PRU assessment of NERL delays in the London Approach service

(26/06/2019)

http://ansperformance.eu

Edition Number: 01-00
Edition Date: 26/06/2019
Category: Performance Monitoring and Reporting

European Organization for Safety of Air Navigation

NOTICE

The EUROCONTROL Performance Review Unit (PRU) has made every effort to ensure that the information and analysis contained in this document are as accurate and complete as possible.

Should you find any errors or inconsistencies we would be grateful if you could please bring them to the PRU's attention. The PRU's e-mail address is pru-support@eurocontrol.int.

EUROCONTROL

Executive Summary

This report studies the provision of air traffic management within the London TMA and at London airports. It provides a review of the coding and reporting of ATFM delays within London TMA and at the London airports.

The analysis includes the additional times during the arrival phase and taxi-in phase to give a broader perspective on the airspace user experience.

En-route

The UK Aeronautical Information Publication lists and defines the London FIR and various elements of the London TMA wherein service is provided by London Control (NERL). The air traffic control unit providing ATS services primarily within the London TMA is referred to as London Terminal Control Centre (TC).

London TC shows a relatively good capacity performance when compared with other area control centres (ACC) that handle similar amounts of traffic. Furthermore, London TC has not been among the most constraining ACCs in the European network during the period 2014- 2018.

NERL and the Network Manager have an agreement that gives NERL a high level of autonomy in providing air traffic flow management service in the UK. NERL manages capacity and traffic at local level using traffic regulation techniques such as Minimum-Departure-Interval (MDI) and other short-term traffic ATFM measures (STAM). In general, such targeted measures are considered as being more effective since they reduce the number of ATFM regulations required and they support a better use of airport/departure sector capacity (in case of MDI) and sector-to-sector capacity (in case of STAM).

Although the arrangement between NERL and the Network Manager works very well for real time operations, the fact that NERL does not provide the Network Manager with the number of available sectors means that transparency is partially reduced for external stakeholders when it comes to post-operations analysis and monitoring.

The review of en route ATFM delay attribution and coding within the London TC revealed the following:

- Cases when ATC sectors were being regulated above the level of published declared capacities, indicating the potential for increasing the declared capacity.
- Cases when ATC sectors were being regulated below the level of declared capacity but the reason for the additional capacity constraint was not evident since the delay cause was attributed to ATC capacity.
- Cases when regulations for collapsed sectors were attributed to ATC capacity, despite the collapsing of the sector (possibly due to unavailability of staffing) causing the initial capacity constraint.
- Cases when regulations were applied in collapsed sectors and delays were attributed to adverse weather, although collapsing of sectors has caused the initial capacity constraint.

2018 saw the highest level of delays in London TC, over the period 2014 -2018, with a significant proportion attributed to the implementation of the new EXCDS electronic flight strip system.

It must be noted that the practice by which NERL attributes and codes ATFM delays is consistent with the current guidelines in the ATFCM manual and has been observed at many other ANSPs across the network.

In its annual Performance Review Report 2017 (PRR2017, published in May 2018) the independent EUROCONTROL Performance Review Commission (PRC) - noting that the ATFCM process does not contain rules for attributing ATFM delay, but only guidelines - recommended that "The Director General [of EUROCONTROL] and the Member States [should] strengthen the ATFCM process by developing and adopting strict procedures for attributing ATFM delay causes, instead of the current guidelines that lead to inconsistencies and opacity in monitoring capacity performance."

According to the PRC, the ATFM delay attribution process should be based on the following principles:

- The primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or airspace management);
- Attribution of delays to external causes (e.g. weather or 3rd party strike) should only be used in cases where no ANSP-internal capacity constraints prevent the deployment of maximum capacity;
- Attribution of delays to ATC capacity should not be used for collapsed sectors or when the regulated capacity is less than the maximum declared capacity of the sector.

Airport

Due to the particularities of operations at each London airport, the respective arrival flows are managed through different operational procedures and techniques.

To maximize the runway throughput, traffic into London Heathrow and to some extent into Gatwick is subject to more tactical arrival management, i.e. flights are accepted to enter the London Approach area and are sequenced through airborne holding and vectoring. ATFM regulations at these airports are initiated only when the anticipated holding time will be excessive.

At the other airports (i.e. Stansted, Luton), ATFM regulations are used more frequently to balance demand and capacity.

When all local airport ANS related delays are considered, traffic into Heathrow is subject to the highest delays, followed by Gatwick, with Stansted and Luton substantially below.

The recurrence of airport arrival ATFM regulations at specific times at Stansted suggests the need for improved scheduling through coordination between the involved parties in the operation at the airport (ANSP, airlines and airport operator), which might help reducing the ATFM delay.

Analysis was performed to expand the scope, beyond local airport ANS related delays, to consider all network-wide ANS related delays affecting the arrivals into the London airports. This analysis reveals that the total ANS delays on arrivals into Heathrow and Gatwick are still higher than those at Stansted and Luton.

Total ANS delays for arrivals into Stansted and Luton have significantly increased in 2018, mainly due to capacity constraints elsewhere in the Network (outside the UK). The increase in en-route delays in the London TMA has also had considerable impact on the arrivals at these two airports, accounting for around 20% of the ATFM delay affecting these arrivals.

Objectives of study

This report provides input to the UK CAA investigation team with a view to address the following questions (Further explanation is provided in section 8.3):

1. Understand the processes by which NERL records, categorises, and reports delays.

The review shows that the manner in which NERL categorises delays is in accordance with the existing ATFCM guidelines and is consistent with other ANSPs throughout the network.

2. Understand whether those processes are robust and follow existing best practice guidance.

Whilst noting that the delays are categorised in accordance with the existing ATFCM guidelines, it is important to recall that, in 2017, the Provisional Council of EUROCONTROL, noting the concerns raised by the PRC, requested the Director General of EUROCONTROL and the Member States to strengthen the ATFCM process by developing and adopting strict procedures for attributing ATFM delay causes instead of the current guidelines that lead to inconsistencies and opacity in monitoring capacity performance.

3. Have (ATFM) delays in practice been recorded appropriately for the London Approach Service in relation to Stansted?

Although analysis of the ATFM regulations shows that ATFM delays have been recorded in accordance with the current guidelines for ATFCM as published by EUROCONTROL, it has raised several anomalies (such as 'conjoint airspace') that could be resolved by improving information exchange between ANSP and NM.

4. What are the underlying causes and contributory factors to ATFM delays in the London area?

The general behaviour is consistent with the ATFM operations observed in other ANSPs across Europe, in that whilst specific reasons for capacity constraints may arise from time to time (such as adverse weather, military activity, equipment/system implementation), increasing levels of traffic will amplify any capacity constraints.

Furthermore, capacity constraints applied for internal ANSP reasons, for example the operation of collapsed sectors due to non-availability of staff (planned or unplanned), can create significant adverse impact to airspace users if traffic demand exceeds the deployed capacity.

5. Interrelation and impacts of other forms of delay on NERL attributable ATFM delays in the London area, and vice-versa.

This report analysed the en-route and arrival ATFM delay observed for London TMA and London airports. Other forms of temporal inefficiencies (i.e. additional ASMA time, additional taxi-in and taxi-out times) have also been analysed. In general, the different components are cumulative from an individual flight perspective.

The estimated total impact on London bound flights is summarised in section 6.3

6. Likelihood of likely consumer harm (including additional costs borne by airlines and airports) arising from NERL attributable delay in the London approach area (including reactionary delay) and put in the context of total flight delay and ATFM delay in other comparable airspace sectors

This report is not in a position to quantify the associated costs to airspace users or airports.

The ATFM performance observed at London TC is good relative to comparable ACCs. (See section 3.1)

7. Understand key constraints faced by the provision of London Approach Service to aircraft using Stansted and Luton airport and what actions might be able to address those constraints in the future

This report highlighted the interplay between the ANS, airports, and airspace users, and how the efficient use of resources is a shared responsibility amongst all parties. The assessment of the impact on airspace users shows that ANS is not the sole factor to be addressed.

This report documents a substantial growth of air traffic within the London multi-airport system, particularly at Stansted and Luton.

The observations point to a general requirement to minimise the need for ATFM measures to be put in place, to ensure the safe and efficient flow of air traffic. The ultimate goal is better modulation of the air traffic demand in light of the available resources across the involved stakeholders.

It is acknowledged that NERL, like any other ANSP, should provide the capacity required for the provision of air traffic services to satisfy peak demand. However, the action on the ANSP does not live in isolation. It needs to be properly balanced with the resources on the airport side, both airside and landside, and the airspace user operations.

Traffic characteristics (long haul, short haul); airline business model (low cost, traditional); infrastructure (multiple, single runway) and traffic demand are heterogeneous across the London airports.

Accordingly, there is variation in the application and type of ATFM techniques used to effectively manage traffic flows.

The ATFCM processes followed by NERL, including delay coding and attribution, are consistent with the current guidelines as published by EUROCONTROL in the ATFCM manual.

The EUROCONTROL Performance Review Commission has identified that the current ATFCM process should be strengthened by developing and adopting strict procedures instead of the current guidelines that lead to inconsistencies and opacity in monitoring capacity performance.

The analyses performed in this report did not reveal any evidence of difference in treatment between airspace users operating at different airports within the London multi-airport system.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

The CAA is seeking data collation, analysis and expert advice to inform and support a CAA investigation under section 34 of the Transport Act 2000 (TA00) into alleged contraventions by NATS (En Route) Plc, known as NERL of its duties under section 8 of TA00 and/or conditions of its licence [1].

The complaints received by the CAA follows

I. A previous CAA investigation (named Oberon) on similar grounds [2]; and

II. The publication of statistics following that investigation.

An important objective of the study is to assess NERL's approach to how it codes and reports delays. Another objective is to assist the CAA with the assessment, from a technical perspective, of those delays (particularly over the past 5 years).

The complainants are concerned that the reasons reported by NERL for delays may not accurately convey the underlying issue. The complainants suggest that some of the delays attributed to "ATC capacity" or other causes may in fact be explained by insufficient numbers of ATC staff.

NERL considers that 2018 ATC capacity delays to Stansted and Luton have been driven by strong traffic growth which exceeded capacity over peak periods. The way Essex airspace is designed means that the Luton and Stansted approach route is shared, which limits the flow to these two airports.

As such, the CAA is keen to better understand:

1. the processes by which NERL records, categorises and reports delays;
2. whether those processes are robust and follow existing best practice guidance;
3. whether delays have in practice been recorded appropriately for the London Approach Service in relation to Stansted;
4. the underlying causes and contributory factors to ATFM delays in the London area. For this it may be helpful to correlate delay events with traffic, staffing availability, weather events, etc.
5. the interrelations and impacts of other forms of delay on NERL attributable ATFM delays in the London area, and vice-versa;
6. the magnitude of likely consumer harm (including additional costs borne by airlines and airports) arising from NERL attributable delay in the London approach area (including reactionary delays) and put it in the context of:
    - Total flight delay experienced by consumers; and
    - ATFM delays in other comparable airspace sectors both in the UK and in Europe, taking into account the reasons for ATFM delays (and in particular the staffing levels and resilience of other comparable airspace sectors).
7. the key constraints faced by the provision of the London Approach Service to aircraft using Stansted and Luton airport and what actions might be able to address those constraints in the future.

1.2 PRU Contribution (Part A – detailed delay analysis)

The PRU was asked to provide a factual (data-driven) analysis including expert judgement as an input to the UK CAA investigation team. This contribution has been coordinated through a Terms of Reference mutually agreed between UK CAA and EUROCONTROL. The associated Part A – detailed delay analysis – is represented by this report addressing the following points:

- Air traffic and air traffic flow characterisation within the London Approach Service area of responsibility;
- Description and characterisation of ATFM Delay and Capacity Demand Balancing by studying ATFM delay causes and associated traffic flows within London Approach area;
- Analysis of air traffic and ATFM delay evolution within London Approach Service area of responsibility;
- Analysis of declared versus delivered capacity under consideration of identifiable delay events;
- Analysis of airspace user experienced delay within London Approach area ;
- Performance related expert opinion on the analysis performed.

2 En-route ATFM delay versus Arrival ATFM delay

This section provides a brief explanation of why ATFM delay is applied and explains the difference between en-route ATFM delay and arrival ATFM delay.

The objective of Air Traffic Flow and Capacity Management (ATFCM) is to optimise traffic flows according to air traffic control capacity while enabling airlines to operate safe and efficient flights.

In Europe, ATFCM activities are divided into three phases:

- Strategic – From one year before flight until one week before real time operations, where inter alia the Network Manager helps ANSPs to predict what capacity they will need in each ACC, and publishes in the Network Operations Plan (NOP);
- Pre-tactical – six days before until day of operations, where the Network Manager, with ANSPs and aircraft operators, coordinates the definition of a Daily Plan aimed at optimizing the overall network performance and minimizing delay and cost;
- Tactical – on day of operations, where Daily Plan is monitored and updated based on developments; work continues on capacity optimization according to real time traffic demand and, where flights receive the benefit of flow management service which includes the **allocation of individual aircraft departure slots**, re-routings to avoid bottlenecks and alternative flight profiles in an attempt to maximize flight efficiency and make best use of available capacity.

The allocation of a departure slot, to prevent too many aircraft being in the same **location** – and leading to an unsafe situation, involves the application of a Calculated Take-off Time (CTOT), or slot, to a specific flight. The aircraft is subsequently required to be at the runway, ready for departure in accordance with its CTOT rather than the Estimated Take-Off Time (ETOT) from its filed flight plan. The difference between the CTOT and the original ETOT is recorded as ATFM delay – for example a flight with an ETOT of 0900, and given a CTOT of 0950 will be recorded as experiencing an ATFM delay of 50 minutes.

If the location being protected by ATFM regulation (necessitating the implementation of CTOTs) is airspace then the delay is counted as en-route ATFM delay. If the protected location is the destination airport, then the delay is counted as arrival ATFM delay. It is important to note that the current ATFCM system works according to the concept of 'most penalising regulation' which determines both the delay and the geographical location to which it is assigned.

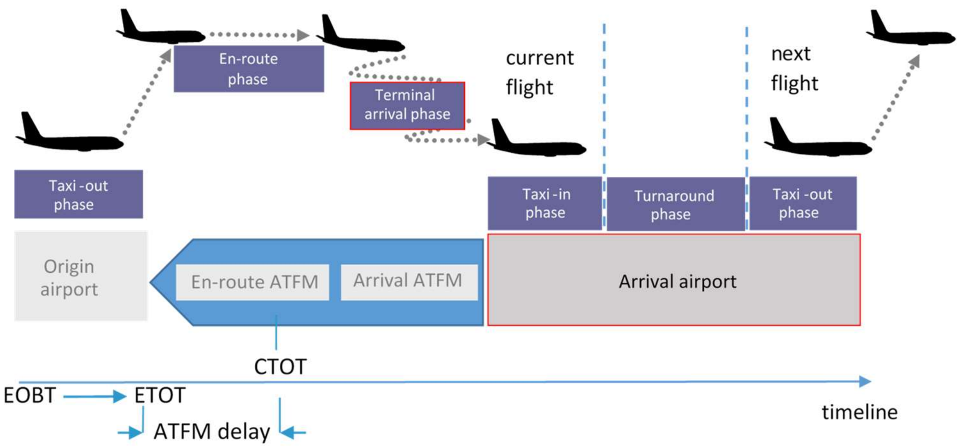


Figure 2-1: Flight perspective

Figure 2-1 shows a flight being performed between 2 airports. The flight is subject to air navigation services ANS during the different phases of flight, and therefore subject to any constraints resulting from capacity demand imbalances, within the different phases.

Any capacity constraints - between take-off and landing - that are managed through the application of ATFM regulations will result in ATFM delays, either as en-route or arrival depending on the location of the constraint.

Capacity constraints can also be managed by tactically increasing the time that aircraft spend in upstream phases. For example the taxi-out phase could be increased to regulate a capacity shortfall on the departure runway or in downstream airspace, or the flight might be held in the arrival TMA to manage a temporary capacity shortfall in the arrival airport.

ATFM delays do not reflect the additional time spent by aircraft that are tactically regulated in this manner, although the inefficiencies can be quantified by monitoring performance indicators such as additional taxi-out time, additional taxi-in time or additional time spent in the Arrival Sequencing and Metering Area (ASMA).

