. For example, it is possible that airport operators could abuse their dominant position to car users at airports in an anti-competitive way (e.g. high prices, insufficient information). As yet there is no clear policy here, but the relevant competition regulator, the Civil Aviation Authority, is currently consulting over this, after a couple of well publicised cases, which may result in further regulatory action (CAA, 2015).

3.5.3 Situation in Germany

In Germany, the "Master-plan for the development of airport infrastructure" (Luftverkehr, 2006) was developed with the goal of contributing to the security and the strengthening of international competitiveness of airports in Germany (ibid, p. 42). The plan details the infrastructure needs resulting from the steadily rising demand for air transport services. Based on this, development strategies were identified in order to strengthen the role of Germany as an air transport hub.

The air law defines the planning of an airport development project and the filing of an application for the required approval procedure as being the responsibility of the airport operator. To undertake these assignments, the operators need planning and legal securities that can be guaranteed at the national level through:

- The simplification and implementation of relevant laws, especially those of the aviation department
- The implementation of a framework for the regional planning act
- The definition of environmental requirements

- The development of an integrated transport concept for optimal connection and use of different means of transport.

There is a need for a construction strategy to increase the capacity of large airports since the available capacity is running out as a result of the 5-6% growth rate in air transport. This capacity expansion approach was similarly identified as necessary for the connection of airports to the nationwide road and rail network.

Major airports that are not sufficiently linked to either the road or rail networks do not comply with the requirements of a modern holistic intermodal transport system. Furthermore, regionally significant airports also need to have sufficient road connections at least. It is important to have a congestion-free landside connection for both private cars and high-frequency intercity railways.

According to the Master Plan (ibid, p. 28), current intermodality and connectivity goals concerning rail transport being worked on by special working groups are:

- To strengthen the air transport hubs in Germany through the potential of intermodality
- Inclusion of international competitiveness and creation of airport job opportunities in the National Transport Plan (Bundesverkehrswegeplan)
- Alternative financing options for rail transport infrastructure projects that significantly connect air and rail transport
- The shift of air freight to rail transport.

The results of the study are expected to be published in a report that offers aviation and rail transport stakeholders an action strategy for strengthening intermodal connections.

3.5.4 Situation in France

France has two major airports: Charles de Gaulle (CDG) some 25km north-east of Paris, and Orly, 20km south of the capital. While there are great similarities in their available surface-access methods (both are directly linked to Paris by major, heavily over-used motorways; neither has a direct connection to mainline Paris rail stations) there are also major differences. Strategies for improving surface access are therefore quite different.

Both of these airports are in the Île de France region and are therefore subject to the Schema directeur de la région Île-de-France 2030 (SDRIF) published by the Direction Régionale et Interdépartementale de l'Équipement et de l'Aménagement Ile-de-France (DRIEA-IDF, 2015). This document, though a general description rather than a set of details, provides among other things for the creation of a Grand Paris Express train (using the current metro line 14) linking CDG and Orly, via Paris. It also calls for the "densification" of populations around railway stations, which will lead to a greater use of public transport in general, and by extension, to the airports.

A 2-volume study was prepared in 2016 by the Institut d'Aménagement et d'Urbanisme-Île de France (IAU-IDF, 2016(1&2)). This study compared surface access at these two airports with the "best-of-breed" internationally and proposed strategies to meet the challenges of the future:

- Environmental - through a better modal share for public and shared transport;
- Socio-economic - by improving access for passengers and employees;
- Competition - through a better access from the surrounding areas for complementary resources to the airport;
- Tourism - by improving airport infrastructure whose image reflects on the region and the country.

It is to be hoped, therefore, that by 2050, if not by 2030, access to the two major French airports will be faster and more environmentally sustainable, and more easily available to a greater catchment area than today.

4 Kerb to gate and gate to kerb

There are numerous airport processes that will be modelled within the DATASET2050 model (WP5): from the method of getting to the right terminal once the passenger has arrived at the airport to the distance that has to be walked from the arrival gate to baggage reclaim, from the time spent in dropping-off baggage, to the time spent in security. These airport processes may conveniently be separated into the Kerb-to-Gate processes and the Gate-to-Kerb processes since these are completely different in nature and are heavily dependent on the specific airport.

The Kerb-to-Gate processes are in fact quite complicated and - as explained in D2.2 - are characterised as shown in the following diagram:

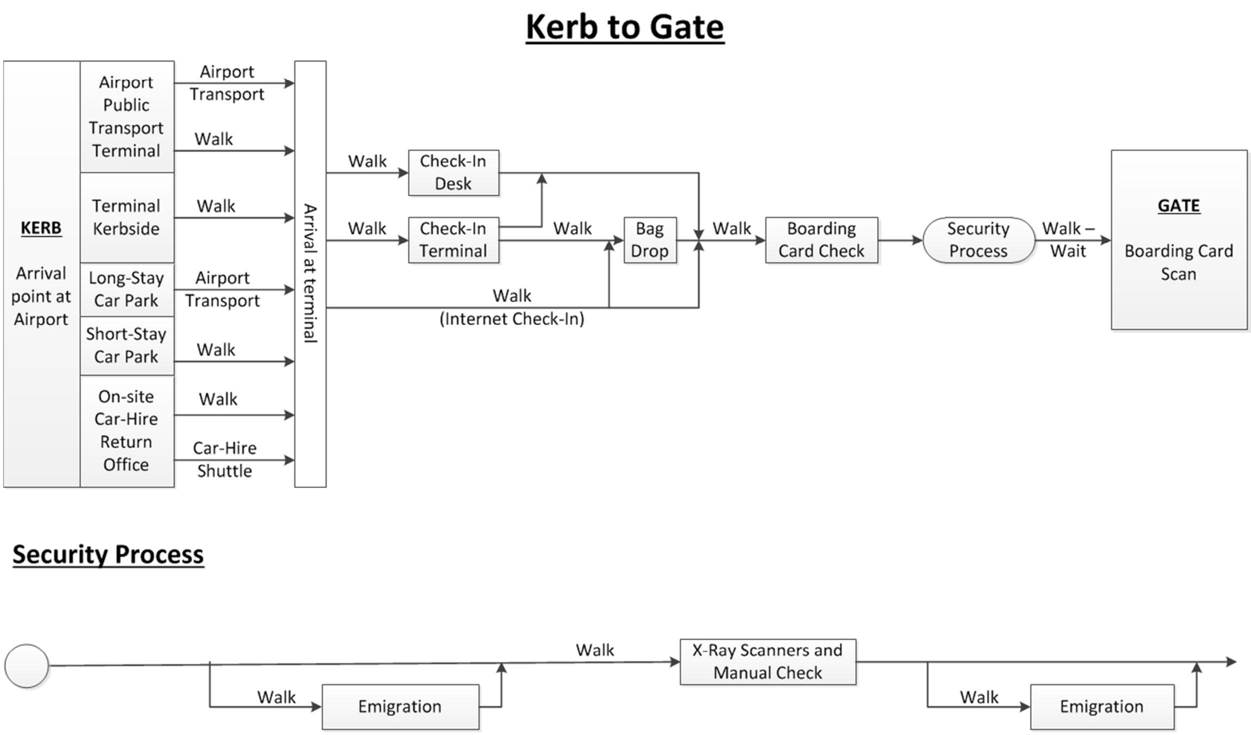


Figure 48: Kerb-to-gate process

On arrival at the terminal, the passenger process depends on whether they have previously checked-in (generally via the internet) and whether they have hold luggage.

Passengers who have not previously checked-in may increasingly do so using automated check-in terminals situated in the check-in concourse; in fact sometimes this is obligatory, there no longer being specific manned check-in desks. These are reasonably rapid to use and involve little queuing. However, they require the passenger who has hold luggage to then check this luggage in at a Bag Drop. Passengers who use a manned check-in desk will be able to check their luggage in at the same time.

As the Security Process diagram shows, Frontier Control (which is not necessary for domestic or intra-Schengen travel) may occur either before or after the obligatory X-Ray Scanning process. This depends on the airport layout, which may require these scanners to be very close to the Gate.

Certain passengers (i.e. domestic or intra-Schengen passengers with no luggage) may skip every aspect of the Gate-to-Kerb process, as shown below:

Gate to Kerb

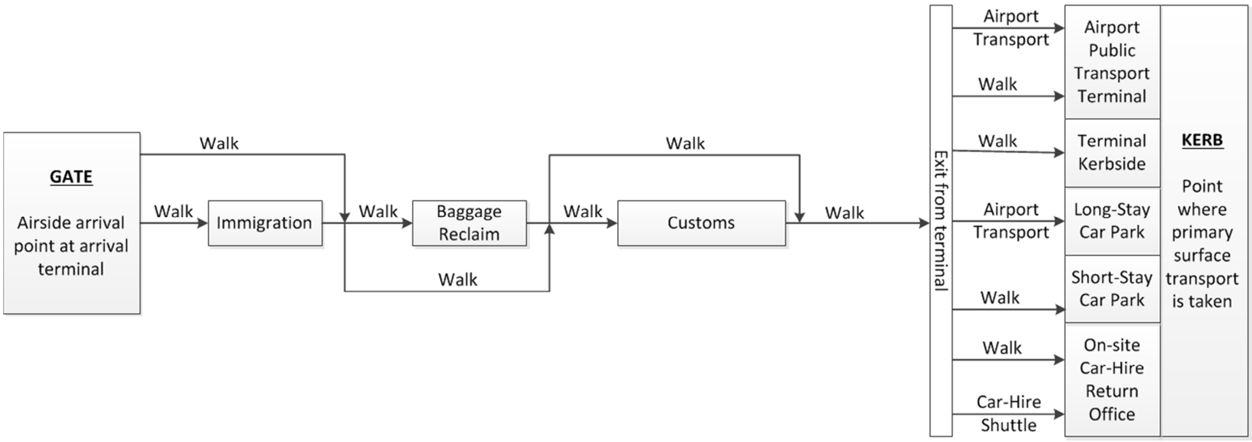


Figure 49: Gate-to-kerb process

As for the Kerb-to-Gate security process, immigration controls are not necessary for passengers arriving on domestic or intra-Schengen flights. Customs controls are not necessary on intra-EU flights. Baggage reclaim obviously does not apply to passengers with no hold luggage. This does not often, however, preclude them from having to walk the same distance as everyone else!

The point of exit from the arrivals concourse will depend on the mode of transport used for egress from the terminal. In the case of valet parking of a private car, there is a delay while the "valet" retrieves the car that needs to be factored in.

4.1 Airport Kerb-to-Gate and Gate-to-Kerb Process Times

Modelling the kerb-to-gate processes is a challenging task for a number of reasons:

- The inherent differences in size, geometry, services and complexity of EU airports. Data are required, either individually or per airport archetype.
- Airports' flexibility to balance the demand (which is pretty desirable!) hinders easy modelling. Kerb-to-gate supply processes are designed to dynamically adapt to the demand, which ultimately depends on the airport traffic; for instance, opening check-in counters and security lines at peak times, and/or reducing them accordingly. The model needs to take into account this airport "flexibility".
- The difference between each individual passenger experience and aggregated statistical figures. This is linked to the way statistical properties (mean, variance etc.) are measured and/or calculated at the airports. The reality is that two airports with very different performance in terms of kerb-to-gate and gate-to-kerb processes can have the same statistical properties. For example, an airport that performs almost ideally and faces an isolated disruption for a very short period of time, with all its passengers experiencing unacceptable waiting times, can have the same average as another airport that is never seriously disrupted, but generally performs rather weakly. Further mathematical information about this can be found in Appendix 6 and will be tackled in depth in D5.1. For the reasons mentioned above, a mixture of inputs are required and are included in the model: from individual airport data (different granularity) - when available and accessible - to airport archetypes/ mean figures. The current section documents some previously reported initiatives in the field.

4.1.1 Acceptable airport processes times

The International Air Transport Association (IATA) has developed guidelines for airports specifying the amount of time passengers can be expected to pass through a given airport process, as shown in Table 22.

Table 22: IATA - level of service maximum waiting time guidelines

Facility	Short to acceptable (min)	Acceptable to long (min)
Baggage claim	0 - 12	12 - 18
Check-in economy passengers	0 - 12	12 - 30
Check-in first and business class	0 - 3	3 - 5
Passport Control inbound	0 - 7	7 - 15
Passport Control outbound	0 - 5	5 - 10
Security Control	0 - 3	3 - 7

Queuing times obviously vary greatly throughout the day and from one airport to the next. Actual average queuing times for security checks/screening at some UK airports are available from the UK Department for Transport as follows:

Table 23: Queuing times at UK airports

Airport	Total pax/year (million)	Average security queue time (min)
Heathrow	72.3	7.27
Gatwick	35.4	4.90
Manchester	20.7	7.39
Stansted	17.8	8.98
Edinburgh	9.8	6.08
Luton	9.7	8.44
Glasgow	7.4	3.32

Source: Data collated from Department for Transport (DfT, 2014) TAG data book, Department for Transport (DfT, 2013) Air passenger experience of security screening survey, & CAA (CAA, 2013) UK Airport Statistics - cited in (PACG, 2014)

The mean weighted average queue time is 6.80 minutes ($\sigma = 1.43$)

4.1.2 CDM modelling

In 2006, EUROCONTROL initiated a "Collaborative Decision-Making (CDM) Landside Modelling Project" (EUROCONTROL, 2006) whose role was to analyse the impact of three of the original ACARE High-Level Target Concepts (HTLCs): Highly Time-Efficient, Highly Customer-Orientated and Highly Secure for three future growth scenarios, called A Segmented Business Model, Constrained Traffic Growth and Block Building. This project, conducted for EUROCONTROL by the German Airport Research Centre (ARC), used the Comprehensive Airport Simulation Tool (CAST) that ARC had developed in collaboration with BAA to simulate the entire landside process at an airport - in this case a slightly modified version of Terminal 2 at Frankfurt.

The Phase 2 Landside Report (EUROCONTROL 2007) gives Levels of Service and timings for most of the airport processes at Frankfurt. It should be remembered that this is for an airport inside Schengen so some of the processes will be different for airports outside Schengen. However changing "Schengen" to "Domestic" and "Non-Schengen" to "International" will provide the correct scenario in this case.

Additionally, some airports will perform a passport check on transfer passengers from international flights.

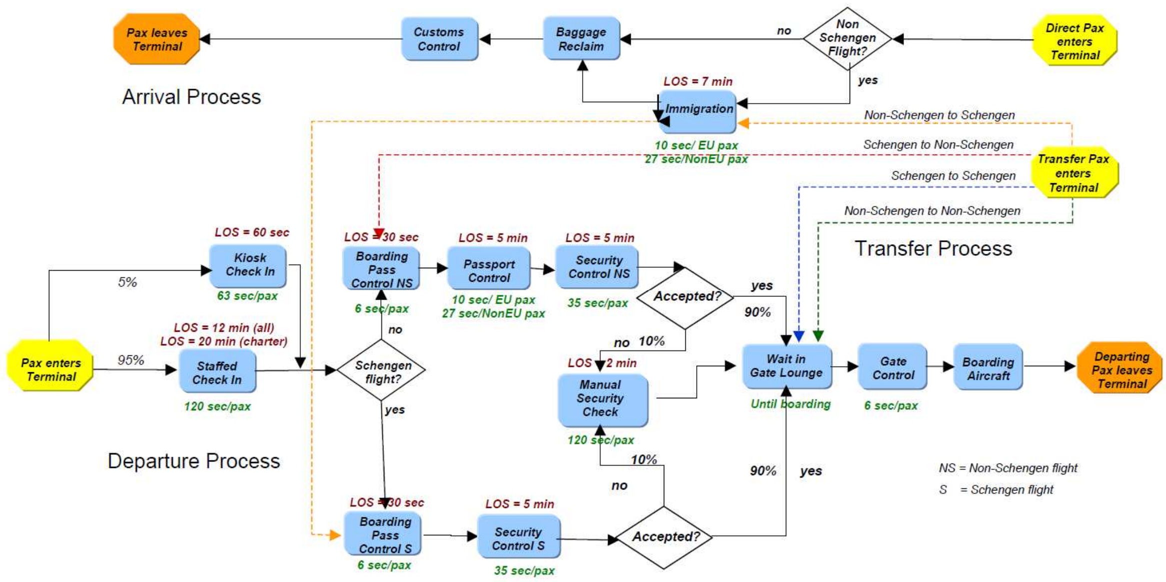


Figure 50: Levels of service and process times

The Level of Service (LOS) is the required maximum timing for queuing only. These were constraints given to the model in order to discover the facilities required (number of terminals/desks) for a given LOS. The process timings found in the simulations of the study are given in green in the above figure.

Note also that as this document is from 2007, this baseline scenario pre-dates widespread internet check-in. The future scenarios studied in the document do have passengers arriving with boarding pass in hand. The bag-drop value included in Table 24 (whose values are taken from Figure 50) includes the process-time values obtained from one of the future scenarios.

Table 24: Calculated process times at Frankfurt not counting queuing

Facility	Process time (secs)
Check-in counter	120
Check-in terminal	63
Bag-drop	45 +25/bag
Boarding-Pass Control	6
Passport Control outbound	10
Security Control (X-Ray)	35
Manual Security Check	120
Gate Control	6
Passport Control inbound	10
Baggage Reclaim/Customs	0*

4.1.3 Walking

Between each queue/processes combination and the next the passenger must walk, though sometimes there are moving walkways to relieve some of the burden of this. Moving walkways do not, however, increase average passenger speed (Daily Telegraph, 2016).

Increasingly, this walking takes place in the shopping mall that airport departure areas are rapidly becoming, with many of them imposing circuitous routes on the unsuspecting passenger to entice him or her to spend their buffer time in the various boutiques along the way. It is clear that there is a dichotomy between the wish of the ACARE group to speed-up the system's passenger throughput, and the wish of airport managers to extend to the maximum the amount of time passengers spend in their shops. In any case, shopping time can be assimilated to buffer time and is not considered in the present section. These "buffer time" passengers could well, on the other hand, hinder the progress of those who are in a hurry.

The authors have been unable to obtain accurate figures for the amount of time passengers spend walking through an airport between the arrival at the terminal and the gate. This must, therefore, be estimated from published airport plans where these are available.

There is no need to separate the different stages of walking between the different processes; one distribution function for "walking" will cover all of these. This has been calculated for a given airport as the distance from the entrance to the start of the departure area (measured using Google Maps), plus half the length of the pier, divided by a standard walking speed of around 1.4 m/s (Browning et al 2006). For multi-pier airports, or airports where the distribution of gates varies greatly along the length of the pier, the pier has been divided into sections and a weighted average taken based on the observed number of gates in each section.

Some terminals have satellites that are accessed by an internal shuttle. The journey times of these have been taken into account (with immediate departure for the minimum time, maximum wait for the maximum time, and half the frequency in minutes for the average time).

Table 25: Walking times from terminal door to gate

Airport	Terminal	Walk (m)			Shuttle (mins)		Time (min)		
		Min	Max	Mean	Time	Frequency	Min	Max	Mean
Munich	T1	100	200	150	0	0	1.2	2.4	1.8
	T1S	300	450	375	0	0	3.6	5.4	4.5
	T2	200	680	440	0	0	2.4	8.1	5.2
	T2S	280	710	440	1	1	4.3	10.5	6.7
Frankfurt	T1	150	800	400	0	0	1.8	9.5	4.8
	T2	150	1350	320	0	0	1.8	16.1	3.8
Schiphol		130	900	500	0	0	1.5	10.7	6.0
Barajas	T1	50	560	260	0	0	0.6	6.7	3.1
	T2	100	450	350	0	0	1.2	5.4	4.2
	T3	50	200	100	0	0	0.6	2.4	1.2
	T4	260	760	580	0	0	3.1	9.0	6.9
	T4S	300	600	420	3	2	6.6	12.1	9.0
Heathrow	T2A	215	340	285	0	0	2.6	4.0	3.4
	T2B	540	1040	830	0	0	6.4	12.4	9.9
	T3	200	950	710	0	0	2.4	11.3	8.5
	T4	200	975	445	0	0	2.4	11.6	5.3
	T5A	150	375	280	0	0	1.8	4.5	3.3
	T5B	200	320	255	3.75[3]	1.5	6.1	9.1	7.5
	T5C	200	305	250	4.5[3]	1.5	6.9	9.6	8.2
Paris Orly	South	140	250	290	0	0	1.7	3.0	3.5
	West	-	-	260	0	0	-	-	3.1
Barcelona	T1	-	-	890	0	0	-	-	10.6
	T2	-	-	600	0	0	-	-	7.1

[3] *3 minutes added to account for descending 5 floors and climbing 3 floors by escalator.*

** The symbol '-' means not estimated.*

Values for a selection of airports can be found in Table 25.

Kerb to terminal entrance

The first element of interest in the Kerb-to-Gate part of the passenger's journey is the time taken to get from the airport kerb, as defined in DATASET2050 - the point of termination of the primary mode of surface transport at the airport, and the entrance to the terminal from which the passenger is flying. The possibilities for this are shown in Figure 48.