3 Air traffic characterisation

3.1 En-route ANS performance in the UK

This section of the report shows the general en-route statistics for traffic and capacity within UK airspace at national level and broken down further for the three area control centres (ACC) London Area Control Centre (AC); London Terminal Control Centre (TC), and Prestwick ACC. It also provides a high-level comparison between London TC and AC and similar ATC centres elsewhere in the Network.

Performance overview: United Kingdom

3.9% of total en-route ATFM delay in the EUROCONTROL area

730 k minutes of en route ATFM delays (+74.6% vs. 2017)

0.29 minutes of en-route ATFM delay per flight in 2018 - (+0.12 min vs 2017)

1.5% of flights within airspace delayed by en route ATFM delays (+0.6% pt. vs. 2017)

19.2 minutes of en-route ATFM delay per delayed flight in 2018 - (+0.4 min vs 2017)

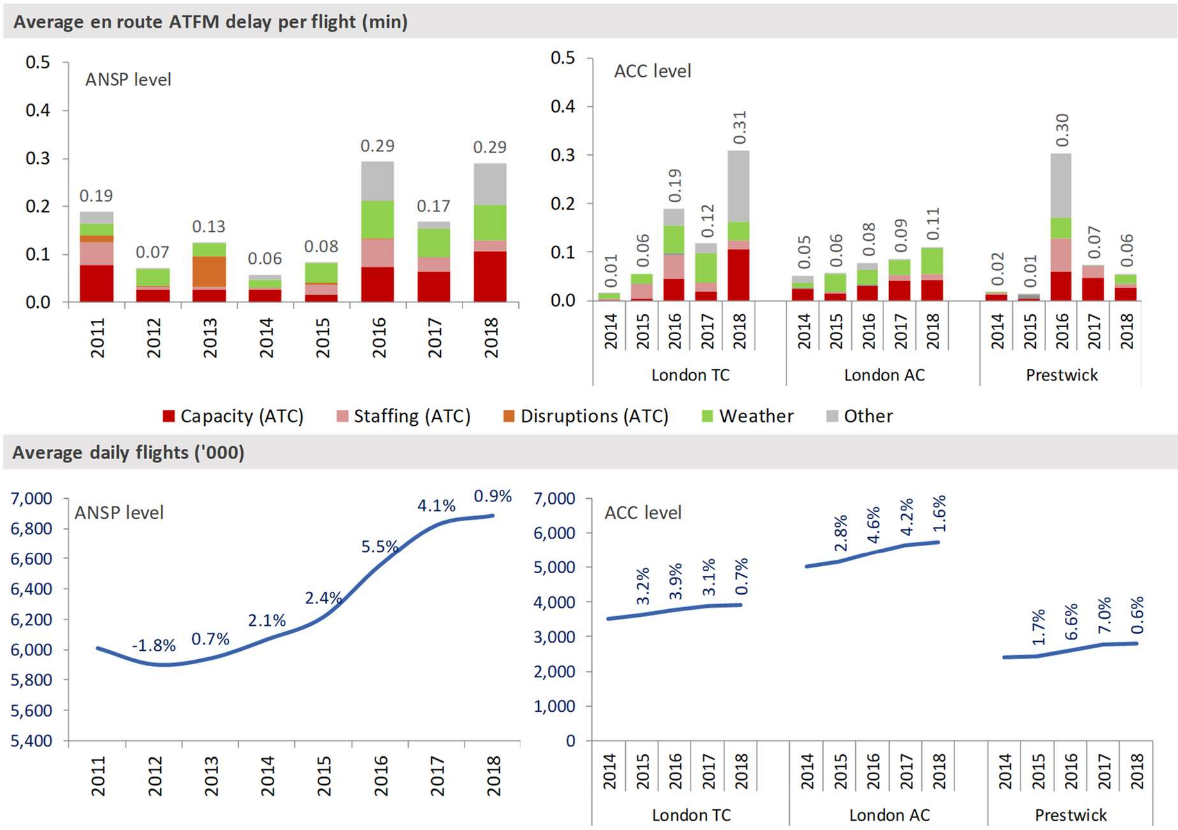


Figure 3-1: Year on year comparison

Average daily flights increased continuously between 2014 and 2018 at both ANSP and ACC level. In 2018, the UK accounted for 3.9% of total en-route ATFM delay in the EUROCONTROL area.

Overall, 1.5% of the flights in UK airspace were delayed by en-route ATFM regulations, with an average delay per delayed flight of 19.2 minutes.

Average en-route delay increased from 0.17 per flight in 2017 to 0.29 minutes per flight in 2018 mainly attributed to the introduction of the Electronic flight strip system EXCDS in April to London TC (replacing the old paper strips system) included in 'Other'.

Figure 3-2 shows the total number of controlled flights (x-axis) and the total minutes of en-route ATFM delay (y-axis) for the largest ACCs in 2018. London AC controlled the highest number of flights (>2million) in 2018 but the second lowest level of en-route ATFM delay after Ankara ACC. London TC controlled more flights than Langen in 2018 but with a lower level of en-route ATFM delays.

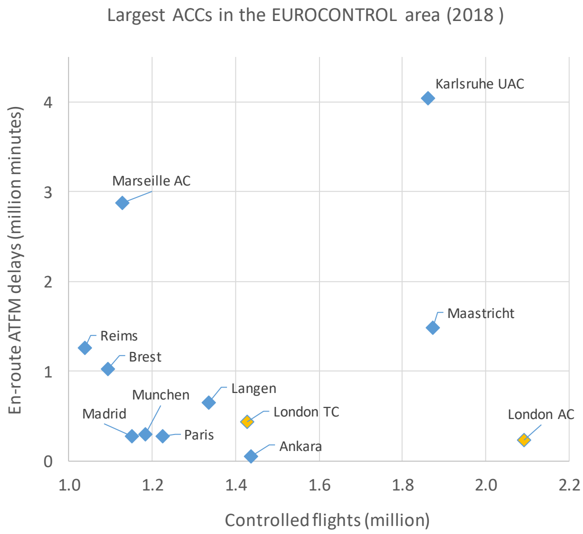


Figure 3-2: London TC and AC with the largest ACCs in the EUROCONTROL area (2018)

Figure 3-3 provides an aggregated view of the most constraining ACCs between 2014 and 2018. The total minutes of en-route ATFM delay are shown on the y-axis while the x-axis shows the share of flights delayed by en-route ATFM delays within the respective airspace. The figures show the aggregated results over the past 5 years. In addition to London AC and TC also a combination of both centres is shown. Over the analysis period, London AC and TC show a comparatively low share of en-route ATFM delayed flights.

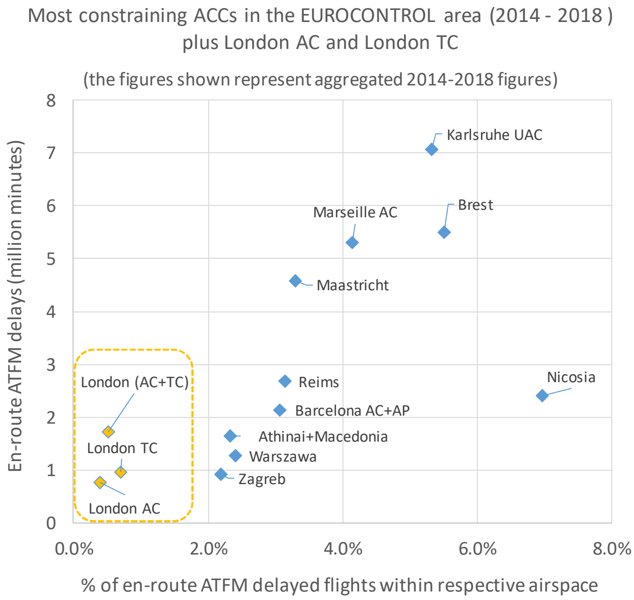


Figure 3-3: London TC and AC compared to the most constraining ACCs (2014-2018)

3.2 London Airports

The London TMA is characterised by a high density of air traffic arriving and departing to multiple airports. It represents therefore the busiest multi-airport system in Europe combining one major international hub, London Heathrow (EGLL), and several busy airports. As can be seen in Figure 3-4, the number of airports and associated density of traffic and resulting complexity of airspace and air traffic flow is unmatched in Europe [3].

Figure 3-4: Movements at major European multi-airport systems (2018)

The multi-airport system of London has seen a considerable growth throughout the last 5 years (c.f. Figure 3-5 and Figure 3-6). Overall traffic into all London airports has increased by 13.7% comparing 2013 vs 2018. There is a strong increase at London Stansted and London Luton. Although the individual share of total London traffic at each airport has increased by around 2-3%, Figure 3-6 shows the absolute traffic increase for both airports is just under 40%.

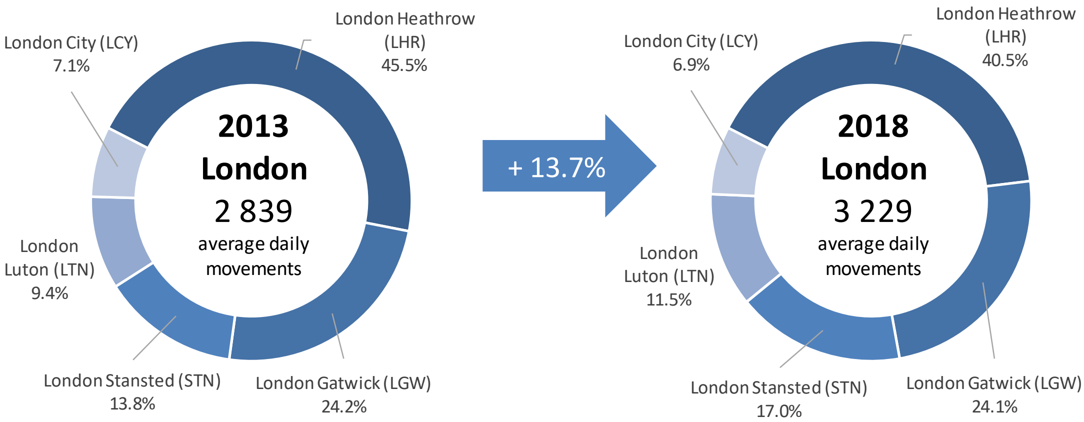


Figure 3-5: Evolution of movement share within the London multi-airport system (2013 - 2018)

The long-term evolution at London airports reflects the general picture of traffic growth over the past decade. With the ripple effects of 2008 through 2010, air traffic has picked up again as of 2011/2012. With London Heathrow operating at its capacity limit, there is only a marginal increase. Next to London Stansted and London Luton, Figure 3-6 also depicts a significant increase of traffic at London Gatwick (i.e. 13.3% between 2013 and 2018). London City also operates a fairly stable level of air traffic. The shift in total movements explains the shift in shares of traffic for the London.

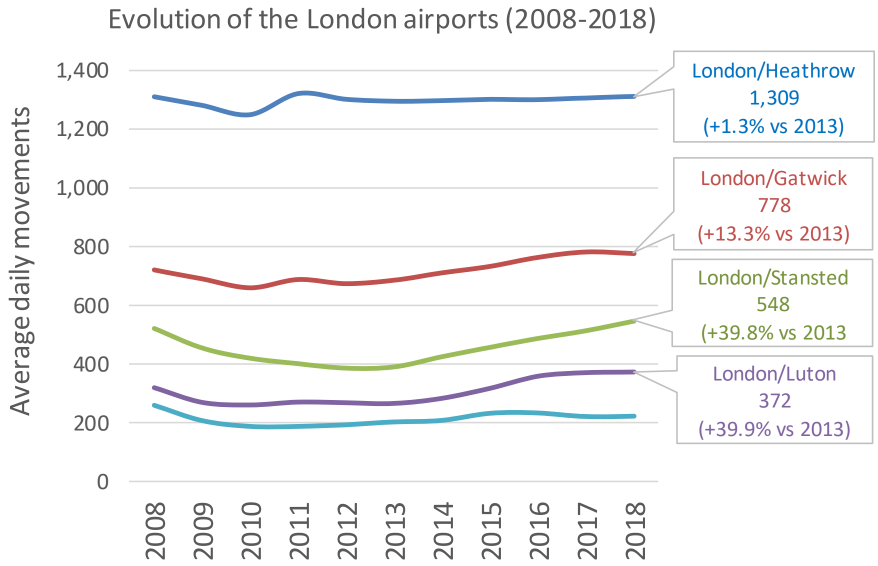


Figure 3-6: Long-term evolution of movements at London airports (2008 - 2018)

It follows that the London multi-airport system has seen a significant increase in air traffic throughout the recent years. Nonetheless, compared to other approach areas in Europe, London Approach (NERL) does not reside amongst the most constraining ACCs.

4 En-route ATFM delay analysis

4.1 Data sources used for the analysis

The analysis uses information published in the Network Strategic Tool (NEST) from EUROCONTROL which provides the historical available and open ATC sector configurations, the applied ATFM regulations with geographical location and delay cause attribution as decided by the Flow Management Position[1] (FMP) requesting the regulation.

The analysis also uses the list of ATFM regulations provided by the Network Manager in the Pan European Repository of Information Supporting the Management of EATM (PRISME) database, the same database used for performance review in both the EUROCONTROL Performance Review Framework and the Performance Review Mechanism of the Single European Sky. This database contains the amount of minutes of ATFM delay for each ATFM regulation, the attributed reason for the regulation, and the geographical location associated for each ATFM regulation.

[*Technically the same geographical location can be covered by more than one ATFM regulation depending on whether or not the sector is collapsed. For example, a geographical location situated in an elementary sector can also be included in a larger collapsed sector (or 'band-boxed' sector as it is referred to in the UK), formed by combining two or more elementary sectors.*]

Network Strategic Tool (NEST)

NEST is a single simulation tool for network capacity planning and airspace design – resulting from the merge of SAAM and NEVAC.

NEST is a scenario-based modelling tool used by the EUROCONTROL Network Manager and the Air Navigation Service Providers (ANSPs) for:

- designing and developing the airspace structure,
- planning the capacity and performing related post operations analyses,
- organising the traffic flows in the ATFCM strategic phase,
- preparing scenarios to support fast and real-time simulations,
- and for ad-hoc studies at local and network level.

NEST is used to optimise the available resources and improve performance at network level.

EU Regulation No 677/2011[2] laying down detailed rules for the implementation of air traffic management (ATM) network functions, describes in Annex V the template for the Network Operations Plan. Appendix 1 of the annex states that "each air navigation service provider shall provide the Network Manager with … [the] number of available sectors: sector configuration/opening scheme per season/day of week/time of day…"

It is evident from the Figure 4-1 that the Network Manager is not updated with the opening or closing of individual ATC sectors. Instead there is an agreement that the Network Manager should consider that all 20 individual ATC sectors (otherwise known as CONF19) in the London Terminal Control Centre are open H24.

[1] FMP: A working position established in appropriate air traffic control units to ensure the necessary interface with a central management unit on matters concerning the provision of the air traffic flow management service. UK FMP is situated in London Area Control (Swanwick) See UK AIP ENR 1-9 for details.

[2] EU Regulation 2019/123 will repeal Regulation 677/2011 when it comes into force on 1st January 2020. N.B. The data requirements on ANSPs to provide remain unchanged in the new regulation.

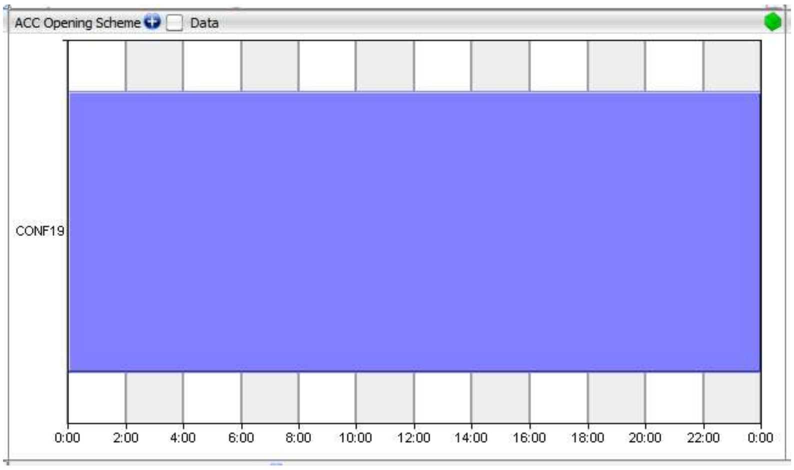


Figure 4-1: Available Sector Configuration at London TC

NERL manages capacity and traffic at local level using agile traffic regulation techniques such as Minimum-Departure-Interval (MDI) and other short-term traffic ATFM measures (STAM), in addition to the more traditional (and blunter) process of allocating AFTM slots via the central Network Manager. NERL considers this approach leads to better capacity management results than simply using the CHMI[3] functionality provided by the Network Manager. In essence, this means that the NERL is responsible for monitoring traffic flows into London airspace and that the Network Manager should only apply ATFM regulations on the request of London FMP.

This situation allows NERL the flexibility, in real-time operations, to manage resources and traffic at a local level, without having to constantly update the Network Manager of the opening and closing of ATC sectors. However, away from the real-time operational environment, it is more difficult, for external stakeholders, to monitor the deployment of ATC resources against the traffic demand.

The reduced transparency about the opening and closing of individual sectors renders it difficult to determine, in post-operations analysis, if a sector was operated in a collapsed mode (band-boxed) at the time of regulation: which could indicate a shortfall in ATC resources such as staffing rather than a higher demand than available ATC capacity for an elementary sector, which should normally be attributed to ATC capacity.

Similarly, operating collapsed (band-boxed) sectors during periods of adverse weather activity can exacerbate an existing shortage of capacity and can result in greater delays than would have been the case if the individual elementary sectors were opened.

The only method of monitoring capacity deployment, that is available to external stakeholders, is to review the individual ATFM regulations that were applied on the request of the local FMP. As stated previously, each regulation contains a geographical location (a sector or a geographical reference point in the air or on the ground) and the reason for the capacity constraint as decided by the FMP.

Basing analysis only on the ATFM regulations, without the ability to cross-reference sector opening schemes produced anomalies which are discussed further in the text (See Note below section 4.7.5).

---

[3] The Collaboration Human Machine Interface (CHMI) is a standalone application which provides a graphical interface for the Network Operations systems allowing users to display data and graphical information (such as routes, route attributes, airspaces, flight plan tracks, etc.) via map displays. This real time information enables Collaboration Decision-Making (CDM) between all partners

4.2 Collapsed sectors

An ATC sector that can be de-collapsed/split into two or more pre-defined operational sectors, to provide additional capacity. ATC workload is the critical element to ensure safety: the ATCO needs to effectively identify, assess, solve, and monitor the resolution of conflicts. Larger sectors mean more potential conflict points to be assessed, solved and monitored – smaller sectors allow ATCO to focus on fewer number of potential conflict points.

Collapsing sectors, whilst reducing ATC workload associated with the handover of traffic, generally raises ATC workload due to increased number of potential conflict points. In certain cases, collapsing sectors may also require the ATCO to change the scaling of the ATM situation display making the assessment of potential conflicts more problematic.

In general, sectors are collapsed when traffic demand permits. However it may be necessary to collapse sectors during periods of higher traffic demand, creating the need for ATFM regulations, due to the unavailability of ATC staff (planned or unplanned) or due to unserviceability of ATC equipment.

4.3 Geographical scope of en-route analysis

The scope of the investigation of en-route ATFM delay in this section includes those ATFM regulations applied at en-route geographical locations within the London TMA. This excludes geographical locations on the ground, i.e. airports, which will be considered in the analysis of arrival airport ATFM delay.

All ATFM regulations allocated to the selected geographical locations associated with London TC are included.

The list of sectors considered in the analysis is shown in Table 4-1. Sectors defined in the NEST as collapsed (band-boxed) sectors are highlighted in blue/yellow. Even though REDFA & LOREL SECTOR and LONDON TC GODLU + JACKO + THAMES SECTOR are listed in NEST as collapsed sectors, NERL reports that they are never operated as collapsed sectors but are defined as such, to capture certain traffic flows. (See section 4.4.)

This is not a complete list of sectors defined within the London TMA but is a list of sectors that experienced capacity constraints requiring ATFM regulations during the timeframe of the study.

Sector	Min FL	Max FL		Sector	Min FL	Max FL
CPT SECTOR	155	215		NORTHWEST COMBINED	35	165
GODLU SECTOR	35	195		OCKHAM SECTOR	55	175
LOND TC LOREL	55	155		REDFA & LOREL SECTOR	45	215
LOND TC NE&LOREL	25	175		SOUTH-WEST DEPARTURE	25	135
LOND TC NORTH	25	175		TC BOVINGDON SECTOR	35	165
LOND TC SE LOW+TIM	0	175		TC JACKO	45	215
LOND TC SOUTH	25	195		TC LAMBOURNE SECTOR	25	175
LOND TC SW	25	175		TC NORTHWEST + BOVINGDON	35	165
LOND TC TIMBA	35	175		TC OCKHAM SECTOR	25	175
LONDON CAPITAL	115	215		TC REDFA	55	215
LONDON TC BIGGIN SEC	35	175		TIMBA, GODLU AND BIGGIN SECTOR	35	195
LONDON TC GODLU+JACKO+THAMES	0	215		TIMBA AND GODLU SECTOR	35	195
LONDON TC THAMES SECTOR	0	85		TIMBA AND WILLO SECTOR	35	195
LONDON TC THAMES SECTOR TEST	0	115		VAT SECTOR	115	215
LONDON TC WILLO SECT	35	175		WELIN	45	215

Table 4-1: List of sectors considered in the London TC analysis

4.4 'Conjoint airspace'

Subsequent to the publication of the initial draft report, where the PRU had identified significant amounts of delay being attributed to collapsed sectors "REDFA & LOREL" and "LONDON TC GODLU+JACKO+THAMES" the ANSP reported that these sectors did not actually exist as collapsed sectors, and since they belonged to separate sector groups, it was impossible to operate these sectors together.

NERL provided the following rationale:

> … NERL uses other advanced techniques to minimise delay, for example when managing MVs [Monitoring Values] in a sector group with two vertical elemental sectors, with demand in excess of capacity in one sector, and demand approaching capacity in the other.
>
> Both elemental sectors are open and one requires ATFCM intervention. Airlines flight planning behaviour can be very agile in response to ATFCM regulation in such vertically stratified airspace, hence NERL would not choose to regulate one of the elemental sectors.
>
> The practice NERL utilises is to regulate the combined sector at a capacity (MV rate) that reflects the overall throughput limit of the two elemental sectors allowing the tactical teams to manage the relative loadings between the two elements. This practice reduces delay overall and provides ATM stability within both the regulation and airspace.[4]

Discussions with the Network Manager have confirmed that considering separate sectors as 'conjoint airspace' is an acceptable operational practice and that, in the opinion of NERL, it facilitates effective regulation of traffic with minimal delays

As instructed by the ANSP, the sectors are described in the NM systems as being 'collapsed' so that the traffic flows can be identified readily. However, the individual sectors cannot be combined operationally and controlled by an individual ATCO (team) – and are therefore, by definition, not collapsible.

Since post-operations analysis relies on the NM systems as the primary source of data for both airspace definitions and regulations, the analysis identified that capacity constraints frequently appeared in 'collapsed' sectors; which normally indicates lack of staffing availability or problems with ATC equipment.

Following the explanation from the ANSP, it is accepted that these 'conjoint airspaces' are not collapsed sectors in the operational sense, since they cannot be controlled by an individual ATCO (team). However since the source data cannot be changed independently (only the ANSP is in a position to re-allocate the delay to the elemental ATC sectors), this report separates the 'conjoint airspace' (CON-ASP) from the collapsed sectors when reporting on en route capacity.

Cross-referencing the ATFM regulations against the actual sector configurations would prevent this issue arising since the post-operations analyst would be able to confirm that the sectors were not actually collapsed when the regulation was applied. This has been used in analyses of other ANSPs that exchange dynamic information on actual sector configurations with the network manager.

[4] Paragraph 27 of Annex B of NERL's letter to the UK CAA dated 3 June 2019

4.5 PRU perspective for capacity analysis

This report, is guided by the work of the Performance Review Commission of EUROCONTROL (PRC). The PRU draws from PRC statements about capacity published in previous Performance Review Reports (PRR) and separate PRC reports[5]. It is noted that both the Provisional Council of EUROCONTROL endorsed (and the Permanent Commission approved) the PRC recommendations regarding capacity in PRR 2017.

Recommendation	***Rationale***
• The Provisional Council is invited to: • recall that PC/45 (2016) had requested Member States to task their ANSPs to provide sufficient capacity to meet demand and to accurately identify capacity constraints that adversely impact service provision; • request the Director General and the Member States to strengthen the ATFCM process by developing and adopting strict procedures for attributing ATFM delay causes, instead of the current guidelines that lead to inconsistencies and opacity in monitoring capacity performance; • submit this recommendation (c.1 and c.2) to the Permanent Commission for approval.	*With traffic now increasing again since 2013, the PRC concerns, outlined in earlier PRR's, were confirmed that delays would increase again, unless sufficient attention was focussed on capacity management.* *Additionally, the PRC has noted significant inconsistencies in the allocation of ATFM delay by the ATFCM operational stakeholders.* *Inconsistency in allocating ATFM delays makes it increasingly difficult to identify the root causes of capacity constraints which in turn prevents appropriate and cost-effective mitigation or resolution.* *The PRC notes that the ATFCM process does not contain rules for attributing ATFM delay, but only 'guidelines'.* *The ATFM delay attribution process should be based on the following principles:* *The primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or airspace management);* *Attribution of delays to external causes (e.g. weather or 3rd party strike) should only be used in cases where no ANSP-internal capacity constraints prevent the deployment of maximum capacity;* *Attribution of delays to ATC capacity should not be used for collapsed sectors or when the regulated capacity is less than the maximum declared capacity of the sector.*

Table 4-2: Extract from PRC Recommendations in PRR 2017

[5] https://www.eurocontrol.int/sites/default/files/publication/files/analysis-most-constraining-en-route-atfm-regulations-attributed-to-atc-capacity-2017.pdf

4.6 NERL Delay Attribution Principles

Source: internal NATS document "Service Performance Improvement Process" (passed to PRU by UK CAA with approval of NERL.)

In April 2017, a set of guidelines were issued to Operations "to clarify the differences between Capacity and Staffing regulations...The principles, summarised below, are used within the day-to-day operation as well as being used for the ruling principles at [NATS internal] Performance Review."

ATFM Delay Attribution
Capacity or Staffing?

Capacity – The number of controllers available for use on a specific sector matches declaration in **PSS**. These controllers must be available to be used on the regulated sector regardless of where they may be rostered on the daily sheet. Regulation is attributable to capacity.

Staffing – The number of controllers available for use on a specific sector is below the declared PSS. Regulation is attributable to staffing.

Table 4-3: Extract from Appendix 3 Service Performance Improvement Process

PRU comment – Basing the sector opening scheme, and the number of available ATCOs, on what has been previously declared in a plan (PSS above), instead of basing it on traffic demand means that the available capacity is highly dependent on the accuracy of the plan in identifying the peak demand periods as well as instances when capacity will be reduced.

The PRC proposal for ATFM delay attribution principles, shown in Table 4-2, proposes that the primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or airspace management) rather than referring to planned capacity.

4.7 En-route ATFM delay attribution and coding

This section of the report gives a more in-depth analysis of the attribution and coding for en-route ATFM delays in London TC over the reference period 2014 – 2018.

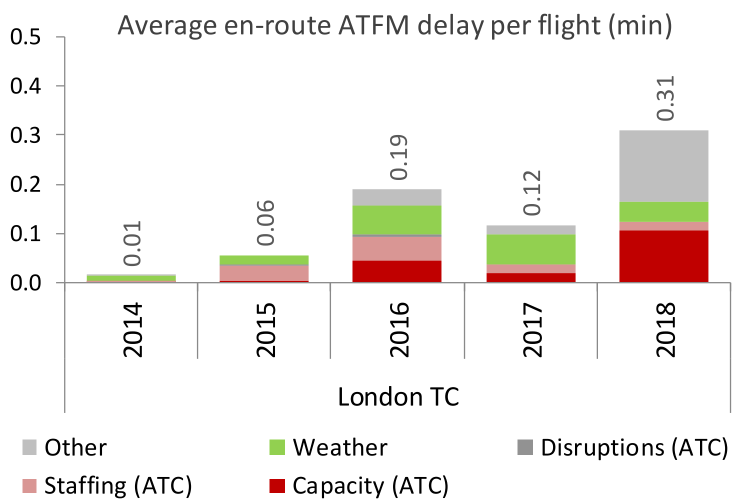


Figure 4-2: en-route ATFM delay per flight in London TC 2014 - 2018

4.7.1 Capacity performance summary (2014)

Summary 2014:

- Total en-route delay in collapsed sectors: 666 minutes
- Total en-route ATFM delay attributed to ATC Staffing 'S' and ATC equipment 'T': 4374 minutes
- No en-route delay attributed to ATC capacity in elementary sectors.

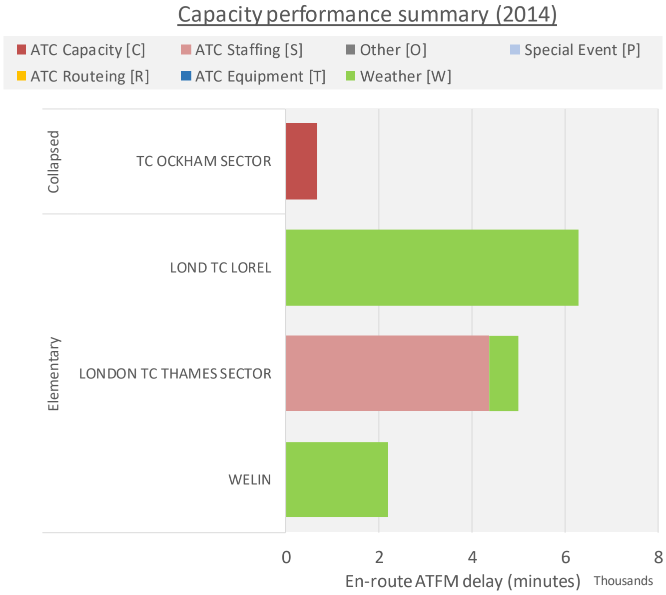


Figure 4-3: Capacity performance summary (2014)

Observations for 2014:

- Excellent capacity performance overall.

4.7.2 Capacity performance summary (2015)

Summary 2015:

- Total en-route delay in collapsed sectors: 3,594 minutes
- Total en-route ATFM delay attributed to ATC staffing 'S' and ATC equipment 'T': 41,304 minutes
- En route delay attributed to ATC capacity 'C' in elementary sectors: 1434 minutes
  - 911 minutes: LONDON TC BIGGIN SEC – declared CAP (50) regulated CAP (between 54 and 58)
  - 523 minutes: TC REDFA – declared CAP (31) regulated CAP (between 31 and 32)

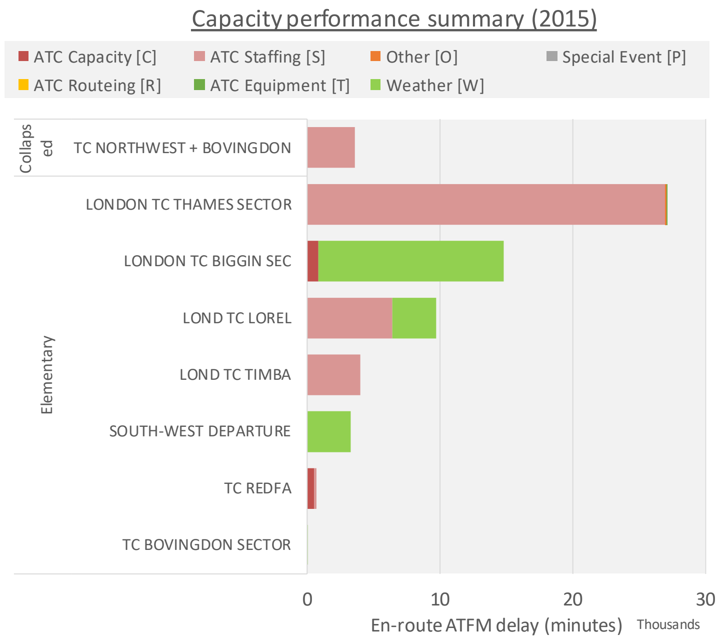


Figure 4-4: Capacity performance summary (2015)

Observations for 2015:

- Significant increase in delays due to ATC staffing, especially in TC Thames sector.
- Delays in collapsed sector (Northwest + Bovingdon) attributed to staffing problems, as would be expected.