In the case of surface transport by taxi or kiss-and-fly this, including time that could be allowed for removing luggage from the taxi/car's boot, paying the taxi driver etc., is short enough to be negligible. The same is true for public transport/hotel shuttles, as well as off-site car-parking/car-hire shuttles, that drop passengers off at the terminal.

For a car parked at the short-term car park, a lift/escalator or perhaps a short walk generally has to be taken. Here, the main time taken is in walking from the parking place to the lift. A standard figure could be chosen for this value. Added to the time taken for removing luggage from the car and taking the lift, a few minutes should suffice. (The driver will probably spend longer trying to find the parking space in the first place!)

Passengers who park their cars in the long-term car park need to take some form of airport transport to the terminal. Additionally, such car parks generally occupy a larger surface are than short-term ones - they are often large ground-level areas - so the walking time to the pick-up point for this airport transport may be considerable - several minutes. The average waiting time for the airport transport must also be considered as well as the time this transport will take to get to the terminal. These values may be estimated from airport maps and published transport schedules.

While some public transport will take the passenger to the desired terminal, for others there is a central transport hub, especially in the case of mainline train services. Sometimes different modes may have different hubs (e.g. Paris CDG's TGV station is at Terminal 2 only, the RER local rail is at a central hub with shuttle and bus stops near Terminal 3). Again, if the hub is not at the required terminal, airport transport will have to be taken, with approximately the same timings as for the airport transport at long-term car parks discussed above.

Finally, on-site car-hire return offices pose their own challenges to the 4-hour door-to-door objective. Not only does the passenger have to wait for and take a shuttle to the required terminal (assuming that the on-site office is not at this terminal; otherwise this time is equivalent to that of the driver of a car in short-term parking) but the time required to process the return of the car must be included.

All of these options may be tabulated as follows:

Table 26: Generic times in minutes from "kerb" to terminal

Transport node	Process/walking time	Waiting time	Transport time
Taxi/Kiss-and-Fly/Shuttle	0	0	0
Public transport to terminal	0	0	0
Public transport hub	x	x	x
Short-term car park	x	0	0
Long-term car park	x	x	x
On-site car-hire return	y	y	x

where values of x are airport dependent and obtained from maps etc. Values of y are standard values for the car-hire industry.

Average transport times in this table are either given on airport web-sites or must be calculated based on distance measured on maps. Buses accelerate at 0.7-0.9 m/s/s times 70% if full and times 85-90% if they have air conditioning (Vuchic 2007). So we can assume an average value of 0.6m/s/s. Deceleration rates are much the same (Madison 2013). If a cruising speed of 50kph is assumed, acceleration and deceleration will cover approximately 325m in 27 seconds. Each further 100m will take 7.143 seconds. (Obviously, shorter journeys will not reach 50kph.)

To this should be added the time taken to board and leave the bus, which is highly dependent on the number of passengers and the amount of luggage they have with them. For this work, an average boarding delay of 1 minute is taken and an average leaving time of 30 seconds, therefore adding 1½ to the total journey time.

Calculated total minimum, maximum and average journey times (walk, wait and shuttle transport) from the different "kerbs" to each terminal of selected airports are given in minutes in Table 27.

4.2 Airport Transfer Process Times

Although flight connections can involve all of the Gate-to-Kerb processes and more, transfers are treated in the Gate-to-Gate section of this document, since that section covers the passenger's journey from the first gate to the last.

Table 27: Times in minutes from "kerb" to terminal for given airports

Airport	Terminal	Short-term car park			Long-term car park			Train			Metro			Bus			Coach			Car-hire		
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Munich	T1	1.2	4.8	1.7	7.2	37.8	34.6	3.6	8.3	6.0	3.6	8.3	6.0	8.3	13.1	10.7	8.3	13.1	10.7	1.2	8.3	4.8
	T1S	1.2	4.8	1.7	7.2	37.8	34.6	3.6	8.3	6.0	3.6	8.3	6.0	8.3	13.1	10.7	8.3	13.1	10.7	1.2	8.3	4.8
	T2	0.0	1.8	0.9	4.8	25.9	26.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	3.0	4.8	3.6
	T2S	0.0	1.8	0.9	4.8	25.9	26.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	3.0	4.8	3.6
Frankfurt	T1	0.0			14.0	17.6	15.8	2.4	2.4	2.4	2.4	2.4	2.4	0.0	0.0	0.0	3.6	3.6	3.6	3.6	3.6	3.6
	T2	0.0			22.0	25.6	23.8				2.4	2.4	2.4	0.0	0.0	0.0	7.1	7.1	7.1	6.3	6.3	6.3
Schiphol		1.2	4.8	2.4	3.0	15.5	9.9	0	0	0				0.0	0.0	0.0				11.5	11.5	11.5
Barajas	T1	0.0	4.8	2.4	3.0	22.2	12.9				4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	0.0	0.0	0.0
	T2	0.0	2.4	2.1	5.0	24.2	14.9				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	4.8	4.8
	T3	0.0	5.4	5.1	5.0	24.2	14.9				2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	7.1	7.1	7.1
	T4	0.0	6.0	3.0	4.0	22.0	12.7				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heathrow	T2	1.5	3.0	2.3	8.6	23.4	16.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6			
	T3	1.5	3.0	2.3	10.2	25.0	17.6	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2			
	T4	0.0	1.5	0.8	3.0	17.2	10.1	2.0	2.0	2.0	1.0	1.0	1.0	0.0	0.0	0.0	0-.0	0.0	0.0			
	T5	2.5	5.0	3.8	4.0	20.0	12.0	3.2	3.2	3.2	3.2	3.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0			
Paris Orly	South	-	-	2.5	-	-	21.8	-	-	-	-	-	11.0	-	-	1.8	-	-	1.8	-	-	11.0
	West	-	-	1.9	-	-	19.8	-	-	-	-	-	1.8	-	-	0.5	-	-	0.5	1.5	2.7	2.1
Barcelona	T1	-	-	3.6	4.9	29.4	14.2	-	-	22.7	-	-	3.1	-	-	0.0	-	-	0.0	-	-	1.0
	T2	-	-	4.9	6.4	24.0	14.2	-	-	6.7	-	-	6.7	-	-	0.0	-	-	0.0	-	-	2.1

5 Gate to gate

The Gate-to-Gate process is the real core of the door-to-door trips involving air transport. It begins when the boarding card is scanned at the departure gate and ends when the passenger enters the terminal at their final destination airport. It is composed of three sub-processes - boarding, the flight itself, and disembarkation. The main gate-to-gate process and sub-processes are shown below:

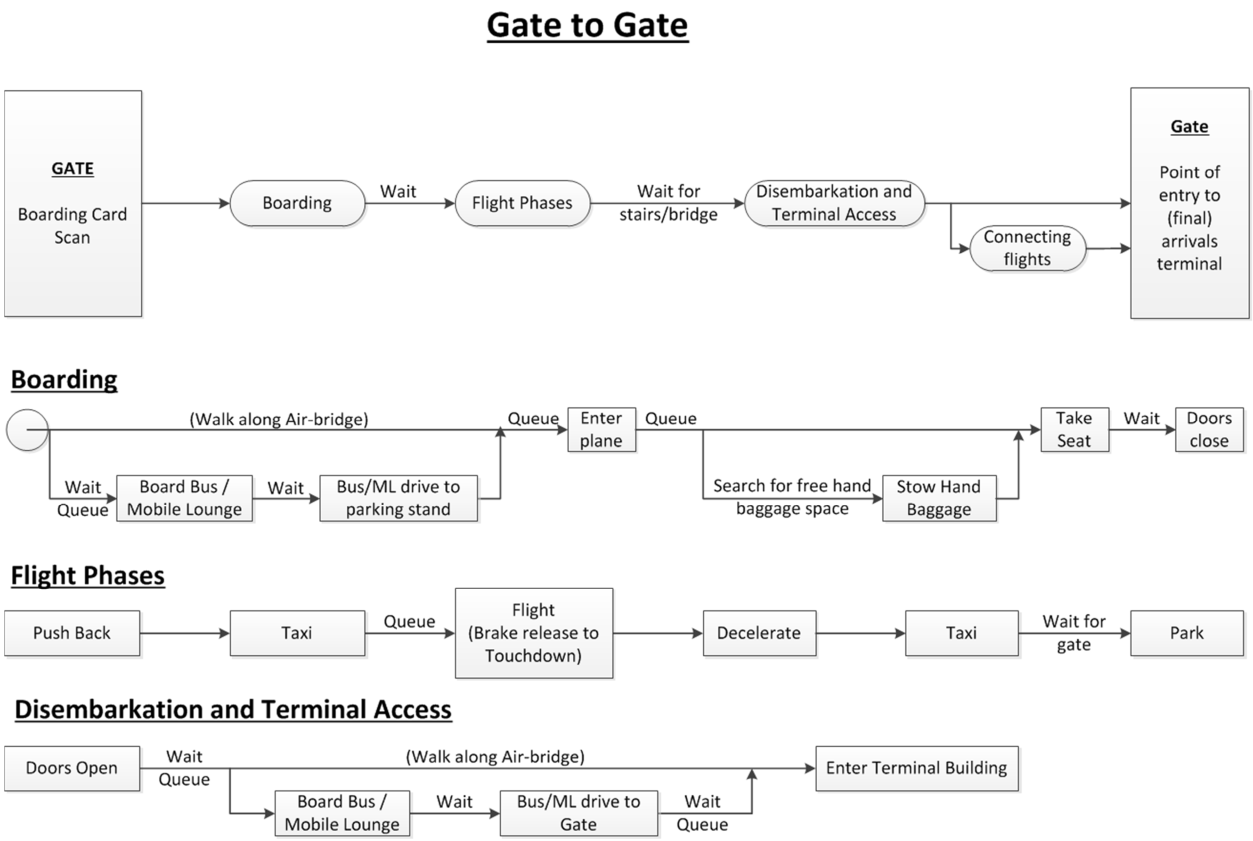


Figure 51: Gate-to-gate process

The Gate-to-Gate phase is further complicated by the possible inclusion of connecting flights and the procedures involved in this connection. This connection process is in turn complicated even more by the fact that it may involve a change of terminal; connections involving a change of airport - e.g. London Gatwick to London Heathrow - are not included in this study. The different connection processes are shown in Figure 52.

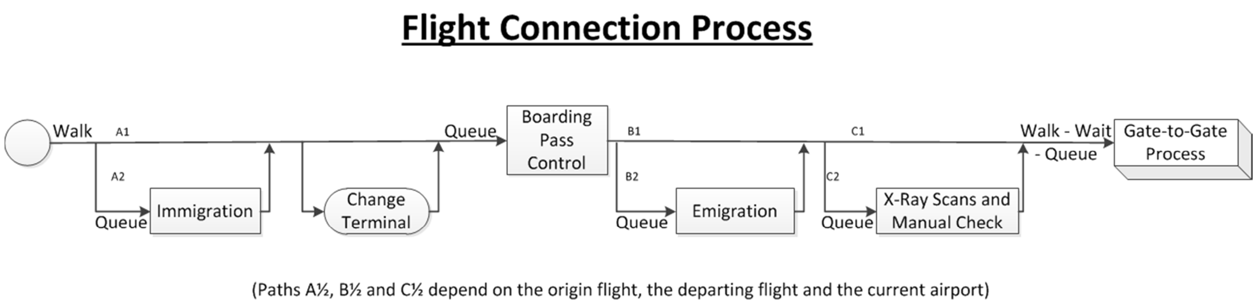


Figure 52: Flight connection process

Whether or not the passenger needs to change terminal depends, of course, on the airport layout and often the airlines used for the two flights. The means used to change terminal will also depend on the airport and could be by foot/moving walkway/escalator, automatic train, bus etc.

The order of Emigration check and X-Ray scans in the above diagram may be reversed. The choice of C1 or C2 depends on the airport layout and local security policy. The C2 path will always be taken in the case of a change of terminal.

The route taken through the immigration and emigration processes depends on whether the airport is in Schengen or not; whether the passenger has come from a Schengen, non-Schengen or domestic airport; and whether the passenger's onward flight is to a Schengen, non-Schengen or domestic airport. Table 28 defines this route according to the given conditions:

Table 28: Process options for flight connections

This airport	Inbound from	Outbound to	Path
Schengen	Domestic	Domestic	A1 - B1
		Schengen	A1 - B1
		Non-Schengen	A1 - B2
	Schengen	Domestic	A1 - B1
		Schengen	A1 - B1
		Non-Schengen	A1 - B2
	Non-Schengen	Domestic	A2 - B1
		Schengen	A2 - B1
		Non-Schengen	A2 - B2 or A1 - B1
Non-Schengen	Domestic	Domestic	A1 - B1
		Schengen	A1 - B2
		Non-Schengen	A1 - B2
	Schengen	Domestic	A2 - B1
		Schengen	A2 - B2 or A1 - B1
		Non-Schengen	A2 - B2 or A1 - B1
	Non-Schengen	Domestic	A2 - B1
		Schengen	A2 - B2 or A1 - B1
		Non-Schengen	A2 - B2 or A1 - B1

In all of these cases, it is assumed that bags have been checked through to destination.

Where there is the possibility of either A1 - B1 or A2 - B2, this will depend on local immigration policy and airport layout. In these cases, the A2 - B2 option will always be used if there is a need to change terminal unless, in very unusual cases, this takes place airside.

5.1 Gate-to-Gate Process Times

5.1.1 Current status of the modelling

Calculating the precise time required by a passenger in gate-to-gate processes is a challenging task. The minimum time required flying between airports in the geographical area within EU28+EFTA (also referred to as intra-European in this section) can be calculated more easily, as can the time required in airport processes (boarding, taxiing, etc.).

Estimated Gate-to-Gate Flight Times

Traffic samples were provided by EUROCONTROL. Two days were studied: a quiet day, 15/01/2016, with 16812 intra-European flights; and a busy day, 01/07/2016, with 24656 intra-European flights. The two days were analysed separately, and unweighted averages of the means and percentiles from the two samples were calculated. These are presented in the table below. Studying a quiet day and a busy day reduces the seasonal effects in the results.

Table 29: Distribution of several measures of flight-time for two days' intra-Europe (EU28+EFTA) flights

	On-Block - Off-Block (hh:mm)	On-Block - Off-Block + De-/Boarding Time (hh:mm)	On-Block - Off-Block + De-/Boarding Time + Regulated Delay (hh:mm)
mean	01:48	02:07	02:09
10 th percentile	00:48	00:54	00:54
25 th percentile	01:03	01:14	01:15
50 th percentile	01:24	01:46	01:47
75 th percentile	02:00	02:26	02:29
90 th percentile	02:40	03:10	03:15
95 th percentile	03:10	03:40	03:45
99 th percentile	04:27	04:58	05:02

where:

- The flight time is on-block minus off-block (2nd column).
- The gate-to-gate time is the on-block minus off-block plus the boarding and de-boarding times (3rd column).
- The fourth column shows the impact of air traffic flow management (ATFM) delay (ground delay imposed by the Network Manager) to cope with congested airspace. The impact of ATFM delay is further treated below.

The table gives real flight times, which are averages from the two traffic samples (15/01/2016 and 01/07/2016). For collaborative decision making (CDM) airports, the real taxi-out and taxi-in times are used. For non-CDM airports, the assumed taxi-out time used by the Network Manager and the taxi-in times in Table 38 in Appendix 1 were used. If the non-CDM airport did not appear in Table 38 it is assumed that the taxi-in time is half that for taxi-out.

Delays attributable to the airline, such as a missing passenger or a technical problem with the aircraft, baggage handling or refuelling are considered to be part of the Kerb-to-Gate segment.

Passenger boarding and de-boarding times have been estimated at 25' and 20' respectively for the A320 family and Boeing 737 analogues. These aircraft account for 48% of all flights in the traffic sample. All passengers will experience the 25' boarding time, whereas the de-boarding time depends on when the passenger leaves the aircraft - a function of how far away from the door he/she is seated - and will be between 0 and 20 minutes. For the A320 family and Boeing analogues, therefore, a boarding time of 25' and a de-boarding time of 10' (mid-point between 0 and 20) have been assumed.

Boarding and de-boarding times for the E170/E190 aircraft types are estimated to be 15 minutes and 10 minutes, respectively, on the advice of a dispatcher who works with these. Similarly sized and configured aircraft types (AT72, AT75, AT76, CRJ9, DH8D) have been assigned the same boarding/de-boarding times as the E170/E190 types. The percentage of the traffic sample that includes estimated boarding and de-boarding times is 67%.

The remaining 33% of flights (made up of diverse aircraft types) are assumed to have zero minutes for boarding and de-boarding, which is obviously an underestimate. An additional cause for under-estimation is that for some flights, passengers are bussed to/from their aircraft, and thus require more time for boarding and de-boarding.

Effect of ATFM Delay

ATFM delay is absorbed on the ground in order to avoid unnecessary fuel-burn and possible fuel-shortage problems or diversions when airborne. Therefore ATFM delay should be assigned to the kerb-to-gate segment while passengers wait in the lounge. However, it is nonetheless informative to see the effect of *real* ATFM delay on *real* traffic, and this is why it is included here. ATFM delay did not have a large effect on network journey times according to the table above, evidenced by the third and fourth columns' showing similar numbers. In support of this, the chart below shows the distribution of gate-to-gate times for flights on 01/07/2016 with and without the ATFM delay that the flights received. There were 76,000 minutes of ATFM delay on this particular day, an average of 3.1 minutes of delay per flight, which is more than usual. The red and green distributions more-or-less overlap, which leads to the conclusion that ATFM delay generally has little impact on gate-to-gate distribution in Europe (although individual affected flights may incur significant delay, of course). In other words, a strong focus on reducing the current level of ATFM delay will do little to achieve the goal of 90% of journeys within four hours!

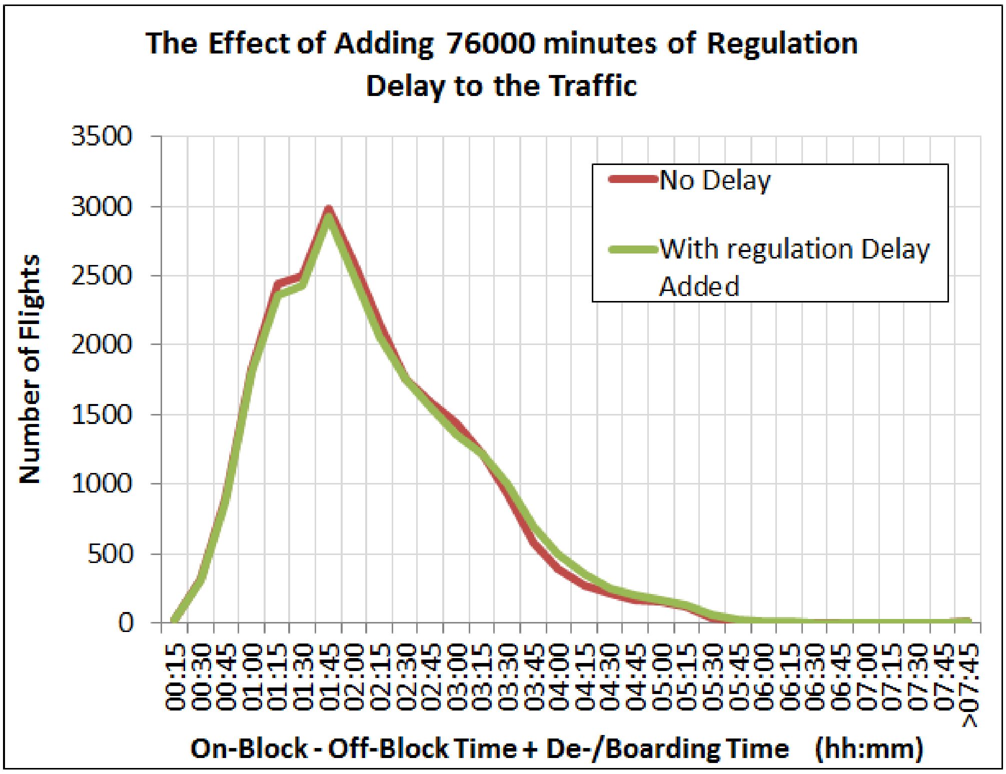


Figure 53: Distribution of journey time, with ATFM delay included and removed. (Only intra-Europe flights for 01/07/2016.)

Estimated Gate-to-Gate Passenger Times

The number of passengers per flight is confidential information to each airline, so the previous analysis focused on the number of flights, not the number of passengers. However, an attempt has been made to estimate passenger numbers in the traffic sample taken from 15/01/2016. The results appear in the Table 38 in Appendix 1. Passengers per flight were estimated by first taking account of the aircraft type for a given flight, assuming a particular seating configuration for this type (several seat configurations are available for a given type), then by assuming an 80% passenger load factor for every flight (this is in line with IATA's global figures for 2015 and the beginning of 2016). Low-cost carriers typically have higher load factors than this (for example, easyJet's passenger load factor is 92% for the year ending August 2016), but using a single industry-wide figure is a simple approach.

The table shows that 90% of flights had a gate-to-gate time of 3:10 or less. When passenger numbers are considered instead, the 90th percentile flight yields the 86th percentile passenger (for gate-to-gate). This means that 90% of flights and only 86% of passengers are within 3:10; 14% of passengers have gate-to-gate times exceeding 3:10. By inspecting the flight times and passenger numbers together it is quite clear that shorter gate-to-gate times correlate with smaller aircraft and therefore fewer passengers per flight, and longer journeys correlate with larger aircraft and more passengers per flight. The 90th percentile gate-to-gate passenger journey time is 3:25. (This is the average figure for 15/01/2016 and 01/07/2016.)

To conclude, it would be better to use the 90th percentile gate-to-gate passenger journey time (3:25) rather than the 90th percentile flight time. It seems highly unlikely that the 90% target of four-hour door-to-door journeys for passengers is met today.

5.1.2 Full passenger connectivity - integrating forward into the model

The estimation of passenger numbers (described above) is being taken forward through the construction of individual passenger itineraries. When work on this task is completed it will provide a unique modelling advantage – itineraries with full connectivity covering 200 airports within the ECAC area. This task closely links with Section 5.2, which introduces the estimation of total connecting passengers and their corresponding connection times at each airport.

In summary, the new individual passenger itineraries are extracted from anonymised, aggregated global distribution system (GDS) data. These are matched with flights, ensuring the 'marketed carrier' of each ticket is compatible with the flight, i.e. flown by the same airline, a partner airline or a member of the same alliance. For multi-leg itineraries, the connection at the intermediate airport(s) must be compatible with the schedule times whilst also respecting the minimum connecting time(s). Different passenger characteristics can be incorporated in itineraries, for example by allowing shorter connection times for business passengers or the opposite for budget travellers.

To facilitate the passenger allocation process, each Demand Data Repository (DDR) flight record requires additional data from other in-house and purchased sources. These enhancements include: clarifying the operator name (to ensure only commercial passenger flights have passengers allocated), assigning an airline type (full-service, regional, low-cost carrier and charter), schedule times and seating capacity. An overall daily passenger target is estimated by applying a load factor for each of the four airline types (derived from published airline reference values), for example, approximately 3.8 million passengers were estimated for a busy day in September 2014, leading to an overall load factor of 84%.

Given these allocation constraints, itineraries are assigned to individual flights probabilistically. Note that some itineraries have to be imputed since GDS coverage is incomplete. Calibration to ensure that allocated passengers per airport (terminating plus connecting passengers) are within expected ranges is carried out using estimates derived from monthly (or annual) ACI EUROPE and Eurostat passenger data in the absence of a pan-European source of daily passenger numbers per airport.

The foundation work for the full passenger connectivity presented above will be developed further in the next DATASET2050 deliverables. The need to address passenger delay with dedicated metrics (as distinct from flight delay) has been established for some while, with the earliest evidence from the US. Based on a model using 2005 US data for flights between the 35 busiest airports, Sherry *et al.* (2008) concur that "flight delay data is a poor proxy for measuring passenger trip delays". For passengers (on single-segment routes) and flights, delayed alike by more than 15 minutes, the ratio of the separate delay metrics was estimated at 1.6 (see Figure 54). Furthermore, heavily skewed distributions of passenger trip delay demonstrated that a small proportion of passengers experienced heavy delays, which was not apparent from flight-based performance metrics (Wang (2007), Calderón-Meza *et al.* (2008)). Early analyses in the European context (based on 200 airports in 2010) concur with such findings (Cook *et al.*, 2013). This work will be further developed in Deliverable 3.2, examining passenger demand evolution set in the context of the (future) meta-scenarios developed in Deliverable 4.2. The issues of (passenger) disruption, and potential regulatory impact, will also be examined further in these deliverables. In Deliverable 4.2 the impact on metrics and metric trade-offs will also be addressed.

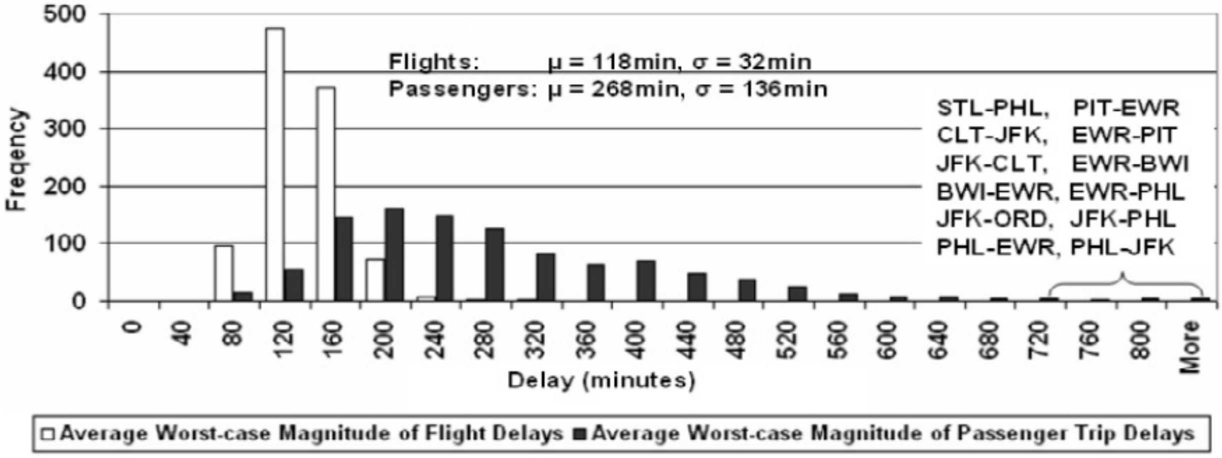


Figure 54: Passenger delays are longer than flight delays on average (Sherry_2008)

5.2 Transfers

Flight connections are a very complicated question. They range from the very simple - boarding card check at the "Flight Transfers" hall, go to departure lounge, wait for next flight - for domestic and intra-Schengen connections, to the extremely complicated transfers that involve changing terminal. This can involve all of the Gate-to-Kerb processes plus all of the Kerb-to-Gate processes (with the exception of luggage reclaim, and bag drop) with a wait for, and a taking of, airport transport in between. However, transfers are treated here since Gate-to-Gate covers the part of the passenger's journey from the first gate to the last.

Whereas total passengers and the split between international and domestics passengers are widely reported by airports, their associations and civil aviation authorities, the proportion of connecting passengers per airport is more difficult to acquire. Generally transfer data are sourced on a case-by-case basis from individual airports, though estimations can be made from GDS ticket data (if available) such as the method outlined by Maertens and Grimme (2015) using the Sabre Airport Data Intelligence database, however such datasets are expensive to source.

Unpublished annual transfer rates have been obtained from ACI EUROPE (personal communication), albeit with incomplete airport coverage. Transfer rates at major European airports in 2014 are given in Table 30.

The information available for such transfers comes from the minimum connecting times (MCT) at each airport. The MCT is the shortest time interval required for a passenger (and baggage) to connect between flights at an airport or metropolitan area. MCTs are administered by IATA and must be observed when tickets are sold and reservations made. 'Standard' MCTs are available for connections between flights that serve: domestic to domestic, domestic to international; international to domestic; and international to international – these are published in airport timetables and may vary according to terminal. (Note: an airport without international flights will only have a standard domestic to domestic MCT.) These times apply to any type of connection, e.g. Schengen to Schengen and Schengen to International.

However there are many deviations from these standard MCTs, referred to as 'MCT exceptions'. Longer times may be specified when connecting between different terminals, and bilateral MCT agreements may be made between airlines. In addition to operational considerations, airlines may specify shorter times in an attempt to gain competitive advantage over other airlines' connection times. MCT exceptions also specify connections that cannot be achieved or that, for various reasons, are required to be suppressed. At major airports, there are often hundreds of MCT exceptions – these are rarely published, but are commercially available from suppliers such as OAG and Innovata.

Table 30: Total passengers and proportion of connecting passengers at the top 15 ECAC airports in 2014

Rank*	Airport	Total passengers	**Transfer passengers
1	London Heathrow Airport	73.4 m	36%
2	Paris Charles de Gaulle Airport	63.8 m	31%
3	Frankfurt Airport	59.6 m	55%
4	Istanbul Atatürk Airport	56.7 m	-
5	Amsterdam Airport Schiphol	55.0 m	41%
6	Madrid Barajas Adolfo Suárez Airport	41.8 m	-
7	Munich Airport	39.7 m	37%
8	Rome Leonardo da Vinci-Fiumicino Airport	38.5 m	-
9	London Gatwick Airport	38.1 m	-
10	Barcelona El Prat Airport	37.5 m	-
11	Paris Orly Airport	28.9 m	7%
12	Antalya Airport	28.5 m	-
13	Copenhagen Airport	25.6 m	25%
14	Zürich Airport	25.4 m	30%
15	Oslo Gardermoen Airport	24.1 m	23%

*ranked by total passengers at ECAC airports in 2014 **proportion of transfer passengers i

Table 31: Munich Airport standard minimum connecting times

Terminal	Connection type	MCTs (minutes)
Within Terminal 1	Domestic to domestic	35
	Domestic to international	
	International to domestic	
	International to international	
Within Terminal 2	Domestic to domestic	30
	Domestic to international	
	International to domestic	
	International to international	
Between Terminals	All	45

A review of minimum connecting times has been carried out using data from 2010, though more up-to-date MCTs will be acquired for further use in DATASET2050. Standard MCTs are traditionally static whereas MCT exceptions change as airlines update their schedules, aircraft, partnerships or move terminals. As an example, Table 31 shows standard MCTs at Munich Airport (unchanged between 2010 and 2016).

Table 32 provides examples of some of the MCT exceptions applicable at Munich Airport during 2010. Compared with the standard MCTs in Table 31, no exceptions allow a shorter connection time.

A subset of usable MCTs can be derived for use in the project from the various standard and exceptional minimum connecting times. Three provisional MCTs per airport are included in Table 38 in Appendix 1: a single standard MCT (average by connection type), a domestic MCT and an international MCT (for all combinations of connections involving international flights). These will be reviewed and updated using new data.

Table 32: Munich Airport standard minimum connecting time exceptions

Terminal	Connection type	Inbound connecting flight	Outbound connecting flight	MCT exceptions (minutes)
Within Terminal 1	Domestic - domestic	Air Berlin arrivals	All (except specified departures)	50
Within Terminal 1	Domestic - domestic	All (except specified arrivals)	Air Berlin departures	50
Within Terminal 1	International - international	Air Berlin AB 7000 - AB 7499	S7 Airlines S7 4898	50
Within Terminal 2	International - domestic	Lufthansa LH 7440 - LH 7599	Lufthansa	45
Within Terminal 2	International - international	United Airlines UA 9435 - UA 9464	United Airlines	40
Between Terminals	All	All (except specified arrivals)	S7 Airlines S7 4893, S7 4898	60
None specified	International - international	United Airlines UA 9435 - UA 9464	United Airlines UA 8694 - UA 9299	30
None specified	International - international	United Airlines UA 8694 - UA 9299	United Airlines UA 9435 - UA 9464	30

5.3 Possibilities for Gate-to-Gate Process Time Reduction

The following are some preliminary ideas and possibilities for Gate-to-gate processes time reduction. These will be expanded in subsequent deliverables: D4.2 and D5.1.

1. There will be very little scope for compressing flight times unless the performance envelope of aircraft engines change, or if shorter flight times become very much more important than the cost of fuel;
2. Flying free routes as opposed to predefined routes and directs will not significantly reduce the distance flown and thereby save flying time. In 2014, the horizontal inefficiency of flight plans was 4.9% (EUROCONTROL, 2014). The horizontal inefficiency of the actual flights was around 2.8%. So the cruise time could be reduced by that much at most. The current implementation of free routes seems to be limited to with a given ACC. This ought to become free routing across an entire functional airspace block (FAB) at some point, and then possible across the whole flight;
3. Item 2 doesn't consider the 40NM around each of the two airports. Arrival managers (AMAN), Point-Merge etc. will remove things like Heathrow stacking and excessive tromboning/vectoring which are factors in the second of these 40NM distances. Departure managers (DMAN) will probably increase the efficiency of the first 40NM;
4. Things like Brake-to-Vacate could reduce the time between touchdown and arrival at the stand by half a minute or so;
5. Taxi times could possibly be slightly compressed, through improved airport layout for example, but it is doubtful that significant changes can be achieved by 2050;
6. Total boarding/de-boarding time would likely be 26'-45' for a passenger on an A320 family aircraft, and 41'-70' on a B777 or similar long haul aircraft - much time is spent queuing and waiting! However, boarding and de-boarding could be speeded-up significantly, but at extra cost to the airline (using more doors, for example) or with more inconvenience to passengers (Daily Mail 2016);
7. Depending on the airport layout, using busses for taking passengers to the terminal building could either increase or reduce passenger journey time. De-boarding passengers onto busses forces them all to experience the full de-boarding time of a flight, but despite this there could be a time saving if

the bus were to eliminate the need for a long walk in the terminal building and reduce the need for taxiing (as in the case of Washington Dulles International Airport, for example);

8. Flight connections can be a major contributor to the total gate-to-gate time and processes for handling transfer passengers could possibly be speeded-up.

As reported in section 5.1, reducing the current level of air traffic flow management (ATFM) delay will do little to speed up gate-to-gate process times. Activities should be concentrated elsewhere.

In summary, the possibilities for reducing the time the passenger spends in the gate-to-gate segment are limited. Note, however, that once the DATASET2050 model is run, the objective is to analyse compression times for each process in the gate-to-gate segment. This may include an analysis per airport.

6 Summary of Results

Many airports and government departments/agencies responsible for aviation undertake passenger surveys that collect precisely the information that this report is looking for: surface access methods, journey times, process times inside the airport, etc. However, these data, if they are published at all, are published in aggregated form sometimes bundling many airports together or bundling passengers by criteria that are not relevant here - e.g. domestic/international. If it is possible to obtain detailed information, this is only available at a price that is beyond the budgetary means of this project. This means that the data that have been obtained have not enabled the determination of values for EU + EFTA passengers. This fact must be taken into consideration when using the following results.

6.1 Surface Access/Egress

Passengers' needs, priorities (e.g., cost and time), geographical locations, etc. are very complex. Additionally, not all destinations are accessible from all airports. These facts greatly affect a passenger's choice of airport, the mode of transport used to access it and thus the time required for this part of the journey.

All airports are different for a variety of demographic, cultural and historical reasons. However, if we categorise those for which we have data into large and small, with the split at around 15 million passengers, we can see that whereas large airports have a private/public transport split of around 60%-40%, that of the smaller ones is 75%-25%.

Table 33: Average private/public transport split for large and small airports

	Large airports (>15M passengers/year)[4]		Small airports (<15M passengers/year)[5]	
	Mean	**SD***	**Mean**	**SD***
Private %	61.0	12.07	75.0	12.98
Public %	38.6	11.78	24.6	12.82
Other %	0.4	0.72	0.7	0.86

**SD = Standard deviation*

It should be noted that the data for the "small airports" includes two grouped values that include several large airports from Table 3 (CDG and Orly) and Table 4 (Frankfurt, Munich, Berlin Tegel, Dusseldorf and Hamburg) and which will bias the "small airports" values towards the "large airports" ones. The "small airports" mean total is not exactly 100 due to rounding errors in the original data.

Private transport in these values includes taxis which account for 25%-29% of surface access at Large airports (Heathrow, Dublin, CDG and Orly), and between 17%-21% for a basket of French and German airports including mostly small airports.

The means of public transport used depend, obviously, on the means available at the particular airport. An analysis of access to Frankfurt has shown that the use of intercity rail for travelling distances of over 150km to the airport is independent of the distance to be travelled and averages around 62% of these travellers.

[4] Gatwick, Heathrow, Manchester, Stansted, Dublin, CDG, Orly

[5] London City, Birmingham, Doncaster, East Midlands, Leeds-Bradford, Liverpool, Luton and 15 French airports (including CDG and Orly) and 22 German airports (including large airports)

While passengers may originate many hundreds of kilometres from the airport, study of UK airports has shown that around 70% of them come from the airport's home region, and 45%-50% from its home county, irrespective of the size of the airport, though there are obviously differences due to geographical and political factors.

While there is only a small difference between access and egress speeds for a given mode, travel by private transport is on average more than twice as fast as public transport (67km/h against 28km/h for 22 airports studied) and in Berlin, it can be faster to cycle than to take public transport! However, these times vary during the day, almost reaching parity during the evening rush-hour and there is a greater variance, and therefore less reliability, in private transport speeds over public transport. Average speeds for both modes are given in Table 43 in Appendix 5. Section 3.4.4 presents specific recommendations for how these speeds should be modified to take factors such as distance travelled and time of day, and perhaps access/egress, and day of week into account (the work on this project only studied the differences between weekdays; factors for weekend days could be the subject of future work). These are summarised here:

Table 34: Summary of speed multiplication factors for airport travel by mode

	Distance travelled (km)							Time of day					Direc-tion		Day of the week		
Travel Mode	**50**	**100**	**150**	**200**	**250**	**300**	**350**	**9:00**	**12:00**	**15:00**	**18:00**	**21:00**	**Access**	**Egress**	**Mon**	**Wed**	**Fri**
Driving	0.71	1.04	1.18	1.28	1.32	1.31	1.31	0.99	1.00	0.98	0.98	1.05	1.02	0.98	1.01	1.00	0.99
Public transport	0.56	1.06	1.43	1.61	1.78	2.09	2.05	1.02	1.03	1.03	0.99	0.94	1.01	0.99	1.00	1.00	1.00

Additionally, if the only measure of distance available is a straight line, this should be multiplied by 1.63 for the driving distance and 2.07 for public transport.

6.2 Airport Processes

There is a clear dichotomy between the ACARE target designed to speed-up the system's passenger throughput, and the wish of airport operators to extend as much as possible the amount of time passengers spend in the shopping malls that boarding gates are now simply an add-on to. This shopping time can be assimilated to buffer time, however, and is not considered in the present analysis. It is clear, though, that modern airport layouts, and the dawdling of these "buffer time" passengers, can hinder the progress of those who are in a hurry.

The processes inside the airport can be broken down into three components: getting to the terminal door; moving through the terminal (mostly walking); and the specific times taken waiting/queuing and being processed.

Table 35: Mean terminal access times

Arrival point (kerb)	Short-term car park	Long-term car park	Train	Metro	Bus	Coach	Car-hire
Mean (min)	2.49	18.54	4.68	3.19	1.97	2.68	4.42
SD (min)	1.23	7.28	5.81	2.68	3.22	3.38	3.35

Table 35 gives the unweighted mean times for access to the terminal from the kerb calculated from data for major airports given in Table 27. The high standard deviations are due to the different airport architectures concerning the position of central transport hubs within the airport etc. These values should, of course, be taken into account with the percentages of passengers using each airport kerb.

The mean unweighted average walking time through the terminal is 5.55 minutes (σ =2.59), calculated from data for major airports given in Table 25. It should be noted that these times are for walking from the terminal door to the gate. They may be much longer for a passenger transferring from a flight at one end of the terminal/airport to a flight at the other end (some terminals - e.g. Madrid T4 - can be a kilometre long or more).

It has not been possible to obtain individual data concerning process times for different airports in Europe other than the weighted average security queue time at selected UK airports, for which the general mean was 6.80 minutes (σ = 1.43). Other acceptable queuing times have been defined by IATA as in Table 36.

Table 36: IATA Acceptable queuing times

Process	**Acceptable queue time (min)**
Baggage claim	12
Check-in economy passengers	12
Check-in first and business class	3
Passport Control inbound	7
Passport Control outbound	5
Security Control	3

The actual process times (once the end of the queue has been reached) have been obtained from simulations performed in 2007 and given in Table 24. These are repeated here.

Facility	**Process time (secs)**
Check-in counter	120
Check-in terminal	63
Bag-drop	45 +25/bag
Boarding-Pass Control	6
Passport Control outbound	10
Security Control (X-Ray)	35
Manual Security Check	120
Gate Control	6
Passport Control inbound	10
Baggage Reclaim/Customs	0

6.3 Gate to Gate

A process diagram for the Gate-to-Gate process is presented in Figure 51. The diagram not only shows the complexity of this journey segment, but will be invaluable for identifying time savings for journeys in 2035 and 2050.

Data on passenger journey times are not readily available. Instead, work has focused on the analysis of flight-time data. However, passenger journey times have been estimated using some assumptions and extrapolation. Based on a small but representative sample of intra-European flights in 2016, an estimate of the 90th percentile Gate-to-Gate time is 03:10 for flights and 03:25 for passengers. Given these values, it seems highly unlikely that the 90% target of four-hour door-to-door passenger journeys is met today, even ignoring the fact that these are lower-bound estimates.