- ATC capacity delays in elementary sectors show regulations applied at rates higher than declared capacity.

4.7.3 Capacity performance summary (2016)

Summary 2016:

- Total en-route delay in collapsed sectors: 42,000 minutes and 14,701 in 'conjoint airspace' LONDON TC GODLU + JACKO + THAMES (CON-ASP)
- Total en-route ATFM delay attributed to ATC staffing 'S' and ATC equipment 'T': 47,859 minutes
- 30,000 minutes of delay attributed to 'Special Event': London Airspace Management Program (LAMP1A) implementation.
- En route delay attributed to ATC capacity 'C' in elementary sectors: 34,989 minutes:
    - 1,228 minutes: LONDON TC LOREL declared CAP (40) – regulated CAP (between 38 and 43)
    - 722 minutes: LONDON TC WILLO SECT declared CAP (43) regulated CAP (47)
    - 6,766 minutes: SOUTH-WEST DEPARTURE declared CAP (42) regulated CAP (between 43 and 48)
    - 15,194 minutes: TC JACKO declared CAP (35) regulated CAP (between 13 and 19 on specific traffic flow)
    - 11,079 minutes: TC REDFA declared CAP (40) regulated CAP (between 38 and 42)

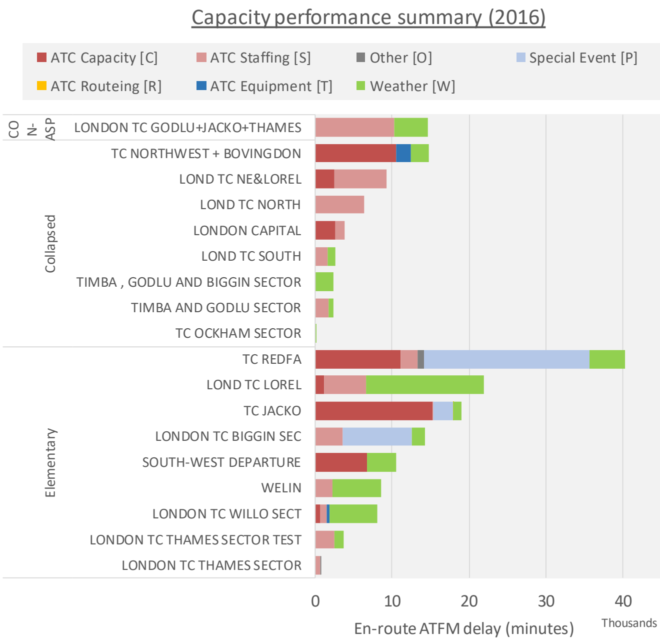


Figure 4-5: Capacity performance summary (2016)

Observations for 2016:

- Almost three times as much delay as in previous year;
- More than 20% of delays occurring in collapsed sectors including 15k of delays attributed to ATC capacity;
- Majority of ATC staffing and ATC equipment attributed delays occurring in collapsed sectors, as would be expected.

4.7.4 Capacity performance summary (2017)

Summary 2017:

- Total en-route delay in collapsed sectors: 15,524 minutes and 1,846 minutes in 'conjoint airspace' LONDON TC GODLU + JACKO + THAMES (CON-ASP)
- Total ATFM delay attributed to ATC Staffing 'S' and ATC equipment 'T': 16,684 minutes
- 13,000 minutes delay attributed to 'Special event': Implementation of EXCDS electronic flight strip system.
- En route delay attributed to ATC capacity 'C' in elementary sectors: 25,278 minutes:
    - 11,062 minutes: LOND TC LOREL declared CAP (40) regulated CAP (38 and 18)
    - 533 minutes: TC JACKO declared CAP (35) regulated CAP (between 19 and 14 on specific traffic flow)
    - 2,261 minutes: TC REDFA declared CAP (40) regulated CAP (between 42 and 38)
    - 10,480 minutes: WELIN declared CAP (50) regulated CAP (between 33 and 24)

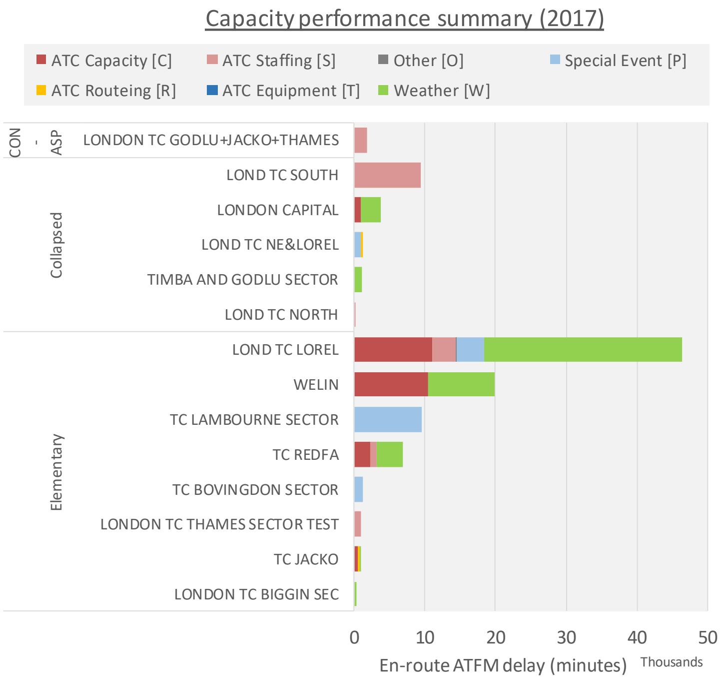


Figure 4-6: Capacity performance summary (2017)

Observations for 2017:

- Significant reduction in delays from previous year;
- Vast majority of delays occurring in elementary sectors;
- LOREL & WELIN sectors regulating below declared capacity levels whilst delay attributed to ATC capacity.

4.7.5 Capacity performance summary (2018)

Summary 2018:

- Total en-route delay in collapsed sectors: 29,628, minutes; 109,102 minutes in 'conjoint airspace' REDFA & LOREL; 10,247 minutes in 'conjoint airspace' LONDON TC GODLU + JACKO + THAMES (CON-ASP)
- Total en-route ATFM delay attributed to ATC Staffing 'S' and ATC equipment 'T': 11,760 minutes
- 100,000 minutes of delay attributed to 'Special event' 'P': Implementation of EXCDS electronic flight strip system
- En route delay attributed to ATC capacity 'C' in elementary sectors: 38,551 minutes
  - 19,221 minutes: LOND TC LOREL declared CAP (40) regulated CAP (between 38 and 18)
  - 6,414 minutes: SOUTH-WEST DEPARTURE declared CAP (35) regulated CAP (between 50 and 40)
  - 9,429 minutes: TC REDFA declared CAP (40) regulated CAP (between 42 and 38)

Observations 2018:

- Almost three times the delay of previous year;
- Almost 50% of delays occurring in collapsed sectors (including nearly 100k of delay attributed to ATC capacity in 'conjoint airspace' see note below).

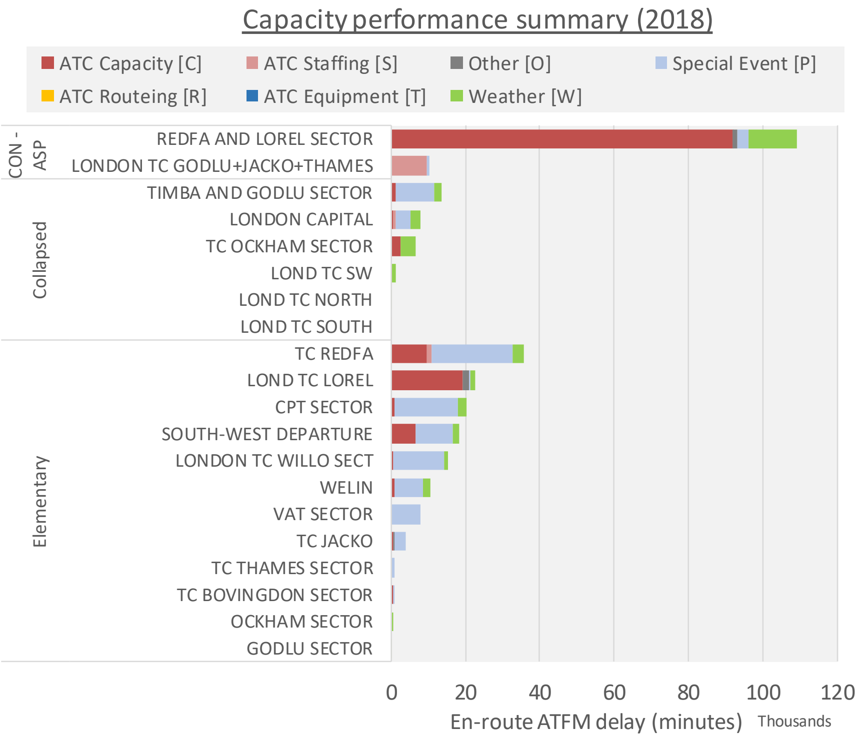


Figure 4-7: Capacity performance summary (2018)

Note: As explained in section 4.4, assignment of delays to geographical locations of 'conjoint airspace' REDFA & LOREL and LONDON TC GODLU + JACKO + THAMES in the NM systems gave the impression that the sectors were collapsed during the period of regulation. Information subsequently provided by the ANSP makes it clear that these sectors cannot be operated in collapsed configurations, but are defined as being collapsed to facilitate the capture of specific traffic flows, which the ANSP can regulate more efficiently.

The lack of transparency about the opening and closing of individual sectors (see Section 4.1 and Figure 4-1) makes it is impossible to cross-reference and remove these anomalies.

4.8 Evolution of en-route ATFM delays attributed to ATC Capacity; ATC Staffing and, adverse weather

This section of the report looks at how the coding of en-route ATFM delays has changed over the reference period.

4.8.1 Evolution of en-route ATC Capacity delays

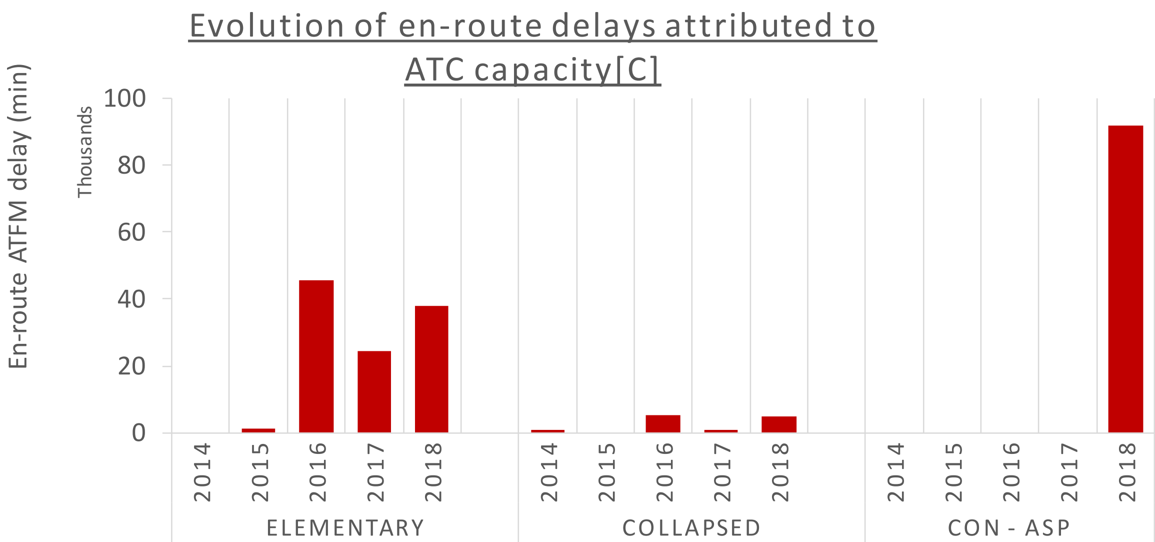


Figure 4-8: Evolution of en-route delays attributed to ATC capacity [C]

ATC Capacity attributed delays have been increased significantly over the past five years. Traffic increase over the past five years places additional pressure on ATC capacity. 2/3 of the total ATC capacity attributed delays in 2018 were in the 'conjoint airspace' REDFA & LOREL sector. (See section 4.4)

4.8.2 Evolution of en-route ATC Staffing delays

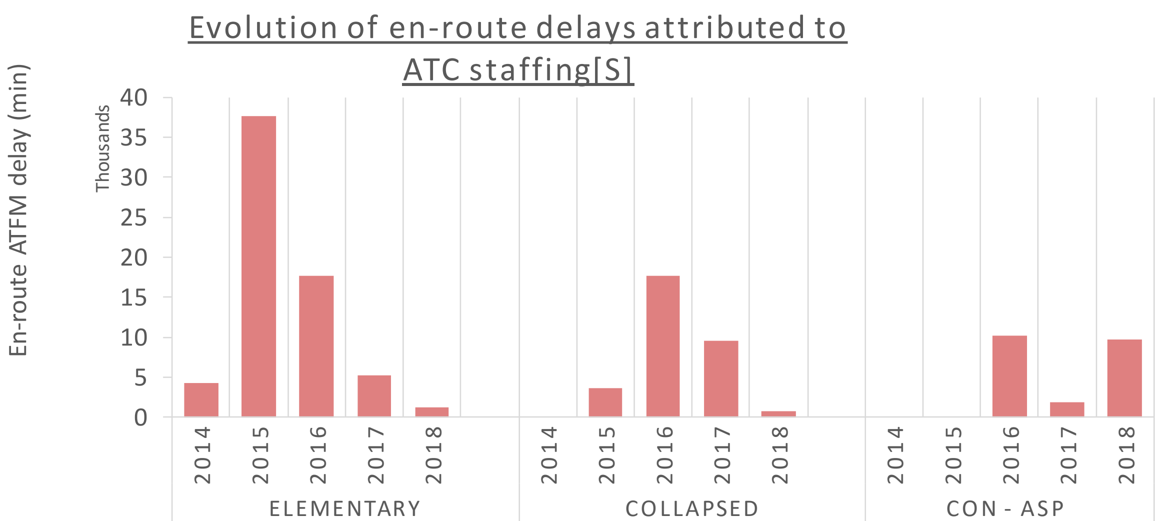


Figure 4-9: Evolution of en-route delays attributed to ATC staffing [S]

Delays attributed to ATC staffing rose significantly in 2015 (predominantly in elementary Thames sector) and 2016 before diminishing again in 2017 & 2018. The majority of ATC staffing attributed delays would be expected to occur in collapsed sectors. The rationale obviously being that if more staff were available then additional sectors would be opened to handle the traffic demand.

4.8.3 Evolution of en-route ATFM delays attributed to adverse weather

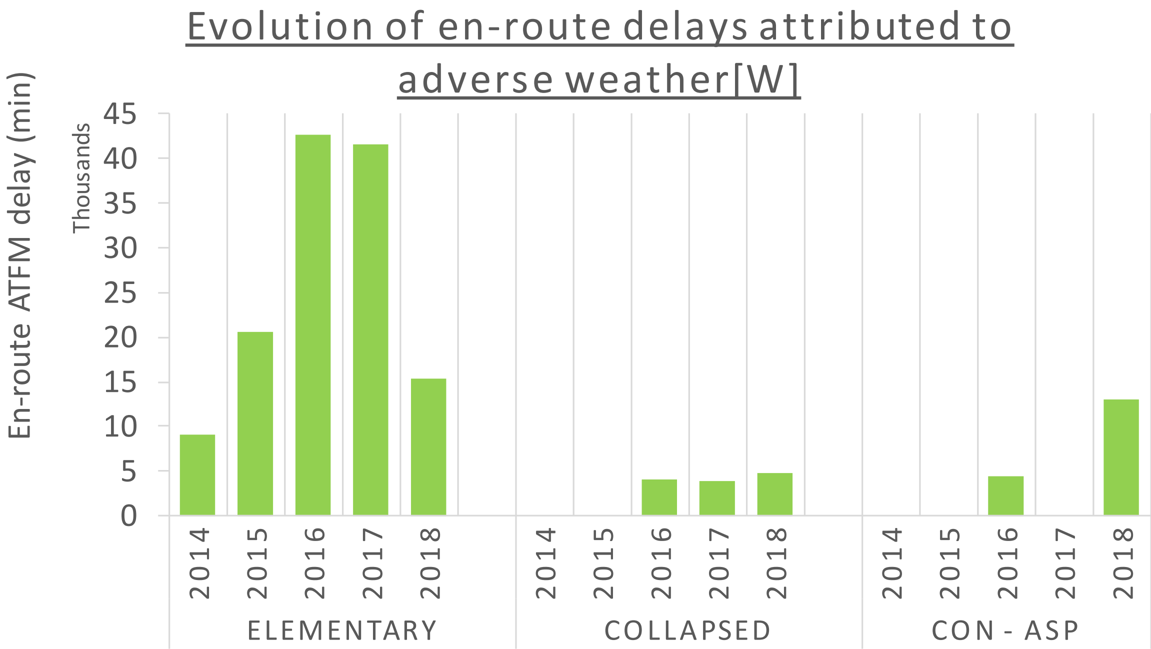


Figure 4-10: Evolution of en-route delays attributed to adverse weather [W]

Delays attributed to adverse weather have increased in the past three years, potentially due to higher traffic levels or arguably due to more prevalent adverse weather phenomena causing greater capacity constraints.

Approximately 4000 minutes of adverse weather attributed delays in 2016, 2017 and 2018 occurred in collapsed sectors.

The PRC has previously noted that adverse weather exacerbates any capacity constraints caused by collapsing sectors, and that the impact of adverse weather could potentially be mitigated by opening additional sectors.

4.8.4 Analysis of en-route ATFM regulations applied to Traffic Volumes

An ATC sector can be further considered as a set of discrete traffic volumes (TFC VOL). A TFC VOL is basically a sub-sector defined in terms of the characteristics of the traffic flow rather than the specific geographic area. For example, a sector may contain three separate traffic volumes such as arriving flights; departing flights and overflights. The arriving and departing flights may require more ATC workload than overflights and therefore may be monitored, and regulated, separately to ensure that the overall ATCO workload is not excessive, even though the nominal total sector capacity is not the limiting factor.

Sector type	SECTOR	FLT DATE	Delay Reason	Declared TV capacity	Regulated capacity TV	Minimum Regulated capacity TV	Delayed flights	Total delay
Elementary	LOND TC LOREL	08 Apr. 2017	S	38	32	18	88	3,353
Elementary	LOND TC LOREL	26 Sep. 2017	C	38	25	21	63	1,721
Elementary	LOND TC LOREL	13 Aug. 2017	C	38	38		86	1,408
Elementary	LOND TC LOREL	16 Apr. 2016	S	38	26		60	788
Elementary	LOND TC LOREL	20 Feb. 2016	S	38	29	20	42	522
Elementary	LOND TC LOREL	31 Mar. 2016	S	38	22		25	392
Collapsed	REDFA AND LOREL	28 Jun. 2018	C	38	39		123	2,481
Collapsed	REDFA AND LOREL	18 Mar. 2018	C	38	36	28	129	2,309
Collapsed	REDFA AND LOREL	25 Mar. 2018	C	38	38	30	114	2,274
Collapsed	REDFA AND LOREL	15 Apr. 2018	C	38	36	34	195	2,111
Collapsed	REDFA AND LOREL	29 Jul. 2018	C	38	38		105	2,096
Collapsed	REDFA AND LOREL	18 Feb. 2018	C	38	33	32	94	1,959
Collapsed	REDFA AND LOREL	14 Jun. 2018	C	38	38		76	1,893
Collapsed	REDFA AND LOREL	12 Aug. 2018	C	38	38		80	1,840
Collapsed	REDFA AND LOREL	26 Apr. 2018	C	38	40	36	104	1,740
Collapsed	REDFA AND LOREL	29 Mar. 2018	C	38	40	36	123	1,700
Collapsed	REDFA AND LOREL	02 Apr. 2018	C	38	36		98	1,674
Collapsed	REDFA AND LOREL	24 Jun. 2018	C	38	38		92	1,672
Collapsed	REDFA AND LOREL	29 Jun. 2018	C	38	38		90	1,642
Collapsed	REDFA AND LOREL	08 Jul. 2018	C	38	38		92	1,601
Collapsed	REDFA AND LOREL	25 Feb. 2018	C	38	34		106	1,489
Collapsed	REDFA AND LOREL	23 Jul. 2018	C	38	38		81	1,461
Collapsed	REDFA AND LOREL	15 Jun. 2018	C	38	38		92	1,341
Collapsed	REDFA AND LOREL	15 Jul. 2018	C	38	38		71	1,219
Collapsed	REDFA AND LOREL	19 Aug. 2018	C	38	41		96	1,193
Collapsed	REDFA AND LOREL	28-May-18	C	38	38		60	1,096
Collapsed	REDFA AND LOREL	01 Jul. 2018	C	38	40	38	86	1,065
Collapsed	REDFA AND LOREL	03 Jun. 2018	C	38	38		39	1,059
Collapsed	REDFA AND LOREL	27 Jun. 2018	C	38	38		67	1,057
Collapsed	REDFA AND LOREL	06 Apr. 2018	C	38	36		102	1,055
Collapsed	REDFA AND LOREL	29 Apr. 2018	C	38	36		95	1,051
Collapsed	REDFA AND LOREL	18-May-18	C	38	38		76	1,038
Collapsed	REDFA AND LOREL SECTOR	26 Mar. 2018	S	38	35		39	71

Table 4-4: Regulations applied to traffic volume EGTTESX

Additional capacity constraints are highlighted in yellow, where the ATFM regulation was applied at a lower throughput than is normally declared for that portion of airspace (DECLARED CAPACITY). Several of these cases are when the ATFM delays are attributed to ATC Staffing (S) where a lack of ATC staff, or training of ATC staff, has resulted in less capacity being available than would normally be expected (Declared capacity).

In several instances, highlighted in red, the ATFM delay was attributed to ATC capacity (C) when other additional capacity constraints were evident (highlighted in yellow). Typical reasons for deploying reduced capacity include inter alia: ATC training, equipment failure (ATC equipment), military operations and training (Airspace Management), loss of capacity due turbulence or thunderstorms (adverse weather).

The suggested advice of the PRC, endorsed by the Provisional Council of EUROCONTROL, is that the ANSP-internal capacity constraints should be addressed first and that delays should only be attributed to external causes (e.g. weather) when no ANSP-internal capacity constraints prevent the deployment of maximum capacity.

4.9 Summary of en-route capacity analysis

4.9.1 Observations on en-route capacity performance

a) Although NERL does not provide dynamic updates to the Network Manager about sector openings, it is possible to analyse capacity constraints through the ATFM regulations, and the geographical location contained therein.

b) The inability to cross-reference capacity constraints against actual sector configurations can lead to anomalies in post-operations monitoring. For example: the identification of certain collapsed sectors (that exist in the NM and ANSP databases but which cannot be deployed operationally) as capacity constraints – the 'conjoint airspace' explained in section 4.4

c) NATS have introduced some delay attribution principles to differentiate between ATC staffing and ATC capacity.

d) There is evidence of sectors being regulated at capacity levels above the published declared capacity which could indicate the potential to increase the published declared capacities.

e) There is evidence of sectors being regulated at capacity levels below the declared capacity but which are still attributed to ATC capacity instead of identifying the constraint preventing full deployment of capacity.

f) There is evidence of ATFM delays occurring in collapsed sectors and being attributed to ATC capacity.

g) Delays attributed to ATC staffing peaked in 2015 and 2016;

h) Delays attributed to adverse weather peaked in 2016 and 2017 but significant portion attributed to collapsed sectors;

i) Delays attributed to ATC capacity peaked in 2018.

4.9.2 PRU findings on en-route capacity performance

I. It would improve transparency to external stakeholders and demonstrate compliance with EU Regulation No 677/2011 if NERL would provide the Network Manager with the dynamic update of actual sector configurations deployed. This would also eliminate the anomalies regarding 'conjoint airspace' highlighted above. This does not need to affect current operational arrangements or responsibilities.

II. In regards observation d) above: PRC recommendation (f) in PRR2015, endorsed by the Provisional Council of EUROCONTROL, requested Member States *to task ANSPs to review sector capacities, both with and without airspace restrictions, to increase network performance*.

III. In regards observations e) and f) above, the PRU recalls PRC recommendation c) from PRR2017, and in particular the rationale containing PRC proposals for ATFM delay attribution:

> *The ATFM delay attribution process should be based on the following principles:*
>
> *The primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or airspace management);*
>
> *Attribution of delays to external causes (e.g. weather or 3rd party strike) should only be used in cases where no ANSP-internal capacity constraints prevent the deployment of maximum capacity;*
>
> *Attribution of delays to ATC capacity should not be used for collapsed sectors or when the regulated capacity is less than the maximum declared capacity of the sector.*

IV. It is noted that the ATFCM process does not contain rules for attributing ATFM delay, but only ‘guidelines’.

V. It is noted that the NATS internal guidance on delay attribution principles refers to the planned sector configuration rather than the sector configuration required to satisfy the traffic demand.

VI. It is noted that previous PRC reviews of capacity performance at other ANSPs raised exactly the same issues and prompted the PRC to make recommendations to strengthen the ATFCM process. NERL is not exceptional by any means in how they attribute ATFM delay.

VII. As part of the SES Performance Scheme, the UK has implemented an incentive scheme for capacity performance. This incentive scheme excludes certain ATFM delays based on the attributed delay codes – typically explained as non-controllable by the ANSP.

VIII. Where Member States have implemented incentive schemes for capacity performance which excludes certain ATFM delays, according to the attributed delay code, there might be benefits from considering a verification process for the attribution of ATFM delay.

5 Delay analysis (London Airports)

NERL (NATS En-route Limited) is responsible for the airspace and the management of London's arrival flows in the TMA. ATC services at London airport's control towers (CTR in Figure 0-2: Conceptual Airspace Organisation) are provided by NATS Services Limited (NSL) or in the case of Gatwick airport, Air Navigation Solutions Limited (ANSL).

As explained in Chapter 0, the arrival flows in the approach and into the airports can be managed pre-departure, through ATFM measures (ground holds [regulated air traffic]) or during the approach phase by air traffic control measures (primarily vectoring[6] and holdings[7] within the terminal airspace [terminal inefficiency])

Figure 5-1 represents the different phases during which a flight might be delayed due to different inefficiencies.

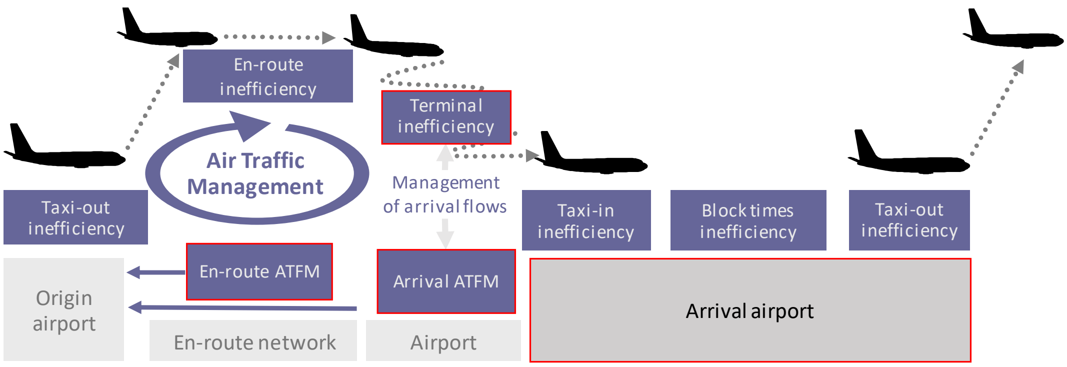


Figure 5-1: Inefficiencies in the different flight phases

The UK CAA request concerns the provision of services by NERL (see Chapter 4.En-route ATFM delay analysis). As explained in Chapter 0, the concept of most penalising regulation means that ATFM delays experienced by airspace users will not be visible in the en-route analysis if the most penalising constraint was located at the airport.

To present a more complete picture of the airspace users' experience, this part of the study provides additional analysis on the provision of services by NSL at Heathrow, London City, Luton and Stansted and ANSL at Gatwick. The review includes arrival ATFM regulations affecting London airports and the additional time ASMA time (Arrival and Sequencing Metering Area ~ terminal area) that captures the time delayed by the vectoring or holdings in the approach.

The analysis also includes the additional taxi-in and turnaround times, although these processes are not under the responsibility of ANSPs.

The assessment is performed by merging ATFM data from the Network Manager with data provided by the airport operators though the Airport Operator Data Flow.

The periods covered depend on the different measures and data availability. The data provided by the airports through the Airport Operator Data Flow, necessary for the analysis of additional ASMA times, Taxi-in, and Turnaround times is not available for all airports / periods.

---

6 Vectoring: Provision of navigational guidance to aircraft in the form of specific headings, based on the use of an ATS surveillance system. [ICAO Doc 4444]

7 Holding Pattern: the usually oval course flown by aircraft awaiting further clearance; especially to land. Holding patterns are flown as a delaying tactic, keeping aircraft within a specified airspace while awaiting further clearance from air traffic control.

5.1 Application of ATFM measures (London airports)

Arrival ATFM delays result from a pre-departure measure (so-called "regulation") put in place to protect specifically the arrival flow at a certain airport. These are regulations where the "Protected Location Id" is the airport and the protected flow is the arrivals.

The regulations for aerodrome locations (AD) can be associated to different reasons:

Reason	Reason Group
A - Accident/Incident - AD	*AD Disruptions*
C - ATC Capacity - AD	*AD Capacity (ATC)*
D - De-icing - AD	*AD Weather*
E - Equipment (non-ATC) - AD	*AD Disruptions*
G - Aerodrome Capacity - AD	*AD Capacity*
I - Industrial Action (ATC) - AD	*AD Disruptions (ATC)*
M - Airspace Management - AD	*AD Capacity*
N - Industrial Action (non-ATC) - AD	*AD Disruptions*
O - Other - AD	*AD Disruptions*
P - Special Event - AD	*AD Events*
R - ATC Routeing - AD	*AD Capacity*
S - ATC Staffing - AD	*AD Staffing (ATC)*
T - Equipment (ATC) - AD	*AD Disruptions (ATC)*
V - Environmental Issues - AD	*AD Capacity*
W - Weather - AD	*AD Weather*
NA - Not specified - AD	*AD Disruptions*

Table 5-1: Regulation reasons and groups

Figure 5-2 shows the evolution (2014-2018) of the Arrival ATFM delay per arrival (primary axis) and the number of arrivals per year (secondary axis) at the five London airports by attributed delay cause.