Of this Gate-to-Gate time, a passenger-weighted average of 12.9 minutes (SD=3.72) is spent on taxiing out and 5.9 minutes (SD=1.64) on taxiing in[6]. Estimated passenger boarding and de-boarding times for certain aircraft types are given in Table 37. These aircraft types cover 67% of the traffic sample studied.

Table 37: Estimated boarding and de-boarding times

Aircraft	Boarding (min)	De-boarding (min)
A320	25	0-20
B737	20	0-20
E170	15	0-15
E190	10	0-10

AT72, AT75, AT76, CRJ9, DH8D have approximately the same times as the E170 and E190.

Whilst passenger journey times have been rather crudely estimated so far, work is ongoing to construct individual passenger itineraries which will provide a more accurate estimate of true passenger journey times. A significant improvement will be the inclusion of transfers, which hitherto have been ignored by assuming there are no intra-European transfers!

Some ideas have been presented to reduce Gate-to-Gate processing times. It seems that little can be done to speed up the flight segment itself. Reducing air traffic flow management (ATFM) delay will have an insignificant effect on the percentile passenger journey times and so this would not be a fruitful avenue to concentrate on for meeting the project's four-hour goal.

[6] Calculated from taxi times and passenger numbers given in Table 38 in Appendix 1

7 Conclusions

This deliverable provides a holistic view of the different, current supply-profile processes involved in European journeys involving at least one air-transport segment. The most important outcome of D4.1 is not the deliverable itself; it is the amount of valuable data (both qualitative and quantitative) that will be used afterwards in the modelling work package, specifically for adequately modelling the current mobility-supply elements. The effort allocated in D4.1 has enabled the team to discover and access difficult-to-reach datasets and to plan how to model the air transport supply profile. This is an important project milestone, in order to contrast current mobility supply and mobility demand (as defined in D3.1). Following the DATASET2050 approach, the door-to-door process has been divided into five simpler phases: door-kerb-gate-gate-kerb-door.

The outcomes of task 4.1 range from the provision of specific data about certain airport processes (e.g. minimum times for different types of flight connection at an airport, the different surface transport options available and their timings) to the scientific research done on how to model the processes (e.g. catchment areas vs an airport feeder approach). The rationale, hypothesis, scope, literature review and some specific case studies that enable an easy understanding of the overall approach, are given in the main text sections of the deliverable whereas the data discovered in quantitative research are presented in tables in the appendices.

The outputs of D4.1 will be used in DATASET 2050 mobility modelling (WP5), and are also the foundation for D4.2, that will describe the future supply side of mobility in Europe.

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Appendix 1 Top 200 Airports in Europe

This table gives the top 200 airports in Europe with their total annual passenger numbers and subsequent ranking, plus average values for runway capacity, minimum connecting times (MCT) and taxi times. The number of passengers (pax) departing from and arriving at a given airport is also given, estimated for an averaged day (see the notes at the foot of the table for a brief explanation of how flights and passenger numbers were estimated). The table is ordered by 'Total EU28+4 Pax'. Turkish and other non EU28+4 airports appear at the bottom of the table and, of course, fall out of scope of the project.

Table 38: Passenger, flight, connection times and taxi times for the top 200 European airports

Airport	ICAO code	Pax 2015	Rank 2015	Cap-acity	EU28+4 flights/day			EU28+4 pax/day			Minimum Connection Time (minutes)			Taxi-out (minutes)		Taxi-in (minutes)	
					Departing	Arriving	Total	Departing	Arriving	Total	Std	Dom.	Int'l	Mean	SD*	Mean	SD*
Frankfurt	EDDF	61,032,022	4	93	441	444	884	53327	53389	106715	45	45	60	13.27	5.33	6.94	3.17
London Heathrow	EGLL	74,985,748	1	100	393	391	784	53170	53004	106174	84	83	84	22.46	7.93	7.96	4.64
Amsterdam Schiphol	EHAM	58,285,118	5	105	512	504	1016	52221	52009	104229	40	25	60	13.65	5.07	7.63	4.20
Munich	EDDM	40,981,522	7	103	472	472	944	49624	49841	99465	40	40	60	12.92	4.80	5.40	1.89
Madrid–Barajas Adolfo Suárez	LEMD	46,828,279	6	107	441	437	877	49525	48843	98368	111	104	114	19.70	8.24	9.36	3.69
Paris Charles de Gaulle	LFPG	65,766,986	2	121	463	449	912	48808	48106	96913	105	99	107	16.51	6.08	9.26	3.23
Barcelona El Prat	LEBL	39,711,276	10	75	366	371	737	47808	47651	95458	59	49	63	15.29	6.23	5.32	2.56
Rome Leonardo da Vinci–Fiumicino	LIRF	40,463,208	8	91	358	355	713	45857	45350	91207	52	45	60	19.20	7.88	8.07	2.92
London-Gatwick	EGKK	40,269,087	9	61	307	306	612	40915	40883	81798	61	55	63	17.99	10.02	7.73	3.56
Copenhagen	EKCH	26,610,332	14	72	325	326	650	35391	35600	70991	41	30	60	11.43	4.02	5.82	2.23
Oslo, Gardermoen	ENGM	24,678,195	17	69	319	318	637	35376	35273	70649	41	35	60	9.78	4.21	4.13	1.82
Paris-Orly	LFPO	29,664,993	11	60	278	277	554	32675	32542	65217	63	50	67	11.44	4.30	5.62	2.72
Berlin Tegel	EDDT	21,005,196	25	51	249	249	498	30236	30333	60568	41	30	60	10.75	3.53	4.39	1.96
Dublin	EIDW	25,049,335	16	47	251	250	501	30055	29895	59950	45	45	60	15.54	5.48	6.35	2.44
London Stansted	EGSS	22,519,178	23	45	228	216	444	29764	29095	58859	45	45	60	14.66	8.13	6.90	2.77
Stockholm-Arlanda	ESSA	23,142,536	20	55	282	284	566	29277	29289	58565	49	27	60	9.60	3.16	5.25	2.02
Zürich	LSZH	26,281,228	15	69	296	294	589	29105	28969	58074	40	40	60	11.27	4.26	5.67	2.11
Palma de Mallorca	LEPA	23,745,131	18	54	239	253	492	28061	28959	57019	41	30	60	13.04	4.90	5.58	3.05
Brussels	EBBR	23,460,018	19	62	284	280	563	27705	27782	55487	42	20	60	11.56	3.85	5.22	1.82

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Düsseldorf	EDDL	22,476,685	24	61	264	262	526	27404	27071	54474	35	35	60	12.88	4.50	4.54	1.82
Vienna International	LOWW	22,775,054	22	69	277	265	541	27155	26884	54038	30	30	60	11.93	5.23	6.61	2.60
Lisbon Portela	LPPT	20,090,418	26	54	208	212	420	24104	24515	48619	56	45	60	12.36	4.14	4.81	1.67
Manchester	EGCC	23,136,047	21	57	230	227	457	23709	23804	47513	39	30	60	15.05	6.33	7.12	3.72
Athens International	LGAV	18,086,894	28	48	213	217	430	22405	22582	44987	48	45	60	13.31	3.82	6.63	2.56
Hamburg	EDDH	15,610,072	31	45	213	208	420	22156	22476	44631	35	35	60	9.55	4.08	4.40	1.70
Geneva International	LSGG	15,772,081	30	50	233	232	464	21100	20974	42073	42	40	60	10.54	3.59	3.70	1.38
Helsinki	EFHK	16,422,266	29	55	199	195	393	19771	19752	39523	31	20	60	9.58	2.92	4.11	2.10
Milan Malpensa	LIMC	18,582,043	27	57	168	171	338	17989	18012	36001	74	87	69	12.15	4.42	5.61	2.57
Edinburgh	EGPH	11,114,587	39	45	169	172	341	16898	17203	34101	45	30	60	11.61	4.23	5.17	3.01
Málaga	LEMG	14,404,170	32	45	143	139	282	17162	16920	34081	48	56	60	11.86	4.43	4.23	3.13
Cologne Bonn	EDDK	10,338,375	44	45	170	170	340	16886	16527	33413	30	30	60	11.29	3.95	5.62	1.84
Nice Côte d'Azur	LFMN	12,016,730	37	46	190	193	383	16186	16229	32415	48	42	60	11.09	3.49	4.22	1.38
Milan Linate	LIML	9,689,635	47	45	185	184	369	16074	15936	32009	42	40	60	11.45	4.38	4.54	0.96
London Luton	EGGW	12,263,505	34	45	150	148	298	15760	15876	31636	50	20	60	13.14	5.16	5.10	2.07
Prague Václav Havel	LKPR	12,030,928	36	47	157	151	308	14372	14194	28566	31	25	60	10.46	4.44	5.00	2.02
Warsaw Frederic Chopin	EPWA	11,206,700	38	45	187	189	376	14240	14287	28527	46	35	60	13.57	5.07	4.47	1.85
Stuttgart	EDDS	10,512,225	42	45	146	148	294	13735	13677	27412	30	30	60	10.32	3.69	5.03	1.99
Bucharest Henri Coandă International	LROP	9,274,629	48	45	125	128	252	12708	13090	25798	52	45	60	10.86	4.09	6.57	1.97
Birmingham	EGBB	10,187,122	46	45	139	139	278	12577	12494	25071	45	45	60	12.05	3.90	6.39	3.53
Milan Orio al Serio	LIME	10,404,625	43	45	103	105	207	12500	12539	25039	50	20	60	12.83	3.67	4.54	3.63
Budapest Liszt Ferenc International	LHBP	10,298,963	45	45	115	114	228	12300	12488	24788	46	20	60	8.96	3.06	3.54	1.64
Alicante	LEAL	10,574,484	41	45	98	97	195	12391	12210	24600	41	30	60	10.62	3.67	4.87	1.72
Toulouse Blagnac	LFBO	7,669,054	56	45	132	133	265	12312	12229	24541	40	40	60	9.80	4.15	4.89	1.78
Lyon-Saint Exupéry	LFLL	8,703,354	52	51	143	144	286	11477	11580	23057	42	35	60	11.27	4.42	4.90	1.80
Gran Canaria	GCLP	10,627,182	40	45	144	144	288	11435	11376	22810	51	25	60	11.91	3.66	4.51	1.49
Venice Marco Polo	LIPZ	8,751,028	50	45	109	109	218	11252	10990	22241	35	35	60	11.68	4.67	4.34	1.84
Marseille Provence	LFML	8,261,804	54	45	134	130	264	11167	10896	22063	40	35	60	10.74	3.52	5.11	1.81
Berlin Schönefeld	EDDB	8,526,268	53	45	102	99	201	10756	10725	21481	52	30	60	11.80	7.64	6.43	1.57

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Porto Francisco de Sá Carneiro	LPPR	8,087,740	55	45	97	99	196	10715	10719	21434	52	30	60	10.29	3.64	4.97	1.66
Glasgow International	EGPF	8,714,307	51	45	117	121	237	10199	10351	20549	41	30	60	11.24	4.13	5.08	2.67
Bergen, Flesland	ENBR	6,020,866	69	45	123	127	250	9784	10190	19974	30	30	60	7.84	3.08	3.48	1.23
Tenerife South	GCTS	9,117,637	49	45	73	76	148	9356	9668	19024	40	25	60	10.40	3.58	5.16	2.42
Catania-Fontanarossa	LICC	7,105,487	58	45	82	82	164	9302	9481	18783	50	20	60	10.24	3.57	4.17	1.62
Naples	LIRN	6,163,188	65	45	97	93	190	9380	9194	18574	40	40	60	10.46	3.56	4.26	1.59
Ibiza	LEIB	6,477,283	63	45	98	101	199	9222	9087	18309	41	30	60	8.97	4.25	4.65	1.60
London City	EGLC	4,319,301	94	45	145	139	283	9119	8813	17931	30	30	60	9.97	4.54	3.64	1.56
Bologna	LIPE	6,889,742	61	45	86	87	173	8850	8807	17657	38	30	60	10.68	2.87	4.08	1.48
Gothenburg-Landvetter	ESGG	6,158,334	66	45	94	93	187	8868	8773	17641	32	30	60	8.84	2.86	3.59	1.24
Bristol	EGGD	6,786,790	62	45	85	87	172	8637	8703	17340	30	30	60	10.06	3.26	4.47	2.84
Heraklion International	LGIR	6,057,355	68	45	64	66	130	8206	8490	16695	50	20	60	9.11	3.75	4.77	2.04
Bordeaux - Mérignac	LFBD	5,331,648	75	45	91	88	179	8228	8053	16280	30	25	60	9.87	2.83	4.72	1.34
Faro	LPFR	6,436,881	64	45	62	64	126	8000	8079	16079	40	40	60	10.85	4.50	4.36	2.02
Basel-Mulhouse-Freiburg EuroAirport	LFSB	7,061,059	59	45	95	98	192	7937	8124	16061	30	30	60	11.31	3.99	4.04	1.11
Brussels South Charleroi	EBCI	6,956,302	60	45	61	58	119	8068	7989	16056	50	20	60	10.59	3.65	5.62	1.70
Palermo Falcone–Borsellino	LICJ	4,910,791	79	45	67	67	134	7635	7596	15230	42	30	60	11.48	5.08	6.05	2.21
Stavanger, Sola	ENZV	4,501,368	86	45	99	100	199	7416	7719	15134	30	30	60	8.20	2.84	3.65	1.24
Valencia	LEVC	5,051,871	77	45	75	79	154	7350	7532	14882	40	25	60	10.31	3.99	4.36	2.05
Nottingham East Midlands	EGNX	4,450,862	87	45	101	93	193	7513	7300	14813	30	30	60	10.84	3.68	4.75	1.45
Rome Ciampino	LIRA	5,834,201	70	45	75	81	156	7344	7374	14717	51	25	60	12.42	3.67	5.31	1.71
Thessaloniki International, "Macedonia"	LGTS	5,341,293	74	45	68	67	134	7370	7281	14651	48	40	60	9.87	3.64	5.74	2.06
Lanzarote	GCRR	6,124,321	67	45	74	74	148	6962	6957	13918	56	45	60	10.12	2.91	4.43	1.63
Belfast International	EGAA	4,391,292	89	45	63	64	126	6956	6956	13911	44	20	60	9.67	3.81	5.25	3.41
Pisa Galileo Galilei	LIRP	4,804,774	81	45	66	61	127	6752	6778	13530	44	40	60	13.33	6.97	4.88	5.86
Hanover Langenhagen	EDDV	5,452,669	71	45	74	74	148	6802	6715	13517	29	25	60	9.60	3.28	4.82	2.06
Trondheim, Værnes	ENVA	4,352,721	91	45	79	79	158	6613	6567	13180	36	25	60	6.86	2.95	2.76	1.07
Riga International	EVRA	5,162,149	76	45	75	76	151	6511	6601	13112	50	20	60	10.01	3.73	4.53	1.45
Reykjvik Keflavík International	BIKF	4,855,505	80	45	52	51	103	6612	6243	12855	39	20	60	10.09	2.52	6.79	1.76

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John Paul II International Kraków-Balice	EPKK	4,221,171	98	45	69	69	138	6391	6421	12812	79	45	90	9.56	3.22	7.32	1.96
Newcastle	EGNT	4,562,853	85	45	67	67	134	6260	6321	12580	38	30	60	11.07	5.93	4.57	2.05
Liverpool John Lennon	EGGP	4,301,495	96	45	53	52	105	6092	6087	12179	30	30	60	11.66	7.73	4.18	1.22
Tenerife North	GCXO	3,815,315	102	45	95	93	188	6174	5990	12164	51	25	60	10.15	3.06	4.04	2.71
Nantes Atlantique	LFRS	4,394,996	88	45	73	73	146	5940	6147	12087	25	20	60	8.70	3.38	4.09	2.68
Bilbao	LEBB	4,277,430	97	45	54	56	109	5841	6234	12075	41	30	60	9.03	3.06	4.46	1.17
Aberdeen	EGPD	3,469,525	105	45	109	106	215	6037	6010	12047	41	30	60	10.84	4.02	4.59	2.36
Bari Karol Wojtyla International	LIBD	3,958,815	100	45	54	53	106	5809	5825	11634	30	25	60	11.88	3.71	4.57	1.69
Menorca	LEMH	2,632,615	117	45	50	50	100	5671	5671	11341	52	30	60	8.96	2.97	4.04	1.42
Turin International	LIMF	3,666,582	104	45	59	56	114	5538	5463	11001	32	30	60	9.62	3.31	7.09	3.04
Eindhoven	EHEH	4,331,658	92	45	45	44	89	5410	5331	10741	30	30	60	10.14	3.63	6.34	2.86
Seville San Pablo	LEZL	4,308,852	95	45	51	53	104	5256	5332	10588	41	30	60	8.88	4.69	3.78	1.52
Malta International	LMML	4,618,642	83	45	42	42	84	5005	4945	9950	39	20	60	7.77	3.32	3.73	1.39
Cagliari - Elmas	LIEE	3,719,289	103	45	42	44	85	4957	4978	9935	39	35	60	10.60	3.23	5.01	1.25
Puerto Del Rosario Fuerteventura	GCFV	5,026,902	78	45	56	56	112	4967	4967	9933	52	30	60	11.00	3.70	4.80	1.45
Sofia International	LBSF	4,088,943	99	45	54	52	106	4912	5007	9919	60	60	60	11.28	3.44	5.28	2.01
Chania International	LGSA	2,702,283	112	45	41	42	83	4732	4800	9532	50	20	60	9.61	4.25	5.20	1.97
Luxembourg Findel	ELLX	2,687,086	114	45	76	81	157	4753	4741	9494	44	20	60	8.78	3.49	4.12	1.23
George Best Belfast City	EGAC	2,692,713	113	45	63	62	124	4628	4531	9159	50	20	60	9.03	2.63	3.87	1.81
Nuremberg	EDDN	3,384,925	107	45	66	71	137	4500	4551	9051	30	30	60	7.93	3.06	3.69	1.29
Rhodes International	LGRP	4,579,023	84	45	39	38	77	4475	4439	8914	50	20	60	8.14	2.99	4.98	2.93
Larnaca International	LCLK	5,407,248	72	45	37	38	75	4386	4483	8869	46	20	60	14.26	4.64	6.28	3.80
Beauvais-Tillé	LFOB	4,330,019	93	45	31	31	62	4268	4340	8608	50	20	60	10.33	3.32	4.24	2.05
Billund	EKBI	2,899,367	110	45	58	56	114	4326	4277	8603	28	20	60	8.78	3.44	4.53	1.40
Stockholm-Bromma	ESSB	2,279,566	126	45	87	86	173	4303	4222	8524	45	20	60	9.19	2.29	3.60	1.47
Leeds Bradford International	EGNM	3,445,302	106	45	50	51	101	4209	4081	8290	45	30	60	11.61	4.20	4.57	1.67
Olbia - Costa Smeralda	LIEO	2,240,016	129	45	55	60	114	3998	4254	8252	39	20	60	8.78	2.85	4.48	1.31
International Katowice in Pyrzowice	EPKT	3,069,279	109	45	36	37	72	4082	4092	8173	34	20	60	10.89	3.08	4.67	2.50