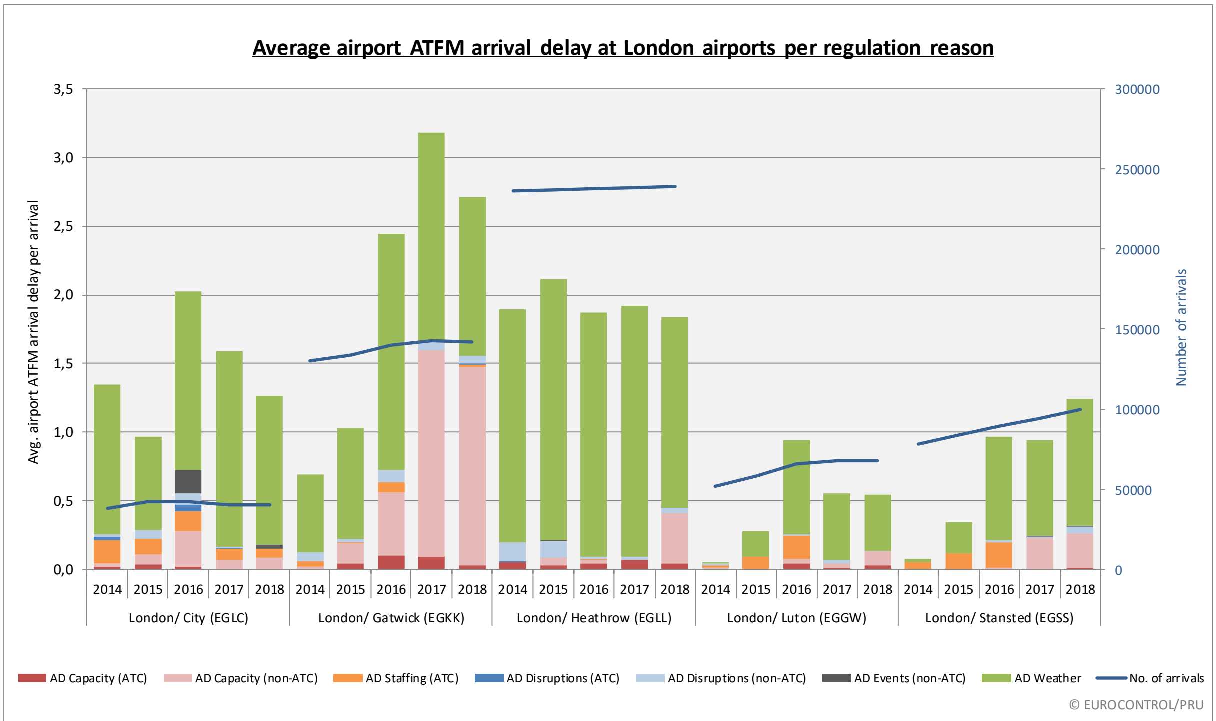


Figure 5-2: Arrival ATFM delay per arrival at London airports per regulation reason (2014-2018)

In 2018, almost all airport ATFM arrival delay in the UK (95.9%) is concentrated at the five London airports: Gatwick (35.6%), Heathrow (40.7%), Stansted (11.5%), London City (4.7%), and Luton (3.4%)

In absolute terms - that is all reasons for Arrival ATFM delay- Gatwick and Heathrow suffer the most delay.

Throughout the past years, the predominant regulation reason reported for Heathrow is weather while 2018 sees an increase of the delay associated with aerodrome capacity. However, given the high level of capacity utilisation at Heathrow, the yearly traffic has remained quite stable over the period (2014-2018) (+1.1% in 2018 vs 2014).

Gatwick on the other hand shows a more significant increase in traffic in the last 5 years (+9.3%). During this time, the ATFM delays due to aerodrome capacity increased drastically. In particular, 2016-2018 show a significant higher level than the years before.

At Stansted the traffic has been increasing gradually and significantly for the last 5 years (+28.4%). While in 2014 this was an airport causing minimal ATFM Arrival delays, it has now more than 1.2 minutes of delay per arrival (on average) due to mainly weather and aerodrome capacity.

Figure 5-3 offers a comparative overview of the average arrival ATFM delays at the European airports in 2018. From the airports above 50 000 arrivals per year, Gatwick accrued the third highest arrival ATFM delay per arrival, after Lisbon and Barcelona. Stansted, Luton and London City show slightly worse performance than other airports with similar number of movements, although it is recognised that the number of movements is not an indication of the capacity constraining issues at these airports, and it is used only as a reference in this graph. As mentioned earlier, the London multi-airport system is the busiest one in Europe and operational constraints also include an element of the complexity and density of operations.

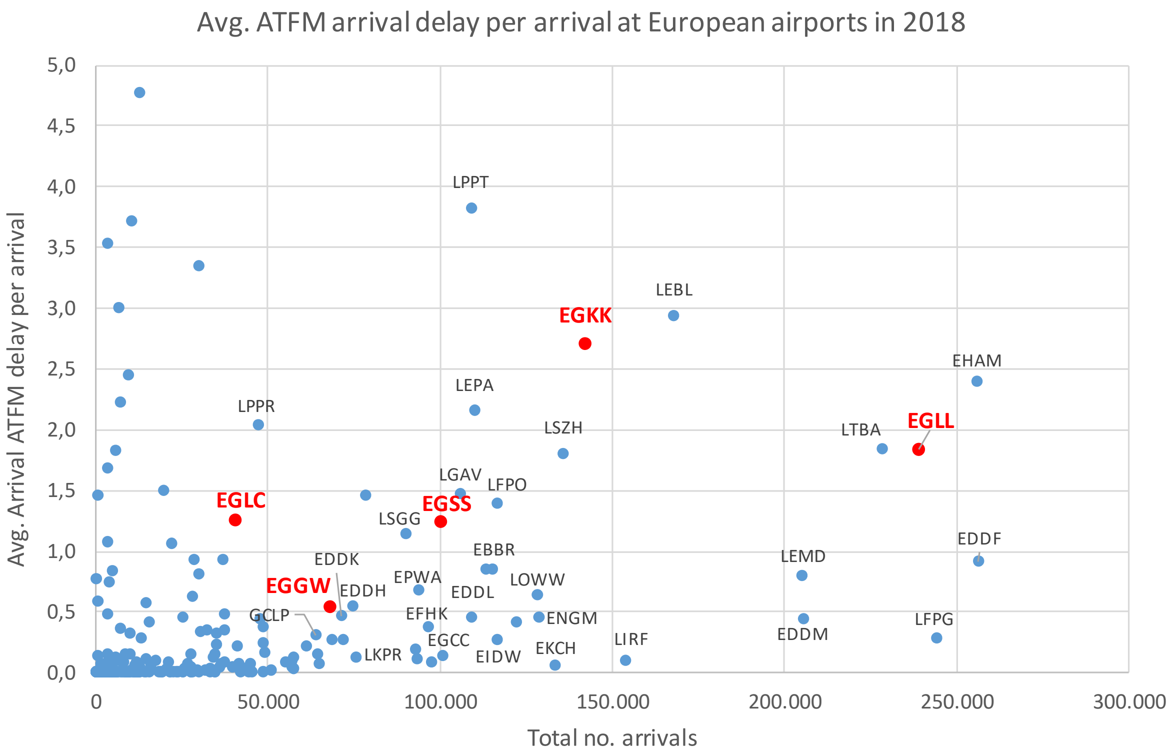


Figure 5-3: Arrival ATFM delay per arrival at European airports (2018)[8]

[8] The list of airports and their ICAO codes can be found in Annex 3 – Airport ICAO Codes

5.2 Specific analysis of capacity constraining arrival ATFM regulations (Stansted airport)

5.2.1 Regulations reasons

This section looks for patterns in the allocation of arrival ATFM regulations at Stansted airport and reasons for them, although these regulations are not under NERL responsibility but NSL.

The PRU has no means of confirming the correct allocation of the reason for the regulations, however previous Figure 5-2 shows a shift in the reason for the regulations in Stansted arrivals: while the years 2014-2016 report on a high share of staffing reasons, the years 2017 and 2018 list aerodrome capacity.

To better identify regulation practices, Figure 5-4 to Figure 5-6 show the daily view of the arrival ATFM delay per arrivals for 2016, 2017 and 2018. This view allows confirming that the staffing delays were indeed concentrated in a few days in 2016 (c.f. Figure 5-4, orange bars) but with high impact on operations, while the aerodrome capacity delays in 2017-2018 (c.f. Figure 5-5 and Figure 5-6, pink bars) are more frequent and more spread, with lower impact every day.

It is also noticeable that the delays related to AD Capacity (non-ATC) regulations observed in Summer 2017 and Spring 2018 have significantly reduced in the Summer 2018 as of July despite higher traffic levels (c.f. Figure 5-5 and Figure 5-6). EUROCONTROL has no information regarding a possible aerodrome capacity increase that might explain this reduction of AD Capacity delays.

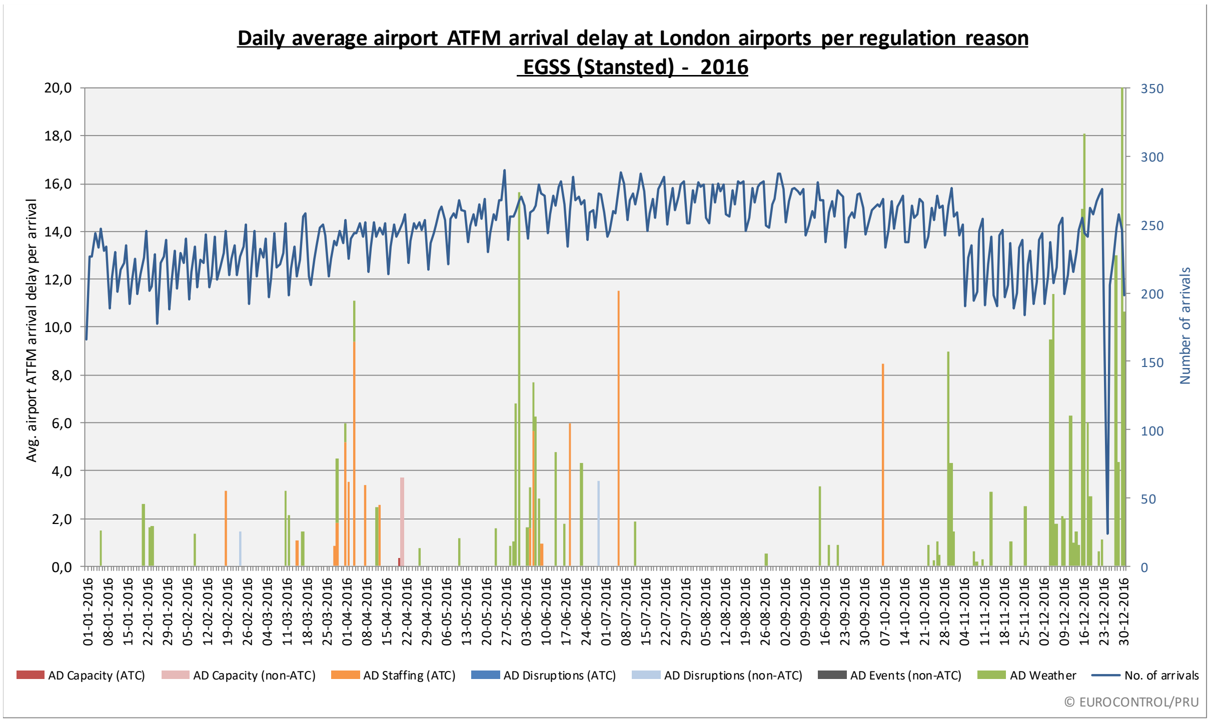


Figure 5-4: Daily Arrival ATFM delay per arrival per regulation reason (2016)

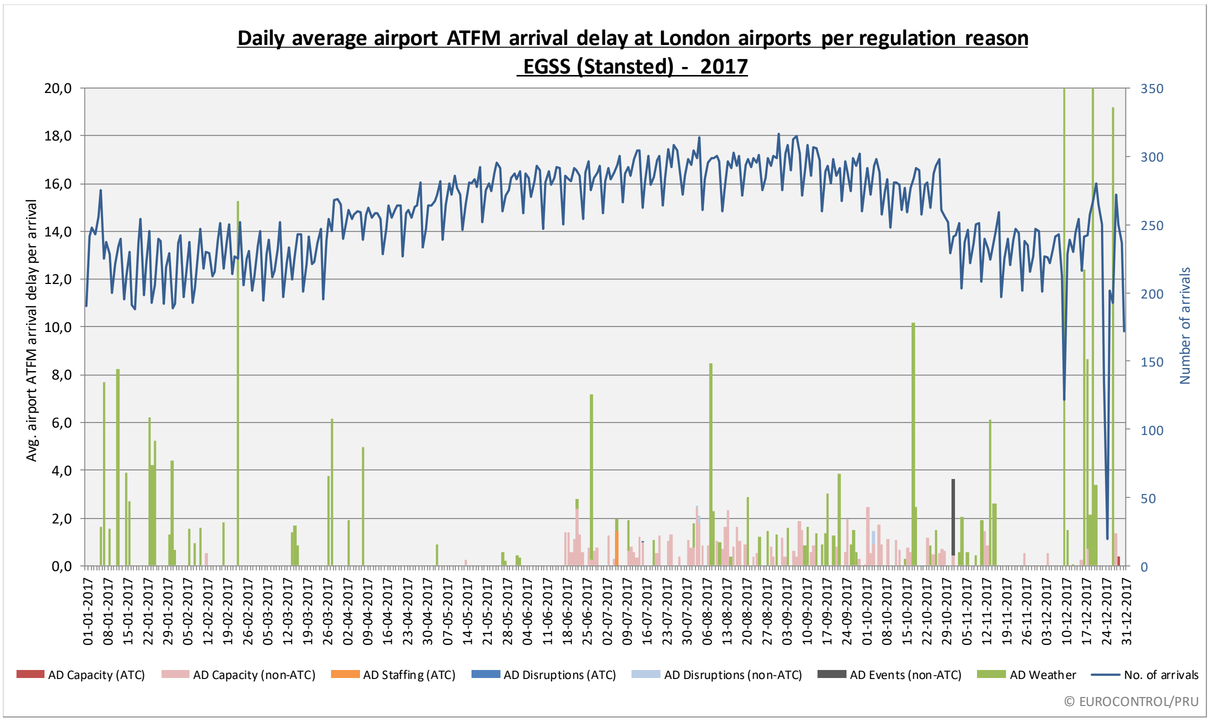


Figure 5-5: Daily Arrival ATFM delay per arrival per regulation reason (2017)

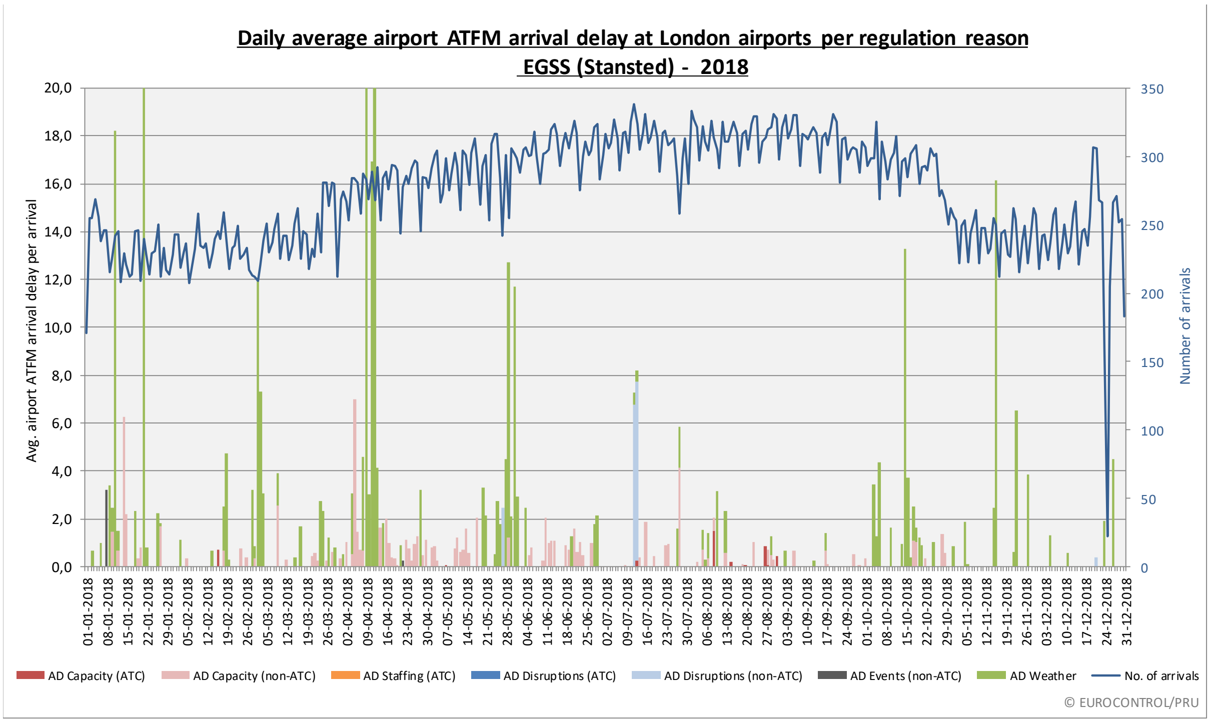
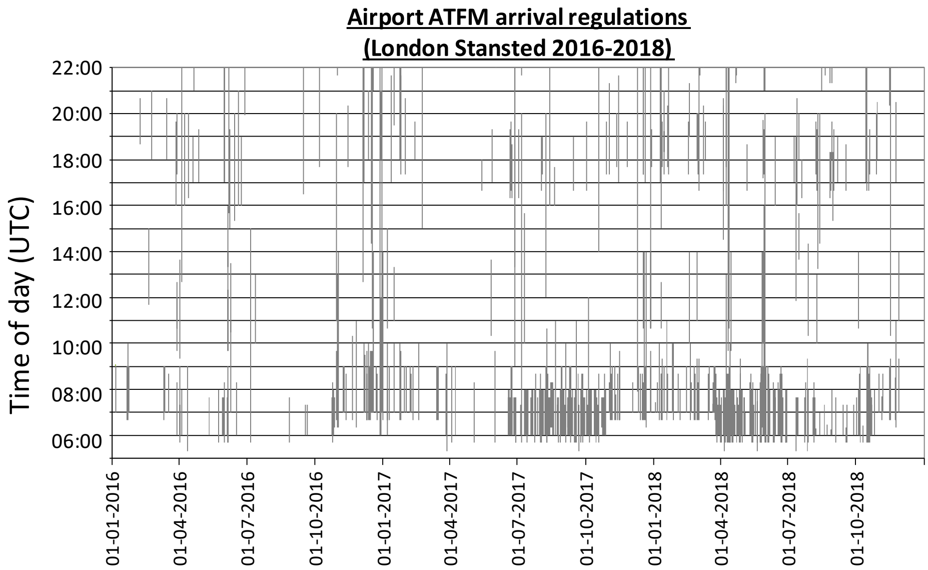


Figure 5-6: Daily Arrival ATFM delay per arrival per regulation reason (2018)

5.2.2 Regulations patterns

PRU has carried out further analysis of the regulations and their elements (times of the day, regulation rates) to detect practices and patterns.