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Vilnius International	EYVI	3,336,084	108	45	43	44	87	4133	4032	8164	50	20	60	7.80	3.37	4.91	1.63
Tromsø	ENTC	2,009,146	136	45	65	66	131	3925	3935	7860	30	30	60	5.70	2.89	2.89	1.43
Zagreb Franjo Tuđman	LDZA	2,587,798	118	45	48	45	92	3841	3664	7505	46	30	60	8.70	3.04	5.44	1.59
Burgas International	LBBG	2,360,320	123	45	35	35	70	3643	3760	7403	50	20	60	8.08	3.05	4.98	3.93
Bremen	EDDW	2,660,754	116	45	42	43	85	3697	3695	7392	20	20	60	9.01	2.63	3.79	1.09
Corfu Ioannis Kapodistrias International	LGKR	2,438,016	120	45	35	36	71	3614	3770	7384	35	20	60	7.54	2.95	4.32	1.69
Leipzig/Halle	EDDP	2,321,975	124	45	80	88	168	3525	3638	7163	50	20	60	11.61	4.66	6.16	2.09
Florence Amerigo Vespucci	LIRQ	2,419,818	122	45	48	49	96	3557	3550	7107	30	30	60	9.30	4.00	5.06	1.77
Verona	LIPX	661,743	198	45	33	34	67	3355	3506	6861	42	20	60	9.75	4.83	4.13	1.24
Malmö-Sturup	ESMS	2,088,628	133	45	38	41	78	3348	3481	6829	30	30	60	7.93	2.82	4.32	1.09
Split	LDSP	1,955,400	139	45	31	33	63	3279	3369	6647	45	30	60	8.56	2.96	3.71	1.04
Brindisi Casale	LIBR	2,258,292	128	45	24	25	49	3295	3282	6577	50	20	60	9.11	3.98	7.10	2.58
Bodø	ENBO	1,733,330	145	45	61	61	122	3243	3220	6463	30	30	60	4.65	2.61	2.81	1.82
Copernicus Wrocław	EPWR	2,085,638	134	45	34	35	68	3205	3199	6404	36	25	60	8.32	2.95	6.86	1.69
Lennart Meri Tallinn	EETN	2,166,663	131	45	46	48	94	3066	3328	6393	45	30	60	7.09	3.01	4.79	1.59
Madeira Cristiano Ronaldo	LPMA	2,459,793	119	45	29	29	58	3188	3158	6346	30	30	60	8.49	3.71	3.80	1.45
Zakynthos International "Dionysios Solomos"	LGZA	1,268,497	165	45	26	25	50	3152	2992	6144	50	20	60	8.31	4.00	4.34	1.49
Shannon	EINN	1,714,872	147	45	29	34	63	2815	3301	6115	45	45	60	10.86	2.41	4.98	1.82
Southampton	EGHI	1,789,470	144	45	59	58	116	3045	2998	6043	30	30	60	10.49	3.16	3.97	2.65
Cork International	EICK	2,071,210	135	45	30	31	61	2998	3002	6000	32	20	60	9.94	3.22	5.03	1.09
Santiago de Compostela	LEST	2,296,248	125	45	22	26	48	2872	3088	5959	41	30	60	9.35	3.38	3.93	1.48
Frankfurt-Hahn	EDFH	2,665,105	115	45	26	27	52	2883	2959	5842	50	20	60	11.44	3.51	5.26	1.12
Varna International	LBWN	1,398,694	162	45	24	25	49	2808	2881	5689	70	40	80	7.51	2.62	4.70	1.32
Dresden Klotzsche	EDDC	1,726,471	146	45	33	31	64	2704	2701	5405	56	45	60	8.73	2.41	3.86	1.24
Jersey	EGJJ	1,554,390	154	45	44	46	90	2690	2699	5389	38	30	60	10.28	3.26	4.95	2.95
Poznań-Ławica	EPPO	1,500,918	157	45	31	30	61	2558	2555	5113	36	25	60	9.94	3.39	6.35	2.09
Santorini (Thira) National	LGSR	1,495,890	158	45	22	22	44	2450	2453	4903	50	20	60	8.42	3.38	5.00	4.28
Stockholm-Skavsta	ESKN	1,813,032	143	45	19	20	39	2389	2409	4798	35	20	60	9.95	2.95	5.50	1.41

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Kos Island International	LGKO	2,143,860	132	45	22	21	43	2350	2274	4624	50	20	60	8.20	3.99	4.49	2.44
Rotterdam The Hague	EHRD	1,692,406	149	45	35	37	72	2315	2285	4599	20	20	60	10.31	2.18	5.04	1.71
Sandefjord, Torp	ENTO	1,542,541	156	45	28	29	56	2225	2240	4465	28	20	60	8.12	2.78	3.82	1.99
Montpellier-Méditerranée	LFMT	1,445,273	160	45	41	41	82	2177	2225	4401	52	30	60	9.38	2.77	3.69	1.52
Salzburg	LOWS	1,819,520	142	45	38	38	76	2176	2130	4306	30	30	60	6.13	2.06	4.61	2.61
Strasbourg Entzheim	LFST	1,190,389	167	45	38	37	75	2149	2144	4292	26	20	60	7.55	2.58	3.71	1.28
Bratislava Milan Rastislav Štefánik	LZIB	1,563,010	153	45	29	25	54	2119	2154	4273	45	30	60	9.43	4.09	4.73	1.78
Genoa Cristoforo Colombo	LIMJ	1,363,240	164	45	29	29	58	2135	2082	4217	45	30	60	9.66	3.28	5.92	1.80
Cluj-Napoca International	LRCL	1,487,603	159	45	22	23	45	1989	2095	4083	50	20	60	8.33	3.12	5.01	1.40
Trapani Vincenzo Florio	LICT	1,586,992	152	45	16	16	31	2011	2011	4021	50	20	60	9.99	3.92	5.78	1.86
Ajaccio Campo dell'Oro	LFKJ	1,366,020	163	45	22	23	45	1979	1944	3923	50	20	60	7.98	3.08	3.65	1.35
Luleå	ESPA	1,177,443	169	45	22	22	43	1907	1972	3878	28	20	60	7.17	2.50	3.74	1.01
Asturias	LEAS	1,119,273	172	45	16	16	32	1903	1895	3798	40	30	60	6.47	3.57	4.31	1.33
Ålesund, Vigra	ENAL	1,077,209	173	45	23	22	45	1827	1898	3725	52	30	60	6.62	1.93	2.74	1.03
Alghero Fertilia	LIEA	1,677,967	150	45	13	14	27	1789	1800	3588	30	30	60	10.29	2.92	4.57	1.09
Kristiansand, Kjevik	ENCN	1,065,638	174	45	26	25	51	1888	1698	3585	36	25	60	6.47	3.15	3.20	1.17
La Palma	GCLA	971,676	181	45	30	29	59	1758	1758	3515	50	20	60	6.80	4.09	5.14	7.16
Ljubljana Jože Pučnik	LJLJ	1,438,304	161	45	28	27	55	1719	1784	3503	46	30	60	8.36	3.00	3.51	1.22
Girona-Costa Brava	LEGE	2,736,867	111	45	18	19	37	1688	1695	3383	45	45	60	10.21	5.06	3.46	1.12
Dubrovnik	LDDU	1,693,934	148	45	15	17	32	1620	1650	3269	47	30	60	9.10	3.07	3.88	1.37
Guernsey	EGJB	894,602	184	45	47	45	91	1603	1598	3201	35	20	60	5.76	2.92	4.63	2.31
Bastia Poretta	LFKB	1,162,840	170	45	20	20	40	1595	1599	3194	50	20	60	6.67	3.41	4.09	1.33
A Coruña	LECO	1,025,688	177	45	18	18	36	1575	1612	3186	52	30	60	8.84	3.58	3.64	1.21
Graz	LOWG	963,396	182	45	27	27	54	1576	1581	3157	30	30	60	6.65	2.75	4.13	1.02
Umeå	ESNU	1,048,000	176	45	23	25	47	1523	1599	3122	19	20	60	6.37	2.23	3.08	0.91
Cardiff International	EGFF	1,160,506	171	45	24	22	46	1607	1466	3073	35	20	60	9.64	2.73	5.21	1.73
Dortmund	EDLW	1,985,379	138	45	19	20	39	1533	1534	3067	30	30	60	9.44	3.29	5.05	1.52
Oulu	EFOU	982,723	180	45	15	13	28	1574	1483	3057	14	20	60	4.42	1.88	2.66	1.02
Lille Lesquin	LFQQ	1,596,700	151	45	24	24	48	1507	1508	3015	38	30	60	8.63	2.84	4.79	1.38

Airport	ICAO code	Pax 2015	Rank 2015	Cap-acity	EU28+4 flights/day			EU28+4 pax/day			Minimum Connection Time (minutes)			Taxi-out (minutes)		Taxi-in (minutes)	
					Departing	Arriving	Total	Departing	Arriving	Total	Std	Dom.	Int'l	Mean	SD*	Mean	SD*
Biarritz-Bayonne - Anglet	LFBZ	1,064,402	175	45	18	21	39	1487	1507	2994	50	20	60	9.25	2.38	2.49	1.05
Innsbruck	LOWI	991,356	179	45	25	27	52	1383	1489	2872	38	30	60	6.05	2.42	4.00	1.43
Exeter International	EGTE	821,257	187	45	23	24	47	1415	1356	2771	41	25	60	9.86	3.10	3.93	2.08
São Miguel - João Paulo II	LPPD	1,265,792	166	45	19	17	36	1357	1357	2713	75	60	80	8.66	3.24	3.60	1.64
Paphos International	LCPH	2,277,741	127	45	11	12	23	1339	1343	2682	65	20	80	9.12	3.35	5.50	2.20
Vigo-Peinador	LEVX	828,725	186	45	13	14	27	1310	1323	2633	70	30	90	7.78	3.32	3.14	1.34
Timișoara "Traian Vuia" International	LRTR	924,459	183	45	17	16	33	1272	1245	2516	50	20	60	9.44	4.91	5.84	2.17
Santander	LEXJ	815,636	189	45	13	13	26	1209	1206	2415	50	30	60	7.18	2.77	4.74	1.15
Murcia-San Javier	LELC	1,181,490	168	45	10	10	20	1121	1200	2321	56	45	60	6.84	2.57	4.55	1.07
Jerez	LEJR	758,309	191	45	19	19	38	1068	1073	2141	56	45	60	10.53	3.85	5.05	1.30
Trieste Friuli Venezia Giulia	LIPQ	741,776	194	45	14	13	26	1040	1056	2096	50	20	60	10.01	4.38	4.75	0.93
Federico García Lorca Granada-Jaén	LEGR	707,268	195	45	12	13	25	1035	977	2012	50	30	60	7.47	3.63	3.92	1.06
Reus	LERS	705,067	197	45	12	13	25	1005	1007	2012	50	20	60	11.00	5.85	3.90	1.73
Münster Osnabrück International	EDDG	817,049	188	45	24	23	47	964	1011	1975	20	20	60	6.26	2.15	4.50	1.16
Almería	LEAM	744,847	193	45	14	12	26	1009	946	1955	52	30	60	7.79	2.97	4.67	1.06
Robin Hood Doncaster Sheffield	EGCN	857,109	185	45	11	11	21	1005	934	1939							
Bournemouth	EGHH	705,443	196	45	20	19	39	886	885	1771	50	20	60	10.84	3.24	5.06	1.55
Glasgow Prestwick International	EGPK	609,937	199	45	11	10	21	990	769	1759	53	20	60	10.16	3.31	3.82	1.68
Kaunas International	EYKA	747,284	192	45	9	8	17	691	672	1362	40	20	60	9.41	3.06	7.40	2.45
Brest Bretagne	LFRB	998,393	178	45	12	12	24	604	651	1255	50	20	60	9.89	2.53	2.88	1.43
Göteborg City	ESGP	807,763	190	45	6	5	10	50	45	95	50	20	60	6.90	2.76	4.57	0.98
Istanbul Atatürk	LTBA	61,322,729	3	60	N/A	N/A	N/A	N/A	N/A	N/A	64	30	75	19.44	9.32	8.58	4.00
Istanbul Sabiha Gökçen	LTFJ	28,112,438	12	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	12.95	3.85	6.91	3.59
Antalya	LTAI	27,724,249	13	47	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	15.33	5.17	6.96	2.56
Ankara Esenboğa International	LTAC	12,326,869	33	45	N/A	N/A	N/A	N/A	N/A	N/A	75	30	90	11.85	3.97	6.41	1.72
Izmir Adnan Menderes	LTBJ	12,139,788	35	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	11.60	2.76	5.22	1.52
Kyiv Boryspil International	UKBB	7,277,135	57	45	N/A	N/A	N/A	N/A	N/A	N/A	120	120	120	12.88	5.30	7.00	2.54
Adana Şakirpaşa	LTAF	5,369,260	73	45	N/A	N/A	N/A	N/A	N/A	N/A	50	30	60	9.58	3.16	5.83	1.83

Airport	ICAO code	Pax 2015	Rank 2015	Cap-acity	EU28+4 flights/day			EU28+4 pax/day			Minimum Connection Time (minutes)			Taxi-out (minutes)		Taxi-in (minutes)	
					Departing	Arriving	Total	Departing	Arriving	Total	Std	Dom.	Int'l	Mean	SD*	Mean	SD*
Belgrade Nikola Tesla	LYBE	4,776,110	82	45	N/A	N/A	N/A	N/A	N/A	N/A	52	30	60	9.91	3.24	4.63	1.46
Dalaman	LTBS	4,377,101	90	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	11.09	2.94	5.29	1.76
Milas-Bodrum	LTFE	3,877,603	101	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	10.11	3.39	5.93	2.21
Trabzon	LTCG	2,429,873	121	45	N/A	N/A	N/A	N/A	N/A	N/A	47	20	60	10.36	2.47	6.44	1.51
Chișinău International	LUKK	2,219,162	130	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	9.50	3.56	4.54	1.49
Tirana International Nënë Tereza	LATI	1,997,044	137	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	10.09	3.23	5.41	1.14
Yerevan Zvartnots International	UDYZ	1,879,667	140	45	N/A	N/A	N/A	N/A	N/A	N/A	225	180	240	12.10	3.62	4.40	1.80
Tbilisi International	UGTB	1,847,111	141	45	N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	11.78	3.61	7.34	2.21
Pristina International	BKPR	1,549,198	155		N/A	N/A	N/A	N/A	N/A	N/A	50	20	60	8.17	1.95	3.58	1.24

*SD=Standard Deviation

Columns six to eleven present the number of departing and arriving flights and passengers at "EU28+4" airports. They have been calculated as follows:

- Two traffic samples were used: 15/01/2016 (this was a quiet day during the year) and 01/07/2016 (one of the busiest days of the year). The number of flights and passenger movements were averaged for the two days. It's an unweighted average;
- Only flights departing and arriving in the EU28 + the four EFTA countries have been counted; that is internal European flights.
- Passenger numbers assume an 80% load factor for every flight, and typical (estimated) seating configurations for the given aircraft type;
- Only the 60 most frequently observed aircraft types, which cover about 90.2% of the flights, have estimated seating configurations. The remaining 9.8% of flights (on 15/01/2016) are made up of 172 aircraft types (on 15/01/2016, a few more on 01/07/2016), most of which are small aircraft with few seats. These flights were given a default of zero passengers. Therefore, although 90.2% flights are included, the percentage of European passenger journeys will be much higher, and probably close to 100%.

Appendix 2 ECAC Airports

The following is a list of all ECAC airports with their IATA code, by order of number of flights to ECAC destinations.

Table 39: List of all ECAC airports

No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City
1	FRA	Frankfurt	101	FUE	Fuerteventura	201	PIK	Glasgow	301	EGC	Bergerac	401	KOK	Kokkola/ Pietarsaari	501	LWN	Gyumri
2	IST	Istanbul	102	NUE	Nuremberg	202	INN	Innsbruck	302	IAS	Iasi	402	SVJ	Svolvaer	502	MLO	Milos
3	LHR	London	103	LBA	Leeds	203	ODS	Odesa	303	KRN	Kiruna	403	ANR	Antwerp	503	WAT	Waterford
4	MUC	Munich	104	GDN	Gdansk	204	PDL	Ponta	304	MSR	Mus	404	DNR	Dinard/ St-Malo	504	ILY	Islay
5	AMS	Amsterdam	105	ECN	Ercan	205	ERZ	Erzurum	305	EAS	San Sebastián	405	EGS	Egilsstadir	505	ORB	Orebro
6	CDG	Paris	106	VNO	Vilnius	206	EZS	Elazig	306	KLU	Klagenfurt	406	VST	Stockholm	506	KSJ	Kasos
7	BCN	Barcelona	107	BRE	Bremen	207	IOM	Isle of Man	307	MST	Maastricht/ Aachen	407	KRF	Kramfors/ Solleftea	507	HAA	Hasvik
8	MAD	Madrid	108	DLM	Dalaman	208	GSE	Goteborg	308	KUT	Kutaisi	408	KAJ	Kajaani	508	MXX	Mora
9	FCO	Rome	109	BJV	Bodrum	209	SDR	Santander	309	RNB	Ronneby/ Karlskrona	409	RLG	Rostock	509	IFO	Ivano-Frankivsk
10	LGW	London	110	BMA	Stockholm	210	SJJ	Sarajevo	310	SZZ	Szczecin	410	ANX	Andenes	510	AOE	Eskisehir
11	OSL	Oslo	111	KEF	Reykjavik	211	HAU	Haugesund	311	BZG	Bydgoszcz	411	RJK	Rijeka	511	KSF	Kassel
12	CPH	Copenhagen	112	RHO	Rhodes	212	SPC	La Palma	312	SMI	Samos	412	EBU	St-Etienne	512	SKU	Skyros
13	VIE	Vienna	113	BHD	Belfast	213	NOC	Knock	313	BDU	Bardufoss	413	XFW	Hamburg	513	CEG	Chester
14	ARN	Stockholm	114	LUX	Luxembourg	214	TRS	Trieste	314	BZR	Beziers	414	PED	Pardubice	514	SVL	Savonlinna
15	ORY	Paris	115	ZAG	Zagreb	215	TSR	Timisoara	315	OSR	Ostrava	415	EDO	Edremit	515	JNX	Naxos
16	SAW	Istanbul	116	TZX	Trabzon	216	EVE	Harstad-Narvik	316	HOR	Horta	416	KEM	Kemi/Tornio	516	SNR	St-Nazaire
17	TXL	Berlin	117	FLR	Florence	217	EXT	Exeter	317	KTT	Kittila	417	PIX	Pico	517	ARW	Arad

No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City
18	PMI	Palma	118	MAH	Menorca	218	JMK	Mykonos	318	LRH	La Rochelle – Île de Ré	418	LKL	Lakselv	518	OHD	Ohrid
19	ZRH	Zurich	119	TOS	Tromso	219	FMO	Muenster/ Osnabrück	319	FRO	Floro	419	ACH	Altenrhein	519	HDF	Heringsdorf
20	DUS	Duesseldorf	120	SUF	Lamezia	220	FMM	Memmingen	320	RNN	Bornholm	420	BVE	Brive-La-Gaillarde	520	DND	Dundee
21	DUB	Dublin	121	VRN	Verona	221	VGO	Vigo	321	FAE	Faroe	421	OSY	Namsos	521	AGB	Munich
22	STN	London	122	GYD	Baku	222	REU	Reus	322	RMI	Rimini	422	RVK	Rorvik	522	PGX	Perigueux
23	BRU	Brussels	123	HHN	Frankfurt	223	TIV	Tivat	323	NKT	Sirnak	423	SGD	Sonderborg	523	HFS	Hagfors
24	MAN	Manchester	124	TSF	Venice	224	XRY	Jerez	324	KLR	Kalmar	424	JYV	Jyvaskyla	524	ONQ	Zonguldak
25	HAM	Hamburg	125	OLB	Olbia	225	PAD	Paderborn/ Lippstadt	325	NQY	Newquay	425	BZO	Bolzano/ Bozen	525	OSI	Osijek
26	MXP	Milan	126	BLL	Billund	226	TGD	Podgorica	326	AEY	Akureyri	426	MHQ	Mariehamn	526	MSE	Manston
27	LIS	Lisbon	127	TLL	Tallinn	227	ZTH	Zakinthos	327	BRN	Berne	427	OER	Ornskoldsvik	527	TAY	Tartu
28	HEL	Helsinki-Vantaa	128	BOO	Bodo	228	KUN	Kaunas	328	LSI	Shetland	428	VHM	Vilhelmina	528	LEN	Leon
29	ATH	Athens	129	BDS	Brindisi	229	INV	Inverness	329	BNN	Bronnoysund	429	JKG	Jonkoping	529	JTY	Astypalaia
30	GVA	Geneva	130	SOU	Southampton	230	GRX	Granada	330	BUS	Batumi	430	GEV	Gallivare	530	TAT	Poprad
31	AYT	Antalya	131	ORK	Cork	231	PUF	Pau	331	LCJ	Lodz	431	KLV	Karlovy	531	RJL	Logrono
32	AGP	Malaga	132	LEJ	Leipzig/ Halle	232	LEI	Almeria	332	VDS	Vadso	432	GMZ	San Sebastián de la Gomera	532	MHG	Mannheim
33	NCE	Nice	133	GRO	Girona	233	MOL	Molde	333	VLL	Valladolid	433	SMA	Santa Maria	533	BAY	Baia
34	ESB	Ankara	134	SCQ	Santiago	234	BOH	Bournemouth	334	PEG	Perugia	434	PDV	Plovdiv	534	UDJ	Uzhhorod
35	LIN	Milan	135	FNC	Funchal	235	DSA	Doncaster/ Sheffield	335	KOI	Kirkwall	435	LPP	Lappeenranta	535	SOB	Balaton
36	PRG	Prague	136	TIA	Tirana	236	TER	Terceira	336	LUZ	Lublin	436	KZR	Kutahya	536	VDB	Fagernes
37	EDI	Edinburgh	137	TRF	Oslo	237	REG	Reggio	337	HUY	Humberside	437	DLE	Dole	537	AVN	Avignon
38	STR	Stuttgart	138	RYG	Oslo-Rygge	238	VAR	Varna	338	CUF	Cuneo	438	BNX	Banja	538	GLO	Gloucester/ Cheltenham
39	CGN	Cologne /Bonn	139	MMX	Malmo	239	PSR	Pescara	339	LUG	Lugano	439	GPA	Patrai	539	SUJ	Satu

No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City
40	LTN	London	140	EVN	Yerevan	240	RZE	Rzeszow	340	MQN	Mo i Rana - Røssvoll	440	IOA	Ioannina	540	JSY	Syros
41	ALC	Alicante	141	DTM	Dortmund	241	LNZ	Linz	341	LDE	Lourdes/ Tarbes	441	AJR	Arvidsjaur	541	RGS	Burgos
42	WAW	Warsaw	142	SIP	Simferopol	242	RNS	Rennes	342	SSJ	Sandnessjoen	442	PXO	Porto	542	SLM	Salamanca
43	BUD	Budapest	143	GZT	Gaziantep	243	MLX	Malatya	343	KVA	Kavala	443	VAW	Vardo	543	KZS	Megisti
44	ADB	Izmir	144	WRO	Wroclaw	244	GNY	Sanliurfa	344	KCM	Kahramanmaras	444	BJF	Batsfjord	544	SLD	Sliac
45	BHX	Birmingham	145	AHO	Alghero	245	OSD	Are/ ostersund	345	PMF	Milan	445	HVG	Honningsvag	545	EVG	Sveg
46	OTP	Bucharest	146	JER	Jersey	246	FSC	Figari	346	LGG	Liege	446	MEH	Mehamn	546	LWK	Shetland
47	BGY	Milan	147	PFO	Paphos	247	MLH	Mulhouse	347	BLK	Blackpool	447	ISC	Isles of Scilly - St. Mary's	547	PJA	Pajala
48	LPA	Gran	148	SZG	Salzburg	248	LWO	Lviv	348	PNL	Pantelleria	448	POR	Pori	548	CAL	Campbeltown
49	VCE	Venice	149	CFU	Kerkyra	249	TLN	Toulon/Hyeres	349	JKH	Chios	449	SDN	Sandane	549	ILD	Lleida
50	TLS	Toulouse	150	DRS	Dresden	250	ZAD	Zadar	350	IGD	Igdir	450	KAO	Kuusamo	550	CVU	Corvo
51	LYS	Lyon	151	NRN	Duesseldorf	251	FDH	Friedrichshafen	351	VDE	Valverde	451	KFS	Kastamonu	551	EBA	Elba
52	BGO	Bergen	152	WMI	Nowy	252	SCN	Saarbruecken	352	GNB	Lyon	452	NAJ	Nakchivan	552	TRE	Tiree
53	CTA	Catania	153	KTW	Katowice	253	VBY	Visby	353	IVL	Ivalo	453	NOP	Sinop	553	VLY	Anglesey
54	TFS	Tenerife	154	NYO	Stockholm	254	AOI	Ancona	354	LPI	Linkoping	454	JSH	Siteia	554	KDL	Kardla
55	MRS	Marseille	155	RTM	Rotterdam	255	TMP	Tampere	355	LMP	Lampedusa	455	VOL	Volos	555	URE	Kuressaare
56	GLA	Glasgow	156	TPS	Trapani	256	AAR	Aarhus	356	AJI	Agri	456	BJZ	Badajoz	556	BRR	Barra
57	OPO	Porto	157	ASR	Kayseri	257	CFE	Clermont-Ferrand	357	LBC	Hamburg	457	ACI	Alderney	557	TYF	Torsby
58	SXF	Berlin	158	KIV	Chisinau	258	GZP	Gazipasa	358	MME	Durham	458	KSD	Karlstad	558	LPY	Le Puy
59	BLQ	Bologna	159	SPU	Split	259	ALF	Alta	359	OST	Oostende/ Brugge	459	SOJ	Sorkjosen	559	PPW	Papa Westray
60	BRS	Bristol	160	MPL	Montpellier	260	KSU	Kristiansund	360	ETZ	Metz/Nancy	460	PAS	Paros	560	NRL	North Ronaldsay
61	NAP	Naples	161	AAL	Aalborg	261	MQM	Mardin	361	AXD	Alexandroupolis	461	JIK	Ikaria	561	KSO	Kastoria
62	BSL	Basel	162	AJA	Ajaccio	262	AGH	Angelholm/ Helsingborg	362	SOG	Sogndal	462	FLW	Flores	562	OLA	Orland
63	IBZ	Ibiza	163	TBS	Tbilisi	263	RVN	Rovaniemi	363	KLX	Kalamata	463	ISE	Isparta	563	KHE	Kherson

No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City
64	CRL	Brussels	164	KGS	Kos	264	MLN	Melilla	364	FNI	Nimes	464	IFJ	Isafjordur	564	XHQ	Artvin
65	FAO	Faro	165	CHQ	Chania	265	DNZ	Denizli	365	MJF	Mosjoen	465	KIT	Kythira	565	VSG	Luhansk
66	SVG	Stavanger	166	IEV	Kiev	266	MJT	Mytilini	366	PNA	Pamplona	466	GBB	Gabala	566	BWK	Brac
67	KBP	Kiev	167	DBV	Dubrovnik	267	CCF	Carcassonne	367	SYY	Stornoway	467	SJZ	São Jorge	567	FIE	Fair Isle
68	HAJ	Hannover	168	DIY	Diyarbakir	268	DOK	Donetsk	368	ADF	Adiyaman	468	SRP	Stord	568	ANE	Angers
69	RIX	Riga	169	LIL	Lille	269	VAS	Sivas	369	JSI	Skiathos	469	XCR	Paris	569	WRY	Westray
70	BOD	Bordeaux	170	GOA	Genoa	270	RKV	Reykjavik	370	GWT	Westerland	470	CBG	Cambridge	570	NDY	Sanday
71	SKG	Thessaloniki	171	SZF	Carsamba	271	TKU	Turku	371	JOE	Joensuu	471	THN	Trollhattan/ Vanersbo	571	SOY	Stronsay
72	CIA	Rome	172	SXB	Strasbourg	272	GIB	Gibraltar	372	SKN	Stokmarknes	472	DCM	Castres	572	OMO	Mostar
73	GOT	Goteborg	173	AES	Alesund	273	BAL	Batman	373	PVK	Preveza/ Lefkada	473	SKE	Skien	573	DIJ	Dijon
74	ACE	Lanzarote	174	BIA	Bastia	274	ZAZ	Zaragoza	374	PIS	Poitiers	474	NVK	Narvik	574	OBN	Oban
75	TRD	Trondheim	175	LJU	Ljubljana	275	BRQ	Brno	375	HOV	Orsta/ Volda	475	BVG	Berlevag	575	LEH	Le Havre
76	BEG	Belgrade	176	GCI	Guernsey	276	NWI	Norwich	376	KRP	Karup	476	CRV	Crotone	576	KZI	Kozani
77	LCY	London	177	KRS	Kristiansand	277	LDY	Derry	377	HAD	Halmstad	477	AGF	Agen	577	VIN	Vinnytsia
78	PMO	Palermo	178	SKP	Skopje	278	CLY	Calvi	378	GRQ	Groningen	478	NRK	Norrkoping	578	FOA	Foula
79	PSA	Pisa	179	SNN	Shannon	279	PGF	Perpignan	379	LKN	Leknes	479	GRW	Graciosa	579	OSK	Oskarshamn
80	VLC	Valencia	180	LLA	Lulea	280	KKN	Kirkenes	380	LRT	Lorient	480	LLK	Lankaran	580	COL	Coll
81	EMA	Nottingham	181	BTS	Bratislava	281	DNK	Dnipropetrovsk	381	VXO	Vaxjo	481	KID	Kristianstad	581	ENF	Enontekio
82	BIO	Bilbao	182	UME	Umea	282	TGM	Tirgu	382	AOK	Karpathos	482	EBJ	Esbjerg	582	CSA	Colonsay
83	NCL	Newcastle	183	SEN	London	283	VAA	Vaasa	383	LYR	Longyearbyen	483	CFN	Donegal	583	BYF	Albert
84	LPL	Liverpool	184	CLJ	Cluj-Napoca	284	KVD	Ganja	384	RDZ	Rodez	484	WIC	Wick	584	OUK	Out Skerries
85	MLA	Malta	185	POZ	Poznan	285	SDL	Sundsvall/ Harnosand	385	TZL	Tuzla	485	LEQ	Land's End	585	EPL	Epinal
86	ADA	Adana	186	OVD	Asturias	286	SFT	Skelleftea	386	CRA	Craiova	486	CND	Constanta	586	SJY	Seinajoki
87	HER	Irakleion	187	LCG	A Coruña	287	PUY	Pula	387	TUF	Tours	487	LRS	Leros	587	ANG	Angouleme
88	BFS	Belfast	188	BOJ	Burgas	288	KSC	Kosice	388	ZQW	Zweibruecken	488	OMR	Oradea	588	PSV	Papa Stour

No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City	No	ID	City
89	CAG	Cagliari	189	BIQ	Biarritz	289	SBZ	Sibiu	389	PLQ	Klaipeda/ Palanga	489	BEB	Benbecula	589	EOI	Eday
90	LCA	Larnaca	190	PRN	Pristina	290	EFL	Kefallinia	390	CMF	Chambery/ Aix-Les-Bains	490	DOL	Deauville	590	LTQ	Le Touquet
91	EIN	Eindhoven	191	BES	Brest	291	LIG	Limoges	391	MZH	Amasya	491	JKL	Kalymnos	591	LYX	Lydd
92	BVA	Paris	192	JTR	Thira	292	KSY	Kars	392	LYC	Lycksele	492	BLE	Borlange/Falun	592	YEI	Bursa
93	TRN	Turin	193	OUL	Oulu	293	BCM	Bacau	393	FDE	Forde	493	LAI	Lannion	593	VIT	Vitoria
94	SVQ	Sevilla	194	MJV	Murcia	294	HRK	Kharkiv	394	TEQ	Tekirdag	494	OZH	Zaporizhia	594	IEG	Zielona
95	BRI	Bari	195	GRZ	Graz	295	NAV	Nevsehir	395	ERF	Erfurt	495	CKZ	Canakkale	595	CWC	Chernivtsi
96	SOF	Sofia	196	KYA	Konya	296	KIR	Kerry	396	DEB	Debrecen	496	RRS	Roros	596	MBX	Maribor
97	ABZ	Aberdeen	197	CWL	Cardiff	297	CIY	Comiso	397	BGG	Bingol	497	HMV	Hemavan/ Tarnaby	597	BZZ	Brize Norton
98	TFN	Tenerife	198	FKB	Karlsruhe/ Baden-Baden	298	KUO	Kuopio	398	LXS	Limnos	498	KCO	Kocaeli	598	TOJ	Madrid
99	NTE	Nantes	199	VAN	Van Ferit Melen	299	HFT	Hammerfest	399	CFR	Caen	499	AUR	Aurillac	599	BWE	Braunschweig/ Wolfsburg
100	KRK	Krakow	200	HTY	Hatay	300	ERC	Erzincan	400	UIP	Quimper	500	RET	Rost	600	UKS	Sevastopol

No	ID	City
601	SCV	Suceava
602	QAQ	L'Aquila
603	PZY	Piestany
604	FLI	Flateyri

Appendix 3 Airport surface access options

Table 40 gives the surface options available for the top 10 airports in the region of Europe within the CSA scope. Additionally, if these cities are served by other airports, these are documented here. Table 41 gives the same for a selection of 5 smaller airports.

Table 40: Surface access options for 10 major airports

Airport	**Metro, Local Rail and Airport Express**		**Mainline Train**		**Bus**		**Coach**		**Car to City Centre**	**Other major airports**
	Destination	**Time**	**Destination**	**Time**	**Destination**	**Time**	**Destination**	**Time**	**Time**	
London Heathrow	London Paddington (Heathrow Express)	0:20			Bus connections to west and south-west London suburbs		Watford Junction for trains to Midlands, north-west of England, and Scotland	0:45	00:40	Gatwick, Stansted, Luton, London City
	London Paddington (Heathrow Connect)	0:30			Feltham for trains to London Waterloo, south-west suburbs and south of England.	00:30	Reading for trains to west of England and south Wales	0:50		
	Central London	0:50					Woking for trains to south of England	0:50		
							Oxford	0:50		
							Luton Airport	1:20		
							Stansted Airport	1:30		
							Gatwick Airport	1:40		
							Bristol	2:05		
							Birmingham Airport	2:40		
							Birmingham	3:55		
							Plymouth	4:00		
							Edinburgh	8:00		
							National Express coaches to/from Heathrow at http://www.nationalexpress.com/wherewego/timetablefinder.aspx			
Paris CDG	RER to Paris and Suburbs	00:30	Lille	0:52	Paris	01:00	No information available, but France generally has very few coach services		00:40	Orly
			Brussels	1:36						
			Le Mans	1:38						
			Lyon (8 direct trains a day)	2:02						
			Strasbourg	2:04						

Airport	Metro, Local Rail and Airport Express		Mainline Train		Bus		Coach		Car to City Centre	Other major airports
			Nantes	3:06						
			Rennes	3:06						
			Marseille	3:48						
			Montpellier	4:04						
			Bordeaux	4:07						
			Quimper	5:32						
			Nice	6:40						
					Orly	01:20				
					Torcy (East-Paris suburb)					
Frankfurt	S-Bahn - HBF	00:18	Cologne	0:49	To local destinations - Kelsterrbach, Rüsselsheim, Bischofsheim, Srendlingen, Darmstadt		Dusseldorf	04:30	00:15	None
	Mainz		Dusseldorf	1:14			Essen	05:15		
	Wiesbaden		Stuttgart	1:15			Bonn	02:40		
			Dortmund	2:12			Karlsruhe	02:40		
			Nuremburg	2:22			Mannheim	01:45		
			Hanover	2:35						
			Leipzig	3:22						
			Munich	3:34						
			Hamburg	3:53						
			Bremen	3:57						
			Berlin	4:24						
Amsterdam Schiphol	Amsterdam Centraal 15 mins		Mainline station on with access to most of the national rail network and to Thalys and ICE high-speed networks		Amsterdam, Leiden, Haarlem etc.		No information available		00:20	None
			Leiden	00:20						
			Rotterdam	00:27						
			Den Haag	00:30						
			Utrecht	00:30						
			Haarlem	00:40						
			Antwerpen	00:56						
			Ede/ Wageningen	01:02						
			Apeldoorn	01:12						

Airport	Metro, Local Rail and Airport Express		Mainline Train		Bus		Coach		Car to City Centre	Other major airports
			Arnhem	01:16						
			Den Bosch	01:18						
			Deventer	01:26						
			Roosendaal	01:26						
			Tilburg	01:31						
			Eindhoven	01:32						
			Brussels	01:37						
			Zwolle	01:44						
			Nijmegen	01:45						
			Breda	01:49						
			Doetinchem	02:01						
			Oberhausen	02:06						
			Enschede	02:09						
			Venlo	02:09						
			Mechelen	02:11						
			Assen	02:13						
			Duisburg	02:15						
			Dusseldorf	02:15						
			Vlissingen	02:20						
			Groningen	02:22						
			Sittard	02:25						
			Leeuwarden	02:34						
			Leuven	02:40						
			Essen	02:40						
			Maastricht	02:41						
			Krefeld	02:45						
			Keulen	02:49						
			Gent	02:50						
			Dortmund	03:02						
			Mönchengladbach	03:15						
			Osnabrück	03:15						
			Münster	03:30						
			Aachen	03:45						
			Frankfurt	04:00						
			Bonn	04:15						
			Hannover	04:30						

Airport	Metro, Local Rail and Airport Express		Mainline Train		Bus		Coach		Car to City Centre	Other major airports
			München	11:00						
Madrid - Barajas	Nuevos Ministerios	00:17	Trains including transit from Barajas to Atocha		Airport Express to Atocha	00:30	Direct Coaches to Barajas		00:25	None
	Cercanias to Atocha (from T4)	00:24	Valladolid	1:40			Valladolid	3:00		
			Zaragoza	2:00			Zaragoza	3:30		
			Córdoba	2:20			Bilbao	4:05		
			Salamanca	2:20			León	4:30		
			Valencia	2:30			Santander	5:00		
			León	2:45			Murcia	5:20		
			Barcelona	3:10			Gijón	5:45		
			Malaga	3:20			San Sebastián	5:45		
			Seville	3:20			Barcelona	7:20		
			Alicante	3:25						
			Castellón de la Plana	3:50						
			Murcia	4:50						
			Santander	4:55						
			Gijón	5:40						
			Santiago de Compostela	5:50						
Munich	S-Bahn – HBF	00:40			City centre	00:40	Memmingen	01:15	00:35	None
							Nurenburg	01:45		
							Bamberg	02:45		
							Erlangen	02:50		
							Innsbruck via Garmisch-Partenkirchen	03:10		
							Zurich	03:45		
							Non-stop to Prague	04:05		
							Zagreb	07:45		
							Geneva	08:50		
							Berlin via Pilzn, Prague, Dresden or Regensburg, Leipzig	10:05		
							Belgrade	11:30		
							Split via Ljubljana	13:45		
							South Tyrol			

Airport	Metro, Local Rail and Airport Express		Mainline Train		Bus		Coach		Car to City Centre	Other major airports
					"Numerous bus routes connect the airport to the surrounding cities" - Erding, Freising, Schwaig, Taufkirchen, Wartenberg etc.		Augsburg, Bamberg, Deggendorf, Dingolfing, Erlangen, Günzburg, Innsbruck, Nuremberg, Passau, Raubling bei Rosenheim, Regensburg, Salzburg, Ulm, Wörgl.			
Rome Fiumicino	Rome Termini	00:32	Trains from Rome Termini (add 32 mins plus waiting time)		Rome	01:00	No information available		00:35	Ciampino - not major. Ranked 70 with <6m pax
			Naples	1:10						
			Florence	1:31						
			Bologna	1:53						
			Milan	3:00						
			Padua	3:17						
			Venice	3:33						
			Turin	4:00						
			Bari	4:06						
			Genoa	4:55						
London Gatwick	Gatwick Express to London Victoria	00:40	Brighton	00:30	Local bus services		Brighton	00:55	01:00	Heathrow, Stansted, Luton, London City
	London Bridge	00:35	Luton Airport including 15 minutes bus transfer	01:35			London Earl's Court	01:05		
	London St. Pancras	00:50	Portsmouth	01:35			London Victoria	01:30		
			Bedford	01:40			Heathrow Airport	01:40		
			Reading	01:40			Reading	02:00		
			Southampton	02:00			Oxford	02:00		
							Luton Airport	02:25		
							Stansted Airport	03:05		
							Bournemouth	03:25		
							Birmingham Airport	03:40		
							Bristol	03:45		
							Birmingham	04:00		
							Cambridge	04:05		
							Cardiff	04:30		
							Norwich	06:05		
							"more than 400 UK towns and cities"			

Airport	Metro, Local Rail and Airport Express		Mainline Train		Bus		Coach		Car to City Centre	Other major airports
							National Express coaches to/from Gatwick at http://www.nationalexpress.com/wherewego/timetablefinder.aspx			
Barcelona El Prat	R2Nord line of the Rodalies to Barcelona Passeig de Gràcia	00:26			Barcelona centre every 5-10 minutes	00:35	Direct Service to Castellon	04:15	00:20	None
	Line 9 links the airport to the university area Change needed to go the city centre.	00:39					Valencia	05:15		
	R2Nord line to Maçanet-Massanes in the north-eastern suburbs	01:38					Alicante	08:05		
							Granada	13:45		
							Malaga	15:15		
Paris Orly	Shuttle bus to "Pont de Rungis + RER to Paris (and suburbs)	00:35			Several bus lines provide links to central Paris	00:40	No information available, but France generally has very few coach services		00:30	CDG
	"Orlyval" + RER to Paris (and suburbs)	00:40			Paris CDG	01:20				
	Tram + Metro to Paris	00:45			Massy (South-Paris suburb)					

Table 41: Surface access options for 5 smaller airports

Airport	Metro, Tram, Local Rail and Airport Express		Local Bus		Public Transport		Car (Off-peak)		Car to City Centre
	Destination	Time	Destination	Time	Destination	Time	Destination	Time	Time
Lisbon Portela	T1 to Saldanha (financial centre)	0:21	Aerobus or Airport Shuttle every 20 minutes		Parque de Nacoes	0:26	Parque de Nacoes	0:10	0:15
	T1 to city centre	0:25	Local buses (208, 705, 722, 744, 783)		Santa Apolonia	0:35	Santa Apolonia	0:14	
	T2: +10-15 minutes				Almada	0:40	Amadora	0:18	
					Amadora	0:42	Agualva-Cacém	0:23	
					Agualva-Cacém	0:57	Almada	0:25	
					Setubal	1:45	Setubal	0:35	
					Coimbra	3:00	Coimbra	2:00	
Nice Côte d'Azur			Gare de Nice rail station	0:15	Bus to/from T1 (T2: +/-5mins)		Antibes	0:30	0:10
			Nice centre (Promenade des Arts)	0:32	Menton	1:00	Menton	0:35	
					Monaco	0:30	Monaco	0:35	
					Cannes	0:50	Cannes	0:36	
					Antibes	0:40	Frejus/St Raphael	0:45	
					Bus+Train:				
					Monaco	0:22			
					Villefranche-sur-Mer	0:23			
					Beaulieu	0:26			
					Cagnes sur Mer	0:30			
					Eze	0:30			
					Cap d'Ail	0:35			
					Cannes	0:37			
					Monaco	0:40			
					Antibes	0:45			
					Menton	0:50			
					Cannes	0:55			
					Les Arcs/Vintmille	1:00			
					Mandelieu	1:05			
					Ventimiglia	1:05			
					San Remo	1:05			
					Frejus, St Raphael	1:20			
Warsaw Chopin			Local buses (175, 188, 148, 331, 32)		Warsaw	0:25	Warsaw	0:22	0:22
					Wroclaw	1:00	Lodz	1:10	
					Lodz	2:00	Poznan	2:30	
					Krakow	3:00	Wroclaw	2:50	