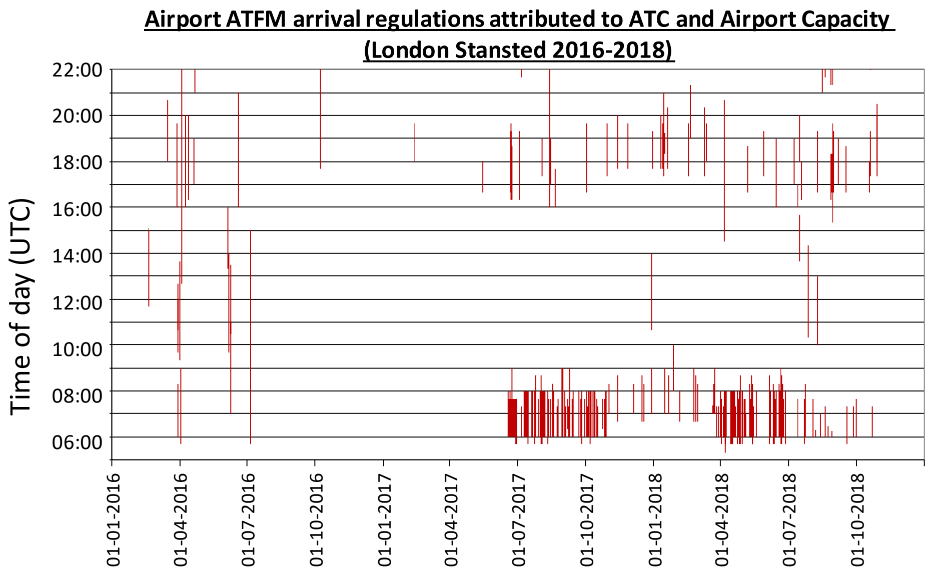
Figure 5-7 represents the periods of the day affected by airport regulations (all causes) at Stansted. While in 2016 there was no clear pattern in the regulated times, as of end of 2016 and especially as of summer 2017, regulations are concentrated in the first arrival wave of the day (i.e. 7 to 9 AM local time).



Source: PRU analysis

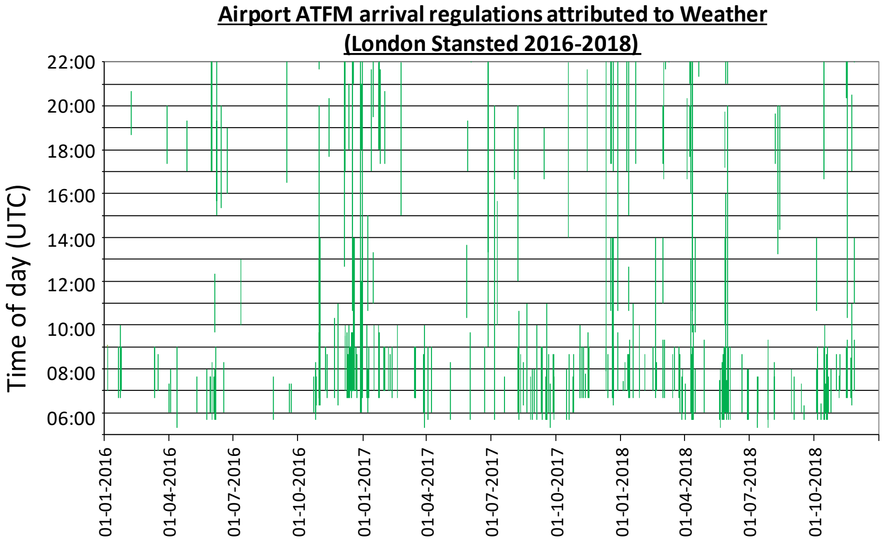
Figure 5-7: Arrival Regulations at Stansted per times of the day (all delay reasons)

Focusing on capacity regulations (c.f. Figure 5-8), the same pattern is observed, but even the weather attributed regulations (c.f. Figure 5-9) show similar concentration in the early morning.



Source: PRU analysis

Figure 5-8: Arrival Regulations at Stansted per times of the day (ATC and Airport Capacity)



Source: PRU analysis

Figure 5-9: Arrival Regulations at Stansted per times of the day (Weather)

ATFM regulations during the first wave will have a bigger impact on airlines, especially on those with several rotations ahead in the day and tighter turnaround schedules.

Regulations with such consistent and repetitive pattern raise questions about the schedule in that first wave and how little buffer for contingency it offers.

Figure 5-10 compares the scheduled throughput versus the actual delivered for 2018. In the time period from 7 to 9 AM local time, there is an arrival peak plus a sustained departure peak that extends from 6 to 10 local time. This high level of demand (scheduled) impacts the requirement for de-confliction through ATFM measures (i.e. arrival ATFM regulations) or sequencing in the approach phase.

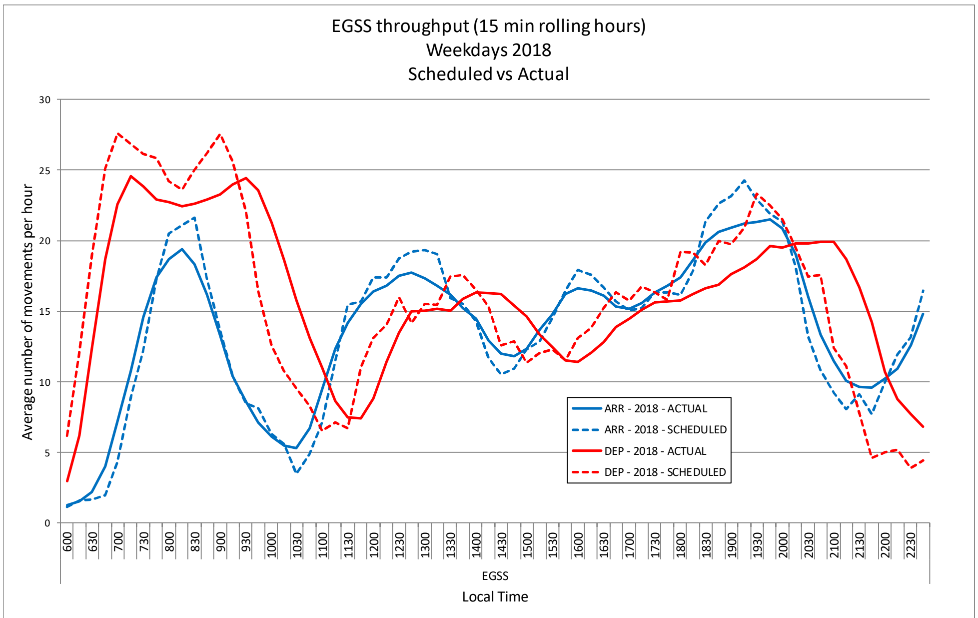


Figure 5-10: Average hourly throughput at Stansted per rolling hours each 15 min (2018)

As observed in the graph, the high peaks in the demand throughput are not achieved, and the actual throughput is lower than the scheduled. As a consequence, the actual throughput is shifted to later (continuous line is usually to the right of the corresponding dashed line).

5.3 ASMA additional time (London airports)

The additional ASMA time is a proxy for the management of the arrival flow, understood as the average arrival runway queuing time on the inbound traffic flow, during periods of congestion at airports.

On the conceptual level, the indicator aims to address the operational penalty associated with techniques used to maximize runway utilisation for inbound traffic flows at an airport, i.e. the accumulation of additional approach time resulting from speed control, path stretching and circling in the vicinity (40 NM) of the airport (use of holding patterns/stacks).

Despite a continuous improvement between 2015 and 2018, London Heathrow still has the highest average airborne holding times (ASMA) in Europe (7.66 minutes per arrival), followed by London Gatwick with 3.90 minutes per arrival (c.f. Figure 5-11 and Figure 5-12).

The increase in traffic at Stansted airport also had an impact on the airborne holdings which continuously increased over the past 4 year to reach 1.86 minutes per arrival in 2018 (c.f. Figure 5-11).

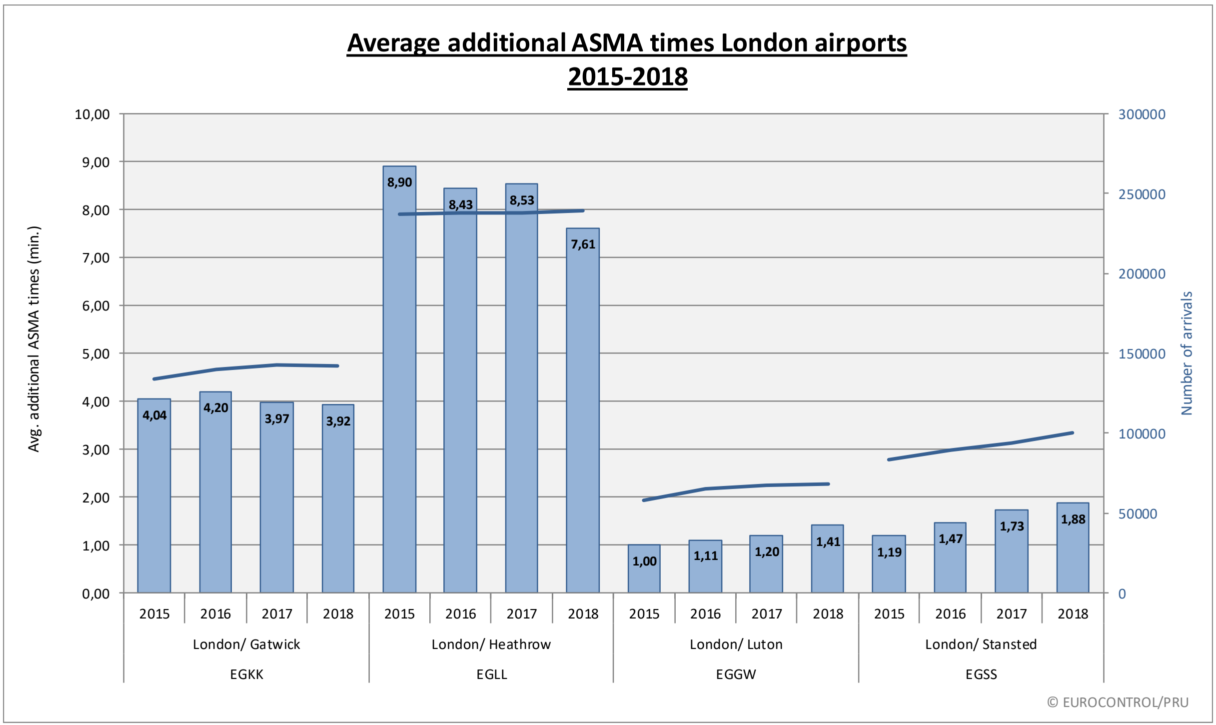


Figure 5-11: Average additional ASMA times at London airports (2015-2018)[9]

As shown for the arrival ATFM delay, Figure 5-12 offers a comparative overview of the additional ASMA times at the European airports in 2018.

[9] Data available only for 2015-2018 period for Gatwick, Luton, Heathrow and Stansted.

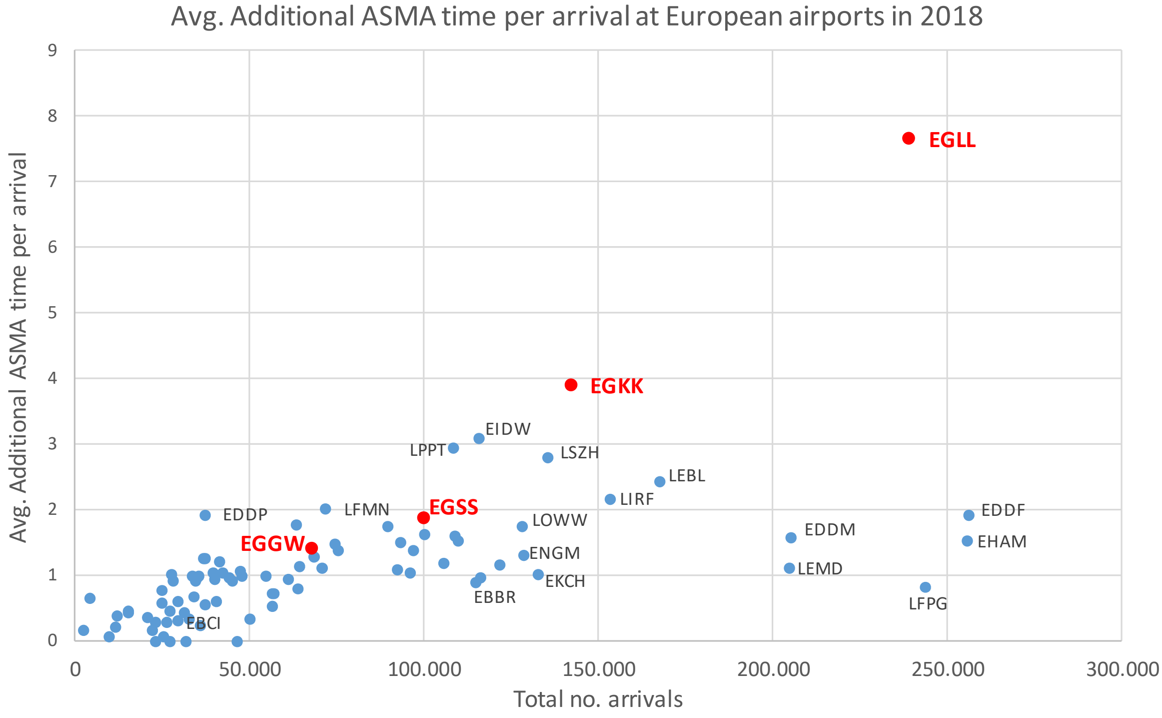


Figure 5-12: Average additional ASMA times at European airports (2018)[10][11]

[10] Data available only for 2018 for Gatwick, Luton, Heathrow and Stansted.
[11] The list of airports and their ICAO codes can be found in Annex 3 – Airport ICAO Codes

5.4 Combined effect of arrival ATFM delay and additional ASMA time at London airports and comparison with other European airports

The arrival flows at different airports can be managed very differently. While some airports might decide to regulate the arrival traffic with an airport regulation, in other cases the airport prefers to handle the traffic in the final approach phase to ensure certain level of demand ready for the runway.

Figure 5-13 presents the combined view of ANS-related inefficiencies on the arrival flow (arrival ATFM delay and additional ASMA time) at main European airports (Top 50 in terms of movements) in 2018, where London airports are highlighted (data for London City not available).The size of the bubble represents the total combined average delay per arrival, while the position in the graph allows to identify if the management of the arrival flow takes place pre-departure through ATFM measures or during the approach through airborne holdings.