Airport	Metro, Tram, Local Rail and Airport Express		Local Bus		Public Transport		Car (Off-peak)		Car to City Centre
					Poznan	3:00	Gdansk	3:10	
					Gdansk	3:30	Krakow	3:30	
Edinburgh	City Centre	0:25	Fife	0:25	Glasgow	1:30	Glasgow	0:55	0:25
			Waverley Bridge (Train Station)	0:30	Dundee	1:50	Paisley	1:10	
			Holyrood	0:35	Paisley	2:00	Dundee	1:20	
			Glasgow	1:00	Aberdeen	3:00	Aberdeen	2:25	
Budapest	M3 metro line to city centre				City centre (Széchenyi Lánchíd)	0:13	Deák Square	0:32	0:15
					Deák Square	0:50	Vac	1:00	
					Sopron	3:50	Nyiregyháza	2:10	
							Sopron	3:00	

Appendix 4 Passengers of 11 UK Airports by region

Table 42: UK NUTS1 regions and counties that passengers originating or departing from each of 11 UK airports came from

Planning Region (NUTS1)	County	Pop (000s)	Gatwick			Heathrow			London City			Luton			Stansted			Birming-ham			Doncaster			East Midlands			Leeds Bradford			Liverpool			Man-chester			Total	
			000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	Airport %	% Pop	000s	% Pop
	Derbyshire	771																						737	16.60	95.64											
	Leicester-shire	981																						698	15.72	71.17											
	Lincolnshire	713																						234	5.27	32.82											
	Northamp-tonshire	694																						145	3.27	20.90											
	Nottingham-shire	1,091																						945	21.28	86.65											
	Rutland	38																						16	0.36	42.55											
East Midlands		4,286	653	1.9	15.23	1,270	2.7	29.63	12	0	0.28	845	8.3	19.71	615	3.2	14.35	1,509	16.7	35.20	133	18.4	3.10	2,776	62.5	64.76	53	1.8	1.24	38	1	0.89	797	3.8	18.59	8701.00	202.99

Total	274.42	37.93						235.39	13.06
	16045.00	985.00						16,745	694
Man-chester	0.53	17.75	195.31	100.84	238.65	132.27	129.68	179.55	6.85
	0.1	2.2	9.59	2.41	31.15	9.23	8.62	61	1.7
	31	461	2,009	504	6,522	1,933	1,804	12,773	364
Liverpool	0.05	1.23	47.73	15.21	17.60	25.11	116.24	42.64	0.79
	0.1	0.8	12.79	1.98	12.53	9.56	42.11	79	1.1
	3	32	491	76	481	367	1,617	3,033	42
Leeds Bradford	0.09	8.82						1.48	0.19
	0.2	7.7						3.5	0.4
	5	229						105	10
East Midlands	1.01	0.50						0.48	0.15
	1.3	0.3						0.8	0.2
	59	13						34	8
Doncaster	0.05	1.00						0.24	0.09
	0.4	3.6						2.4	0.6
	3	26						17	5
Birming-ham	1.59	0.50						0.98	0.15
	1	0.1						0.8	0.1
	93	13						70	8
Stansted	97.16	1.69						1.69	0.73
	29.8	0.2						0.6	0.2
	5,681	44						120	39
Luton	52.98	0.69						1.04	0.53
	30.3	0.2						0.7	0.3
	3,098	18						74	28
London City	4.02							0.11	0.02
	0.5	0						0	0
	235	0						8	1
Heathrow	65.20	2.81						4.79	2.05
	8.1	0.2						0.7	0.2
	3,812	73						341	109
Gatwick	51.74	2.93						2.39	1.51
	8.6	0.2						0.5	0.2
	3,025	76						170	80
Pop (000s)	5,847	2,597	1,029	500	2,733	1,461	1,391	7,114	5,314
County			Cheshire	Cumbria	Greater Manchester	Lancashire	Merseyside		
Planning Region (NUTS1)	East of England	North East						North West	Scotland

Planning Region (NUTS1)	County	Pop (000s)	Gatwick			Heathrow			London City			Luton			Stansted			Birming-ham			Doncaster			East Midlands			Leeds Bradford			Liverpool			Man-chester			Total	
	Berkshire	864	877	2.49	101.53	2,319	4.90	268.46	9	0.25	1.04	208	2.03	24.08	192	1.01	22.23																				
	Buckingham -shire	757	453	1.29	59.87	1,026	2.17	135.61	23	0.65	3.04	766	7.48	101.24	197	1.03	26.04																				
	East Sussex	527	2,162	6.14	410.09	531	1.12	100.72	20	0.56	3.79	26	0.25	4.93	116	0.61	22.00																				
	Greater London	8,539	14,965	42.48	175.26	24,926	52.68	291.92	3,057	85.85	35.80	3,605	35.22	42.22	10,104	52.91	118.33																				
	Hampshire	1,760	1,848	5.25	105.01	1,777	3.76	100.98	10	0.28	0.57	138	1.35	7.84	184	0.96	10.46																				
	Isle of Wight	138	101	0.29	72.98	57	0.12	41.18	0	0.00		1	0.01	0.72	4	0.02	2.89																				
	Kent	1,731	2,505	7.11	144.68	948	2.00	54.75	100	2.81	5.78	112	1.09	6.47	408	2.14	23.56																				
	Oxfordshire	655	625	1.77	95.45	1,396	2.95	213.19	8	0.22	1.22	231	2.26	35.28	185	0.97	28.25																				
	Surrey	1,136	2,443	6.93	215.15	2,076	4.39	182.83	30	0.84	2.64	124	1.21	10.92	161	0.84	14.18																				

Planning Region (NUTS1)	County	Pop (000s)	Gatwick			Heathrow			London City			Luton			Stansted			Birming-ham			Doncaster			East Midlands			Leeds Bradford			Liverpool			Man-chester			Total	
	West Sussex	809	2,100	5.96	259.61	915	1.93	113.12	11	0.31	1.36	68	0.66	8.41	74	0.39	9.15																				
South East		16,915	28,078	79.7	165.99	35,970	76	212.65	3,270	6.9	19.33	5,280	51.6	31.21	11,624	60.9	68.72	442	4.9	2.61	2	0.3	0.01	43	1	0.25	2	0.1	0.01	11	0.3	0.07	70	0.3	0.41	84,792	501.28
South West		5,289	1,852	5.3	35.02	3,187	6.7	60.26	17	0	0.32	269	2.6	5.09	354	1.9	6.69	464	5.1	8.77	0	0.1		31	0.7	0.59	2	0.1	0.04	4	0.1	0.08	69	0.3	1.30	6,249	118.15
Wales		3,063	481	1.4	15.70	837	1.8	27.32	5	0	0.16	53	0.5	1.73	93	0.5	3.04	307	3.4	10.02		0		13	0.3	0.42	1	0	0.03	227	5.9	7.41	849	4.1	27.71	2,866	93.55
	Hereford-shire	184																159	1.76	86.60																	
	Shropshire	310																319	3.53	102.86																	
	Stafford-shire	1,098																545	6.04	49.62																	
	Warwick-shire	547																729	8.07	133.39																	
	West Midlands	2,808																3,518	38.96	125.27																	

Planning Region (NUTS1)	County	Pop (000s)	Gatwick			Heathrow			London City			Luton		
	Worcester-shire	567												
West Midlands		5,513	511	1.5	9.27	1,162	2.5	21.08	6	0	0.11	451	4.4	8.18
	East Riding of Yorkshire	591												
	Lincoln-shire (Part)	329												
	North Yorkshire (part)	806												
	South Yorkshire	1,366												
	West Yorkshire	2,227												
Yorkshire & the Humber		5,319	301	0.9	5.66	557	1.2	10.47	6	0	0.11	122	1.2	2.29
Ireland		6,378	0	0		0	0		0	0		0	0	
Total		67,635	35,228	100	52.09	47,317	100	69.96	3,561	100	5.27	10,237	100	15.14

Planning Region (NUTS1)	County	Stansted			Birming-ham			Doncaster			East Midlands		
	Worcester-shire				696	7.71	122.86						
West Midlands		310	1.6	5.62	5,967	66.1	108.23	5	0.7	0.09	783	17.6	14.20
	East Riding of Yorkshire							98	13.57	16.59			
	Lincoln-shire (Part)							75	10.39	22.79			
	North Yorkshire (part)							51	7.06	6.33			
	South Yorkshire							220	30.47	16.11			
	West Yorkshire							87	12.05	3.91			
Yorkshire & the Humber		216	1.1	4.06	157	1.7	2.95	531	73.5	9.98	681	15.3	12.80
Ireland		0	0		0	0		0	0		0	0	
Total		19,096	100	28.23	9,029	100	13.35	722	100	1.07	4,441	100	6.57

Planning Region (NUTS1)	County	Leeds Bradford			Liverpool			Man-chester			Total	
	Worcester-shire											
West Midlands		5	0.2	0.09	151	3.9	2.74	1,250	6	22.67	10,601	192.28
	East Riding of Yorkshire	196	6.60	33.18								
	Lincoln-shire (Part)	30	1.01	9.12								
	North Yorkshire (part)	599	20.17	74.35								
	South Yorkshire	165	5.56	12.08								
	West Yorkshire	1,568	52.79	70.40								
Yorkshire & the Humber		2,557	86.1	48.08	269	7	5.06	4,274	20.4	80.36	9,671	181.83
Ireland		0	0		31	0.8	0.49	0	0		31	0.49
Total		2,970	100	4.39	3,840	100	5.68	20,938	100	30.96	157,379	232.69

Appendix 5 Average Speed Tables

The following tables give the mean and standard deviation (StD) speeds in km/h for both driving and public transport travel modes and for each airport by:

- travel mode (Table 43)
- travel distance in multiples of 50 km (Table 44 and Table 45)
- time of day (Table 46 and Table 47)
- travel direction - access and egress (Table 48)
- day of the week - Monday, Wednesday, and Friday (Table 49)
- cardinal direction - North, East, South, and West (Table 50 and Table 51)

Table 43: Driving and public transport speeds (km/h) by airport

Mode	Driving		Public transport	
Airport	**Mean**	**StD**	**Mean**	**StD**
AMS	73.27	19.44	32.62	17.13
BCN	55.21	23.71	21.99	8.86
BRU	68.83	22.69	30.81	14.89
CDG	71.39	19.02	27.54	11.45
CPH	63.63	23.91	29.27	17.03
DUB	57.51	22.37	21.93	10.05
DUS	75.23	20.81	31.55	17.97
FCO	62.02	20.23	31.68	15.49
FRA	73.08	22.18	38.06	21.68
LGW	65.34	18.58	31.64	16.03
LHR	61.71	23.10	28.29	15.35
LIS	70.28	25.34	15.13	10.29
MAD	73.98	19.63	19.04	7.95
MAN	61.65	20.05	26.86	14.12
MUC	74.25	18.52	30.55	16.95
ORY	65.63	23.36	19.13	9.56
OSL	63.04	13.44	26.89	13.73
PMI	47.98	16.27	14.95	4.92
STN	65.26	19.88	29.35	16.68
TXL	64.98	25.43	25.53	14.22
VIE	73.77	19.32	29.73	14.17
ZRH	66.00	19.26	32.91	13.93
Total	**66.67**	**21.86**	**28.16**	**15.61**

Table 44: Driving speed (km/h) by travel distance (km)

Distance	50		100		150		200		250		300		350		400		Total	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	56.70	12.31	76.38	13.15	88.65	11.24	94.65	7.76	98.71	6.23	97.94	5.57					73.27	19.44
BCN	43.08	13.48	48.68	20.61	73.85	18.90	91.18	6.54	82.10	9.13	77.73	34.85	81.76	25.24	80.04	1.04	55.21	23.71
BRU	42.02	11.59	71.33	12.32	83.62	8.92	90.41	11.78	95.12	9.56	90.14	15.18	92.36	2.15	109.62	3.08	68.83	22.69
CDG	53.31	12.28	72.66	11.09	78.26	10.38	86.50	9.58	96.89	7.42	97.75	8.25					71.39	19.02
CPH	40.08	15.69	73.42	16.19	75.55	21.04	81.59	1.86	79.66	27.75	73.21	20.14	70.46	16.60			63.63	23.91
DUB	40.12	12.02	63.25	17.07	80.54	7.91	84.03	18.74	71.32	23.06	68.23	24.76	44.56	5.90	47.17	0.66	57.51	22.37
DUS	50.01	14.66	79.95	9.84	86.72	7.37	93.98	10.38	90.02	5.71	96.62	6.60	98.70	1.36			75.23	20.81
FCO	45.53	14.44	66.11	9.38	74.32	11.08	40.90	1.89	84.28	4.58	89.39	6.25	88.76	3.35	56.17	31.36	62.02	20.23
FRA	48.58	15.90	76.87	13.38	84.14	11.21	90.57	9.40	90.71	9.15	97.47	6.56	99.14	4.93			73.08	22.18
LGW	51.41	14.66	71.08	12.27	74.57	14.20	64.69	26.51	82.37	15.27	82.34	16.08	74.51	14.80			65.34	18.58
LHR	39.01	13.27	70.01	16.00	77.97	11.03	76.93	21.28	93.04	6.14	86.24	8.08					61.71	23.10
LIS	48.42	16.94	75.51	12.90	92.52	11.97	97.18	7.29	103.65	4.51			100.52	7.58			70.28	25.34
MAD	54.44	14.68	70.77	10.96	81.81	9.00	92.69	8.56	92.54	7.55	97.58	8.34	99.71	8.53	97.02	1.37	73.98	19.63
MAN	42.16	12.60	65.03	14.59	72.66	11.75	80.49	7.77	82.57	8.86	76.45	21.13	88.50	5.04			61.65	20.05
MUC	57.14	13.14	73.18	12.72	85.07	10.85	89.29	12.09	93.56	11.14	90.40	12.09	98.96	6.47	85.79	5.18	74.25	18.52
ORY	39.09	12.37	66.60	12.04	80.40	9.78	88.83	7.78	90.51	7.63	94.70	10.05	105.51	4.19			65.63	23.36
OSL	53.87	14.19	62.40	11.28	70.30	8.57	72.02	8.92	71.54	7.51	71.34	7.71	75.69	2.03			63.04	13.44
PMI	45.81	12.42	57.35	16.92	34.75	14.46	27.98	0.11	28.08	0.15	29.17	3.07	37.57	1.00			47.98	16.27
STN	47.96	10.47	72.80	12.98	77.22	18.30	76.77	19.55	87.57	8.44	82.73	13.42	53.52	27.42			65.26	19.88
TXL	36.09	8.99	69.09	13.01	77.11	8.09	90.47	9.74	96.44	7.07	95.08	7.58	106.10	8.05			64.98	25.43
VIE	58.10	18.67	68.05	16.37	83.11	9.00	88.53	10.18	89.29	8.14	89.62	10.35	93.81	9.49			73.77	19.32
ZRH	44.35	12.30	68.79	13.03	72.82	8.28	86.62	4.97	83.32	9.89	78.56	8.01	91.64	7.08	73.20	4.08	66.00	19.26
Total	**47.16**	**15.02**	**69.30**	**15.27**	**78.92**	**13.89**	**85.24**	**15.51**	**88.01**	**14.18**	**87.56**	**17.86**	**87.63**	**19.40**	**72.01**	**25.82**	**66.67**	**21.86**

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Table 45: Public transport speed (km/h) by travel distance (km)

Distance	50		100		150		200		250		300		350		400		Total	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	19.66	6.65	35.70	12.58	44.43	9.19	56.82	11.00	62.03	14.27	60.75	13.58	49.61	24.37	90.22	0.42	32.62	17.13
BCN	18.92	6.92	24.67	5.58	32.85	1.90							23.16	11.51	45.60	16.79	21.99	8.86
BRU	19.07	5.63	33.06	9.07	37.92	10.38	48.04	13.16	46.92	16.17	67.96	26.79	60.33	20.39	55.14	21.98	30.81	14.89
CDG	14.94	6.99	32.39	5.58	43.84	8.63					23.85	0.00					27.54	11.45
CPH	15.03	6.06	35.95	7.98	41.87	12.04	48.13	12.52	49.82	11.39	63.56	16.77	63.14	7.61			29.27	17.03
DUB	16.48	5.37	27.93	6.51	38.58	4.88	50.87	4.38	36.99	19.55							21.93	10.05
DUS	16.00	5.82	33.56	10.09	39.60	9.13	50.03	11.62	51.21	13.96	49.69	12.31	50.33	16.76	65.73	17.14	31.55	17.97
FCO	14.63	3.58	28.56	5.73	47.78	7.02					43.79	14.97	57.44	19.98	37.41	11.58	31.68	15.49
FRA	20.51	9.41	32.90	6.07	48.18	15.14	59.15	2.85	71.79	20.76	71.10	16.38	64.66	14.41	41.27	11.66	38.06	21.68
LGW	15.60	6.15	32.47	10.13	43.46	9.70	48.65	9.24	47.85	14.17	52.37	11.85	61.70	10.47	45.61	7.17	31.64	16.03
LHR	15.27	4.22	26.37	6.86	38.65	8.15	43.76	9.20	56.02	13.40	63.37	13.67	52.91	23.25	63.73	11.14	28.29	15.35
LIS	11.33	4.18	34.73	10.00	34.58	11.82											15.13	10.29
MAD	11.39	6.22	18.90	3.97	37.44	4.46	29.82	2.90	42.18	2.13							19.04	7.95
MAN	13.53	4.48	27.55	7.45	35.62	6.73	40.81	7.50	45.55	11.89	52.30	9.44	56.46	11.62	66.04	5.86	26.86	14.12
MUC	21.43	10.30	27.62	6.95	47.93	11.21	42.85	14.02	32.14	6.58	72.13	23.30	54.42	17.95	63.00	17.36	30.55	16.95
ORY	14.39	4.66	27.25	7.16	41.15	9.67											19.13	9.56
OSL	17.71	6.52	31.81	11.55	41.56	11.26	38.08	17.65	44.87	4.81	48.12	17.86	30.65	6.99	40.09	9.36	26.89	13.73
PMI	12.93	3.20	19.99	4.82	7.93												14.95	4.92
STN	16.31	5.80	28.37	8.27	38.38	10.81	47.11	12.15	47.50	12.71	70.77	15.13	67.00	24.19	31.42	1.23	29.35	16.68
TXL	17.16	4.70	27.60	6.51	33.32	9.97	59.80	18.94	63.32	17.35	60.73	16.10	61.78	13.90			25.53	14.22
VIE	19.92	12.80	30.25	7.42	38.26	10.39	37.89	12.75	35.74	14.36	62.49	24.15	67.11	19.64	26.69	3.57	29.73	14.17
ZRH	20.90	6.21	37.03	8.94	43.26	10.93	42.62	11.55	45.29	17.16	44.98	8.24	58.62	15.86	49.36	13.35	32.91	13.93
Total	**16.76**	**6.90**	**29.89**	**9.35**	**40.24**	**10.63**	**45.34**	**13.04**	**50.19**	**17.52**	**58.86**	**18.15**	**57.67**	**18.48**	**55.96**	**20.11**	**28.16**	**15.61**

Table 46: Driving speed (km/h) by time of day

Time	9:00		12:00		15:00		18:00		21:00		Total	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	72.04	19.13	72.10	18.68	72.01	18.47	72.64	19.87	77.55	20.46	73.27	19.44
BCN	54.68	23.63	55.23	23.51	55.45	23.80	54.71	23.96	55.96	23.73	55.21	23.71
BRU	67.92	22.35	68.39	21.49	65.96	21.65	66.71	23.84	75.14	22.93	68.83	22.69
CDG	70.21	19.28	72.16	18.62	70.58	18.30	68.88	19.69	75.10	18.63	71.39	19.02
CPH	63.46	23.47	62.86	23.21	60.93	23.25	64.95	24.76	65.96	24.62	63.63	23.91
DUB	58.05	22.28	57.90	22.14	56.90	22.15	54.91	22.06	59.77	23.03	57.51	22.37
DUS	74.26	20.53	74.04	19.78	72.54	19.53	76.30	21.70	78.99	21.86	75.23	20.81
FCO	61.64	20.02	62.92	20.47	62.51	20.44	60.08	20.15	62.97	20.04	62.02	20.23
FRA	72.52	21.73	72.76	21.59	70.89	21.42	73.19	23.03	76.02	22.82	73.08	22.18
LGW	64.65	18.12	64.63	17.14	64.84	17.75	60.88	17.48	71.70	20.59	65.34	18.58
LHR	61.94	22.74	61.99	21.72	60.23	22.16	55.28	22.07	69.09	24.63	61.71	23.10
LIS	69.88	25.39	70.78	24.68	71.28	24.73	69.34	26.24	70.13	25.71	70.28	25.34
MAD	73.22	19.99	74.94	19.32	72.23	20.06	74.03	19.44	75.49	19.23	73.98	19.63
MAN	61.75	20.05	62.00	19.09	60.93	19.03	56.81	19.95	66.77	20.87	61.65	20.05
MUC	73.38	18.12	72.99	17.93	72.65	17.94	75.10	19.26	77.14	18.96	74.25	18.52
ORY	64.62	23.16	67.27	22.93	65.51	22.18	58.50	23.61	72.25	22.88	65.63	23.36
OSL	63.33	13.22	62.70	13.20	61.50	12.97	63.76	13.75	63.91	13.95	63.04	13.44
PMI	47.40	15.94	47.41	16.04	48.60	16.55	47.40	15.97	49.11	16.83	47.98	16.27
STN	64.93	19.71	64.83	19.26	63.90	19.12	63.36	19.04	69.29	21.66	65.26	19.88
TXL	64.15	25.13	64.17	24.57	61.83	25.79	66.98	26.23	67.76	25.00	64.98	25.43
VIE	73.60	19.17	73.44	19.15	72.53	19.39	74.35	20.00	74.93	18.82	73.77	19.32
ZRH	66.25	18.74	66.32	18.91	64.31	18.30	64.24	19.99	68.90	20.01	66.00	19.26
Total	**66.21**	**21.58**	**66.57**	**21.23**	**65.39**	**21.22**	**65.23**	**22.49**	**69.97**	**22.42**	**66.67**	**21.86**

Table 47: Public transport speed (km/h) by time of day

Time	9:00		12:00		15:00		18:00		21:00		Total	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	33.23	17.02	33.31	17.79	33.95	18.65	32.62	17.42	30.00	14.23	32.62	17.13
BCN	21.84	8.99	22.53	8.73	21.96	9.00	21.63	8.54	22.01	9.11	21.99	8.86
BRU	31.71	14.32	32.18	15.49	32.06	15.30	31.12	15.55	26.95	13.05	30.81	14.89
CDG	27.16	11.51	27.46	11.56	27.52	11.80	27.50	11.55	28.07	10.95	27.54	11.45
CPH	30.09	17.48	29.84	17.57	29.81	17.83	29.17	17.13	27.42	14.98	29.27	17.03
DUB	21.93	9.91	21.40	9.20	22.09	10.77	21.96	10.65	22.26	9.71	21.93	10.05
DUS	33.11	18.09	33.09	18.61	33.18	19.48	30.43	16.87	27.76	15.96	31.55	17.97
FCO	32.19	14.69	33.04	15.84	33.41	16.83	29.85	14.42	29.80	15.39	31.68	15.49
FRA	39.06	22.07	39.58	22.23	39.54	22.65	37.76	21.53	34.33	19.51	38.06	21.68
LGW	31.58	15.87	33.25	17.03	33.08	16.80	30.07	14.57	30.24	15.54	31.64	16.03
LHR	29.12	16.53	28.64	15.61	28.85	15.47	27.75	14.80	27.09	14.22	28.29	15.35
LIS	15.01	9.55	14.60	10.51	14.40	10.31	16.29	11.15	15.36	9.89	15.13	10.29
MAD	19.63	8.26	19.14	8.43	19.11	7.63	19.20	7.81	18.09	7.58	19.04	7.95
MAN	27.36	14.61	27.25	14.42	28.11	14.18	26.58	14.20	24.95	12.96	26.86	14.12
MUC	31.19	16.91	30.36	16.91	31.74	18.57	30.83	17.59	28.60	14.37	30.55	16.95
ORY	18.48	9.86	19.61	9.65	19.58	9.86	19.84	10.21	18.12	8.02	19.13	9.56
OSL	26.75	14.46	26.87	13.22	27.44	14.10	26.82	13.47	26.56	13.43	26.89	13.73
PMI	15.08	4.74	15.09	4.94	15.05	5.06	14.92	4.68	14.59	5.23	14.95	4.92
STN	30.46	16.72	30.60	17.23	29.77	16.95	28.35	16.34	27.57	16.01	29.35	16.68
TXL	26.19	14.37	26.04	14.78	26.00	14.39	25.16	14.57	24.28	12.91	25.53	14.22
VIE	30.94	13.98	31.04	14.62	30.66	14.43	29.63	15.06	26.35	12.09	29.73	14.17
ZRH	33.67	14.13	34.39	14.28	33.60	13.65	32.80	14.27	30.02	12.94	32.91	13.93
Total	**28.72**	**15.83**	**28.91**	**16.11**	**28.97**	**16.28**	**27.87**	**15.48**	**26.32**	**14.11**	**28.16**	**15.61**

Table 48: Driving and public transport speeds by travel direction

	Driving speed (km/h)						Public transport speed (km/h)					
Direction	**Access**		**Egress**		**Total**		**Access**		**Egress**		**Total**	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	74.99	18.57	71.54	20.12	73.27	19.44	32.57	17.38	32.67	16.88	32.62	17.13
BCN	56.01	23.27	54.40	24.12	55.21	23.71	21.28	10.33	22.69	7.09	21.99	8.86
BRU	73.30	21.68	64.35	22.80	68.83	22.69	32.00	14.90	29.62	14.79	30.81	14.89
CDG	72.28	19.31	70.49	18.69	71.39	19.02	27.26	11.73	27.83	11.18	27.54	11.45
CPH	64.32	23.77	62.94	24.05	63.63	23.91	29.33	18.11	29.21	15.92	29.27	17.03
DUB	59.89	22.76	55.12	21.73	57.51	22.37	22.54	9.99	21.32	10.09	21.93	10.05
DUS	77.28	20.05	73.17	21.35	75.23	20.81	31.91	18.24	31.18	17.71	31.55	17.97
FCO	63.69	20.46	60.36	19.87	62.02	20.23	32.30	16.75	31.03	14.05	31.68	15.49
FRA	74.67	21.87	71.48	22.37	73.08	22.18	38.31	21.57	37.80	21.81	38.06	21.68
LGW	66.20	18.39	64.47	18.74	65.34	18.58	32.11	16.17	31.18	15.89	31.64	16.03
LHR	62.79	22.64	60.63	23.51	61.71	23.10	28.60	15.89	27.98	14.78	28.29	15.35
LIS	71.10	25.54	69.46	25.12	70.28	25.34	15.19	10.12	15.07	10.47	15.13	10.29
MAD	73.80	19.99	74.16	19.27	73.98	19.63	18.97	8.08	19.10	7.83	19.04	7.95
MAN	61.82	20.21	61.48	19.89	61.65	20.05	27.59	14.59	26.12	13.59	26.86	14.12
MUC	73.84	19.21	74.66	17.79	74.25	18.52	30.32	16.85	30.79	17.05	30.55	16.95
ORY	65.75	23.79	65.51	22.94	65.63	23.36	19.27	9.83	18.99	9.30	19.13	9.56
OSL	65.71	12.83	60.37	13.52	63.04	13.44	26.92	13.29	26.86	14.17	26.89	13.73
PMI	50.87	15.88	45.09	16.15	47.98	16.27	14.42	4.46	15.49	5.30	14.95	4.92
STN	65.06	20.08	65.47	19.68	65.26	19.88	29.30	16.16	29.39	17.20	29.35	16.68
TXL	65.17	25.56	64.78	25.30	64.98	25.43	25.65	13.89	25.42	14.54	25.53	14.22
VIE	73.75	20.05	73.78	18.56	73.77	19.32	30.32	13.74	29.12	14.60	29.73	14.17
ZRH	66.62	19.01	65.39	19.50	66.00	19.26	33.18	13.56	32.64	14.29	32.91	13.93
Total	**67.76**	**21.76**	**65.58**	**21.90**	**66.67**	**21.86**	**28.42**	**15.75**	**27.90**	**15.48**	**28.16**	**15.61**

Table 49: Driving and public transport speeds by weekday

	Driving speed (km/h)								Public transport speed (km/h)							
Weekday	**Monday**		**Wednesday**		**Friday**		**Total**		**Monday**		**Wednesday**		**Friday**		**Total**	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	73.18	19.62	73.34	19.61	73.28	19.10	73.27	19.44	32.67	17.24	32.68	17.25	32.52	16.92	32.62	17.13
BCN	55.37	23.70	55.11	23.63	55.14	23.83	55.21	23.71	22.03	8.85	22.04	8.85	21.92	8.91	21.99	8.86
BRU	69.33	22.87	69.25	22.53	67.90	22.66	68.83	22.69	30.73	14.92	30.73	14.91	30.97	14.86	30.81	14.89
CDG	71.40	19.14	71.24	18.90	71.52	19.02	71.39	19.02	27.55	11.45	27.51	11.47	27.57	11.48	27.54	11.45
CPH	63.70	23.90	63.26	23.70	63.93	24.17	63.63	23.91	29.12	16.97	29.09	16.95	29.60	17.21	29.27	17.03
DUB	57.77	22.43	57.38	22.37	57.37	22.36	57.51	22.37	21.83	9.95	22.17	10.33	21.79	9.90	21.93	10.05
DUS	75.77	20.93	74.70	20.64	75.20	20.87	75.23	20.81	31.43	17.85	31.50	17.97	31.72	18.13	31.55	17.97
FCO	62.25	20.21	62.00	20.13	61.82	20.39	62.02	20.23	31.76	15.53	31.66	15.59	31.62	15.42	31.68	15.49
FRA	73.77	22.41	72.67	22.01	72.80	22.11	73.08	22.18	38.11	21.74	38.05	21.58	38.02	21.77	38.06	21.68
LGW	66.15	18.74	65.52	18.78	64.35	18.19	65.34	18.58	31.48	16.03	31.70	16.08	31.75	16.00	31.64	16.03
LHR	62.87	23.10	62.58	23.36	59.68	22.71	61.71	23.10	28.31	15.46	28.33	15.38	28.23	15.22	28.29	15.35
LIS	70.50	25.09	70.15	25.41	70.19	25.55	70.28	25.34	15.11	10.24	15.11	10.24	15.17	10.43	15.13	10.29
MAD	74.48	19.57	74.03	19.32	73.44	20.01	73.98	19.63	19.05	7.96	19.05	7.96	19.01	7.96	19.04	7.95
MAN	62.19	20.20	61.72	20.22	61.04	19.73	61.65	20.05	26.86	14.05	26.84	14.14	26.89	14.18	26.86	14.12
MUC	74.94	18.75	74.18	18.48	73.63	18.31	74.25	18.52	30.58	16.98	30.61	17.02	30.47	16.87	30.55	16.95
ORY	65.83	23.46	65.66	23.44	65.41	23.21	65.63	23.36	19.10	9.59	19.12	9.59	19.17	9.53	19.13	9.56
OSL	63.06	13.36	62.95	13.32	63.12	13.66	63.04	13.44	26.73	13.74	26.81	13.72	27.13	13.75	26.89	13.73
PMI	48.15	16.38	48.14	16.28	47.66	16.17	47.98	16.27	14.97	4.93	14.97	4.93	14.91	4.92	14.95	4.92
STN	65.94	20.07	65.47	20.00	64.38	19.56	65.26	19.88	29.33	16.73	29.18	16.68	29.53	16.65	29.35	16.68
TXL	65.42	25.34	64.85	25.38	64.66	25.58	64.98	25.43	25.54	14.36	25.46	14.19	25.60	14.13	25.53	14.22
VIE	74.28	19.30	73.68	19.27	73.34	19.39	73.77	19.32	29.71	14.13	29.71	14.13	29.78	14.28	29.73	14.17
ZRH	66.98	19.57	65.50	19.18	65.53	19.02	66.00	19.26	32.81	13.99	32.84	13.86	33.07	13.96	32.91	13.93
Total	**67.11**	**21.94**	**66.64**	**21.80**	**66.27**	**21.83**	**66.67**	**21.86**	**28.12**	**15.62**	**28.14**	**15.61**	**28.22**	**15.61**	**28.16**	**15.61**

Table 50: Driving speed (km/h) by cardinal direction

Direction	East		North		South		West		Total	
Airport	Mean	StD	Mean	StD	Mean	StD	Mean	StD	Mean	StD
AMS	80.26	16.81	69.92	17.48	75.87	21.66	59.50	12.35	73.27	19.44
BCN	32.59	8.42	66.56	16.12	31.55	4.23	70.93	21.82	55.21	23.71
BRU	73.86	22.98	70.35	18.88	64.47	24.97	66.70	22.11	68.83	22.69
CDG	74.13	19.71	75.79	19.63	69.81	17.41	65.84	17.72	71.39	19.02
CPH	75.18	14.33	68.17	29.57	47.45	16.56	62.97	21.58	63.63	23.91
DUB	36.46	9.87	63.04	20.40	52.58	20.54	72.75	18.27	57.51	22.37
DUS	72.79	19.33	77.96	18.87	72.16	22.00	78.11	22.05	75.23	20.81
FCO	69.72	18.79	72.25	13.61	42.58	11.60	41.02	12.00	62.02	20.23
FRA	72.94	20.30	72.61	24.82	74.99	21.16	71.70	22.12	73.08	22.18
LGW	60.56	17.72	69.15	21.24	65.46	16.39	65.44	16.92	65.34	18.58
LHR	59.34	23.98	64.04	23.96	52.57	19.72	69.77	20.96	61.71	23.10
LIS	80.42	24.66	71.95	20.72	61.78	29.66	55.03	10.00	70.28	25.34
MAD	80.03	14.70	70.13	21.21	75.30	17.03	70.47	22.85	73.98	19.63
MAN	53.53	19.06	65.60	20.65	61.24	16.51	66.12	21.48	61.65	20.05
MUC	71.33	17.31	75.68	18.51	69.23	15.42	80.96	20.38	74.25	18.52
ORY	66.68	24.96	61.63	21.20	65.85	26.24	68.18	19.80	65.63	23.36
OSL	64.90	10.59	67.98	12.90	62.41	16.65	56.60	9.81	63.04	13.44
PMI	56.58	15.22	50.18	14.77	46.77	14.20	38.70	14.93	47.98	16.27
STN	58.71	18.11	69.00	20.09	64.35	18.25	68.67	21.05	65.26	19.88
TXL	63.28	26.82	67.80	23.15	63.29	25.47	65.73	25.81	64.98	25.43
VIE	79.78	18.60	70.17	20.15	70.26	19.14	75.01	17.67	73.77	19.32
ZRH	66.48	22.17	68.42	18.08	60.50	17.19	67.94	18.07	66.00	19.26
Total	**67.33**	**22.43**	**68.89**	**20.85**	**63.28**	**22.25**	**67.11**	**21.51**	**66.67**	**21.86**

Table 51: Public transport speed (km/h) by cardinal direction

Direction	East		North		South		West		Total	
Airport	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**	**Mean**	**StD**
AMS	33.58	14.06	28.82	11.67	39.42	21.34	21.45	7.93	32.62	17.13
BCN	14.95	2.41	25.64	8.42	11.65	4.83	19.78	7.52	21.99	8.86
BRU	34.80	18.23	32.71	15.46	26.52	11.81	29.33	11.65	30.81	14.89
CDG	30.01	15.35	32.35	2.49	26.41	11.85	27.52	9.23	27.54	11.45
CPH	31.92	18.56	36.32	20.31	18.32	5.73	25.33	11.42	29.27	17.03
DUB	15.95	4.90	17.64	8.52	22.40	10.67	25.64	9.85	21.93	10.05
DUS	30.57	18.39	28.46	14.43	30.55	17.28	36.69	20.08	31.55	17.97
FCO	30.22	16.74	36.82	13.78	30.38	1.75			31.68	15.49
FRA	32.94	18.30	32.32	21.63	48.08	21.55	44.47	21.64	38.06	21.68
LGW	28.83	15.64	35.24	16.50	25.68	11.10	33.97	17.06	31.64	16.03
LHR	27.10	10.41	30.49	16.59	20.80	9.98	32.90	18.35	28.29	15.35
LIS	15.86	14.94	15.70	8.56	15.00	8.97	12.92	3.12	15.13	10.29
MAD	23.11	6.46	18.33	7.19	17.64	2.39	16.15	10.28	19.04	7.95
MAN	27.42	14.37	25.22	15.50	26.77	14.39	28.07	11.52	26.86	14.12
MUC	29.58	14.17	33.54	24.98	31.83	11.78	27.19	12.60	30.55	16.95
ORY	18.75	9.47	20.38	8.05	16.29	11.72	21.18	7.80	19.13	9.56
OSL	27.11	13.14	30.08	14.13	27.34	14.05	20.66	10.99	26.89	13.73
PMI	16.76	5.78	16.50	4.94	11.76	4.16	14.98	3.20	14.95	4.92
STN	22.55	11.95	31.82	19.39	26.57	12.93	34.89	17.82	29.35	16.68
TXL	22.49	7.81	25.54	12.70	24.32	13.37	31.43	20.66	25.53	14.22
VIE	24.84	9.23	30.48	11.58	27.53	10.96	33.80	18.98	29.73	14.17
ZRH	34.71	15.28	32.01	11.83	27.33	10.89	36.28	15.15	32.91	13.93
Total	**27.69**	**15.07**	**29.19**	**16.08**	**26.57**	**15.07**	**29.21**	**16.05**	**28.16**	**15.61**

Appendix 6 Statistical equivalence

Further mathematical information about statistical equivalence can be found in the Wikipedia article on Anscombe's Quartet. The example below shows four very different datasets:

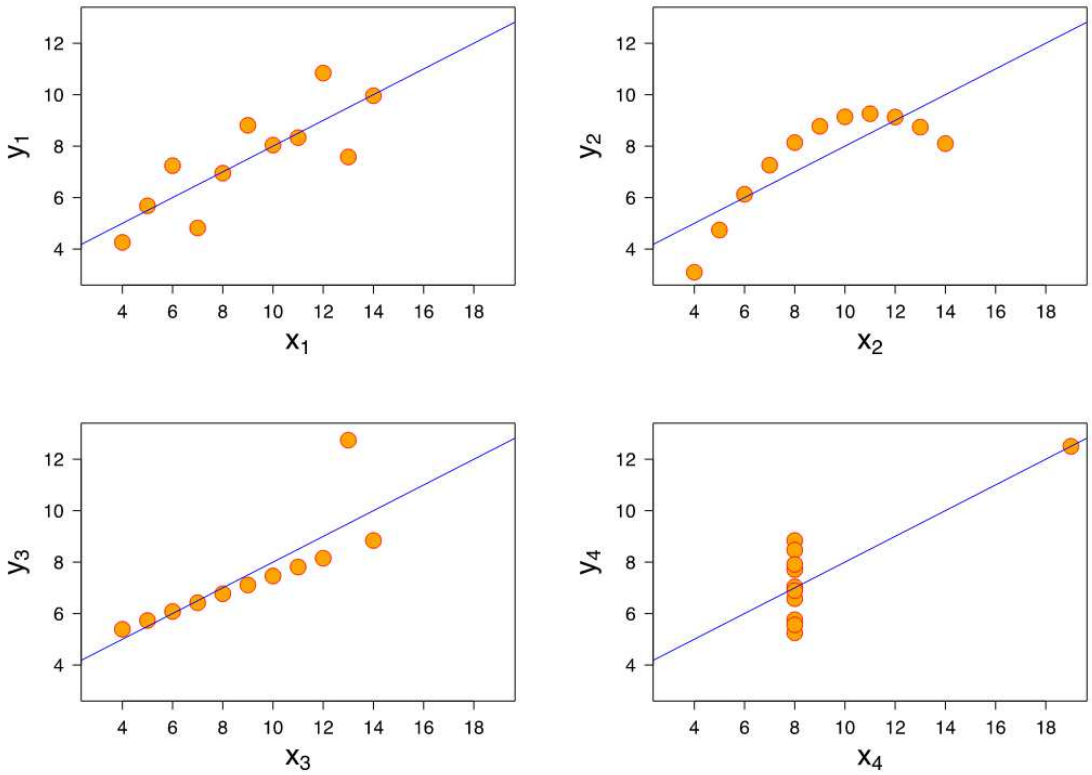

Figure 55: Examples of statistical equivalence

Source: https://en.wikipedia.org/wiki/Anscombe%27s_quartet

All of these have identical statistical properties.

Table 52: Statistics for statistically equivalent examples

Property	**Value**
Mean of *x* in each case	9 *(exact)*
Sample variance of *x* in each case	11 *(exact)*
Mean of *y* in each case	7.50 *(to 2 decimal places)*
Sample variance of *y* in each case	4.122 or 4.127 *(to 3 decimal places)*
Correlation between *x* and *y* in each case	0.816 *(to 3 decimal places)*
Linear regression line in each case	$y = 3.00 + 0.500x$ *(to 2 and 3 decimal places, respectively)*