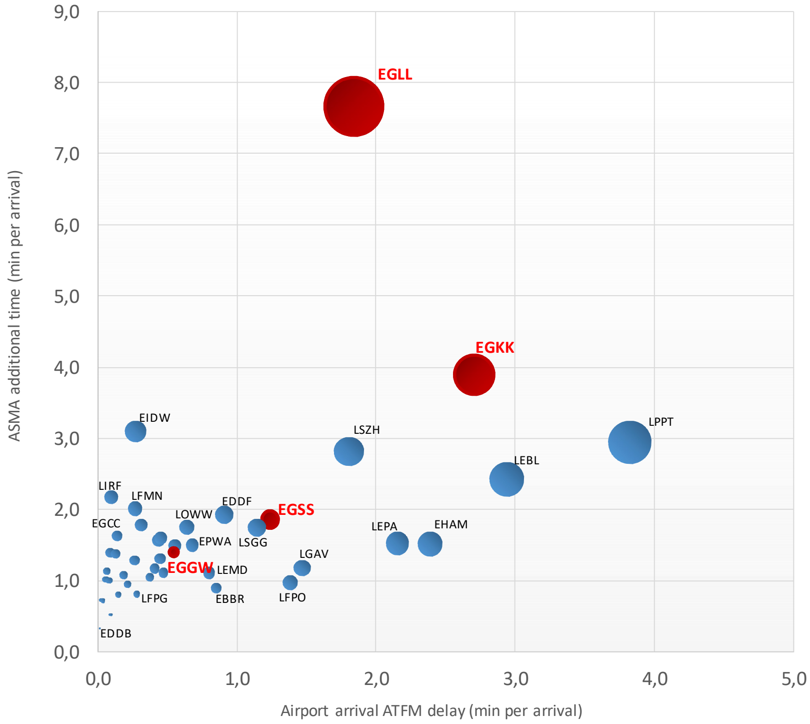


Figure 5-13: Combination of airport ATFM arrival delays and ASMA (airborne holdings) at London airports. Comparison with Top 50 European airports (2018)[12]

Heathrow and Gatwick are the European airports with higher delays due to congestion in the arrival flow. While the issues at Gatwick are managed through a combination of arrival ATFM delay and holding in the approach, Heathrow is clearly a different case, where the maximization of runway throughput takes priority and the traffic is preferably managed during the flight in the approach phase, ensuring constant demand on the runways.

Although arrival ATFM delay and additional ASMA times are both delays affecting arrival punctuality, any ground holding (ATFM delay) has lower environmental impact and lower fuel consumption for the aircraft operators.

[12] The list of airports and their ICAO codes can be found in Annex 3 – Airport ICAO Codes

5.5 Summary of London airport capacity analysis

5.5.1 Observations on London airport capacity

a) In the European context, London airports form the biggest airport system in Europe which adds complexity to the TMA operation. Heathrow and Gatwick are first and third airport in Europe in terms of ANS-related delays per arrivals. Stansted and Luton on the other hand show similar delays to comparable airports in Europe in terms of traffic.

b) Arrival flows into London airports are managed differently. For Gatwick, Stansted and Luton delays pre-departure and airborne are similar, whereas for Heathrow the main part of the observed arrival delays were airborne holdings.

c) The data shows that adverse weather was the main cause for arrival ATFM delays at London airports. Nevertheless, at Gatwick, which imposes the highest arrival ATFM delay from the 5 airports, the main problem in the last two years is aerodrome capacity.

d) Regulations due to aerodrome capacity are becoming more and more significant at Luton, Gatwick and Stansted in light of increasing traffic. Despite similar traffic levels at Heathrow, regulations attributed to aerodrome capacity appear in 2018.

5.5.2 Findings on London airport capacity

I. PRU does not find any evidence of wrong regulation reason attribution at Stansted, but there is a clear regulation pattern in the mornings, coinciding with the highest peaks in demand, that suggests that the resilience of the airport to accommodate its schedule is very low.

This page is intentionally left blank

6 Estimated total impact of traffic management initiatives on arrivals at London Airports

6.1 Estimated total impact on London bound flights (airport view)

To understand the combined effect on arrivals at London airports of the different ANS inefficiencies (c.f. Figure 5-1), Figure 6-1 represents the different average delays per arrival due to these inefficiencies in the past year 2018 and Figure 6-2 represents the monthly evolution of the same indicators in 2016-2018.

London City airport cannot be analysed due to the lack of required data.

The stacked columns represent the average delay (minutes/arrival) for each type of ATM measure:

ATM measure		Column
Airport Arrival ATFM regulations		ATFM dly/arr AIRPORT
Airspace ATFM regulations in the London TMA		ATFM dly/arr LONDON TMA
Airspace ATFM regulations in the rest of UK-NATS		ATFM dly/arr UK
Airspace ATFM regulations anywhere else in the network		ATFM dly/arr OTHER
Additional ASMA time		Add. ASMA per arr
Additional Taxi-in time		Add. Taxi-in Time per arr

The Additional Taxi-in is an indicator that, in a similar way to Additional ASMA Time, aims to address the delay in the Taxi-in phase from the landing time till the in-block time at the stand. These delays are usually not due to ATC or ATM inefficiencies, but more to the proper gate allocation and apron congestion.

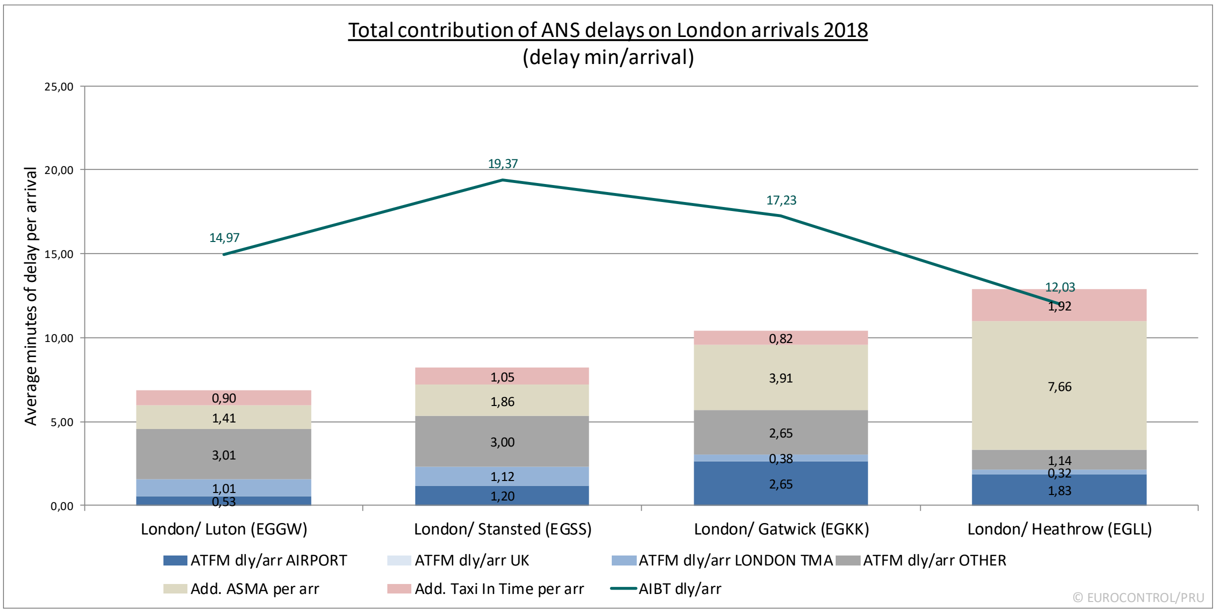


Figure 6-1: Aggregated impact of arrivals management inefficiencies at London airports vs arrival punctuality (2018)

In addition, the line in the graph represents the average arrival punctuality (Actual In-block Time[13] delay/arr) calculated not as percentage of flights arriving on time but as the average minutes of delay in the actual in-block time (with respect to the scheduled time of arrival)

Total ATFM delays (en-route and airport combined) on flights bound for London airports are considerably higher at Gatwick (5.68 min/arr), Luton (4.57 min/arr) and Stansted (5.32 min/arr) than at Heathrow (3.30 min/arr).

Nevertheless, the total ANS related delays at Heathrow are the highest (10.96 min/arr), mainly due to the airborne holdings (7.66 min/arr). This is the way Heathrow operates, preferring to manage the arrival flow during the approach phase and load their stacks to generate the best landing sequence to maximise their runway throughput.

The London TMA related ATFM delays, that is by regulations on London TMA, are significantly higher in both Luton (1.01 min/arr) and Stansted (1.12 min/arr) than in Heathrow or Gatwick where, on the other hand, the airport related ATFM delays are higher.

The biggest contributor to the ANS related delays at both Luton and Stansted arrivals are in fact regulations outside the control of UK/NATS, that is, regulations in the rest of the European airspace (3.01 min/arr and 3.00 min/arr respectively).

For all London arrivals, there is a considerable increase of en-route ATFM delay in 2018 related to regulations in the European airspace. This is in fact observed all over Europe due to the capacity crisis.

The arrival punctuality shows how this delay in the in-block at Gatwick, Luton and Stansted is much higher than the ANS attributable delays.

There are many other factors affecting the punctuality which are outside of the scope of this report (inter alia late departures and unrealistic schedules).

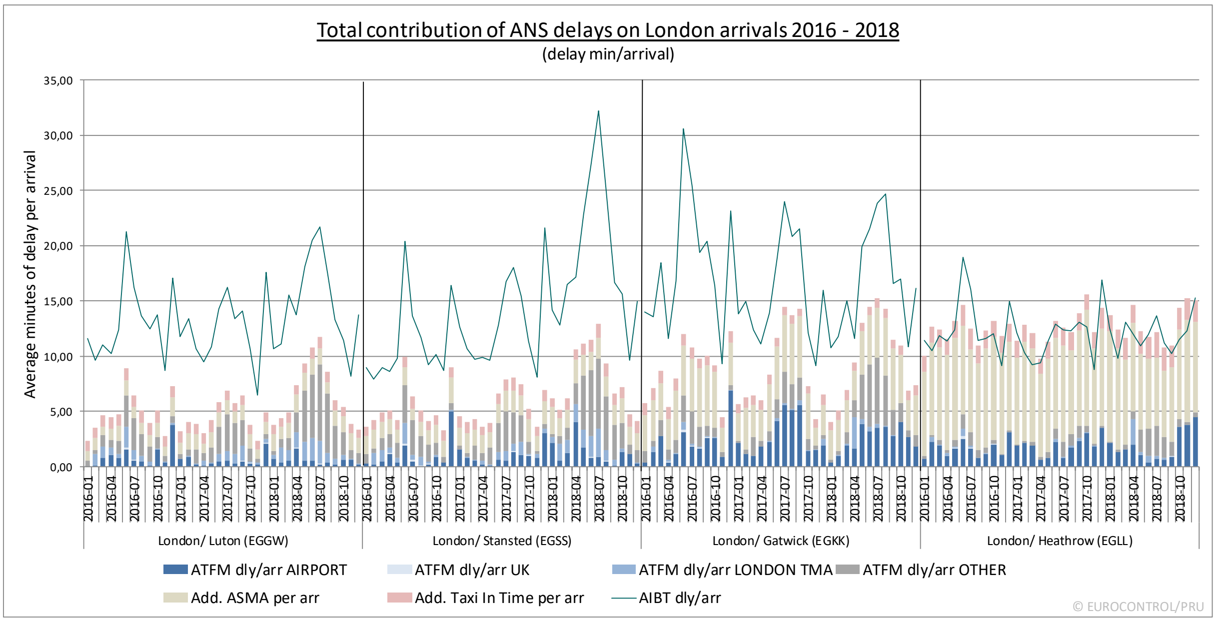


Figure 6-2: Aggregated impact of arrivals management inefficiencies at London airports vs arrival punctuality. Monthly evolution 2016-2018

[13] Actual In-block Time (AIBT): The actual date and time when the parking brakes have been engaged at the parking position.

The evolution (c.f. Figure 6-2) shows how the situation in Luton and Stansted is deteriorating considerably compared to 2016 and 2017, while the performance at Gatwick and Heathrow remains similar. The average arrival punctuality in Stansted in the summer of 2018 has reached significantly higher levels, with a delay in the in-block of more than 30 min/arr in July 2018.

6.2 Estimated total impact on London bound flights (airspace user view)

The four main operators flying into London airports account for 54% of the total movements: British Airways –BAW (22%), EasyJet – EZY (15%), Ryanair - RYR (13%) and Wizz Air – WZZ (4%).

Assessing the total ANS-related impact on the arrivals at the different London airports, the impact of ATFM delays (i.e. en-route and arrival ATFM experienced by a flight) and the additional time in the terminal airspace (i.e. additional ASMA time) have been analysed per major airspace user. Figure 6-3 depicts the encountered total delay aggregating the arrival ATFM delay for the London airports, the en-route ATFM delay attributed to the London Approach area, the en-route delay attributed to other parts of the UK system and the non-UK network, and the additional time arrivals to the London airports are hold within the last 40NM before arrival. The total cumulated delay is shown per arrival experienced by the different major airspace users.

The reasons for late departures and reactionary delays are outside of the scope of this report as the arrivals into London airports might be affected by reactionary delays produced in airports all over Europe along the day.

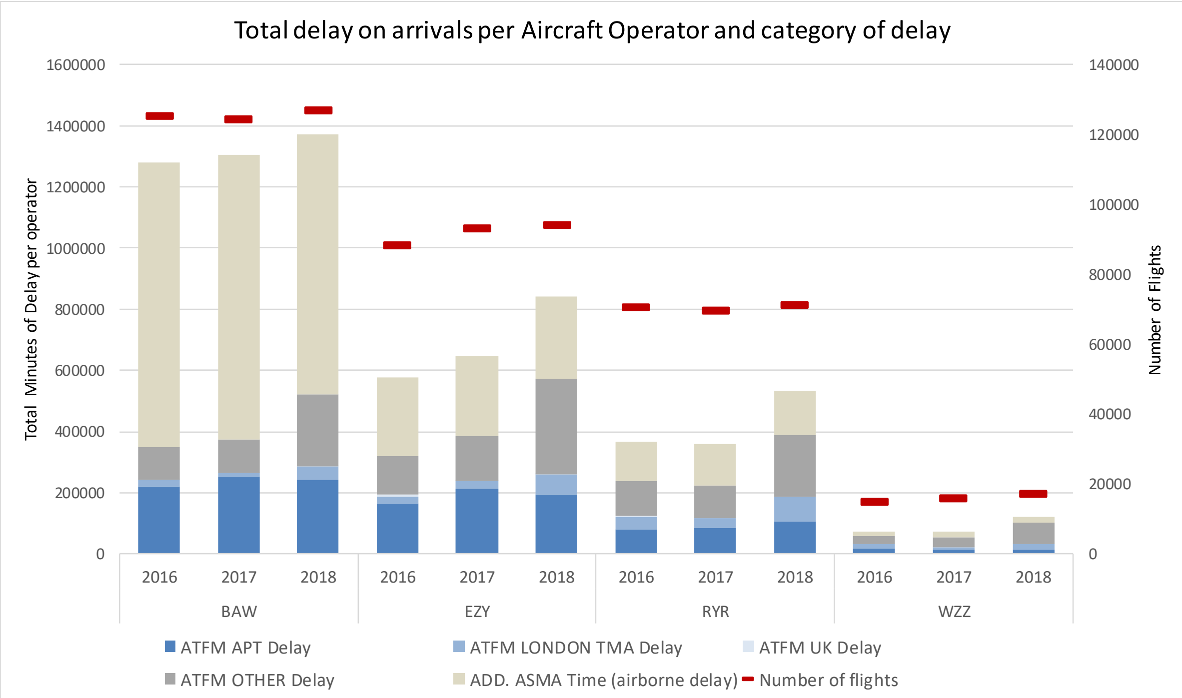


Figure 6-3: Total cumulated delay for inbound flights to London airports per operator

British Airways, as the main operator, suffers the highest total delay in its arrivals into Heathrow and Gatwick. Figure 6-4 shows how in terms of delay per arrival, operation into Heathrow (the main destination for British Airways) is affected by higher delay, most of it due to holding. Taxi-in for BAW at Heathrow is also higher. The airport regulations affect equally BAW flights at Gatwick or Heathrow.

However, in terms of in-block punctuality, we observe better performance in those arrivals into Heathrow, where in fact the in-block delay is less than the ANS delays, which suggests that the airline foresees some delays and builds them into their schedule. It also suggests little reactionary delay in those operations.

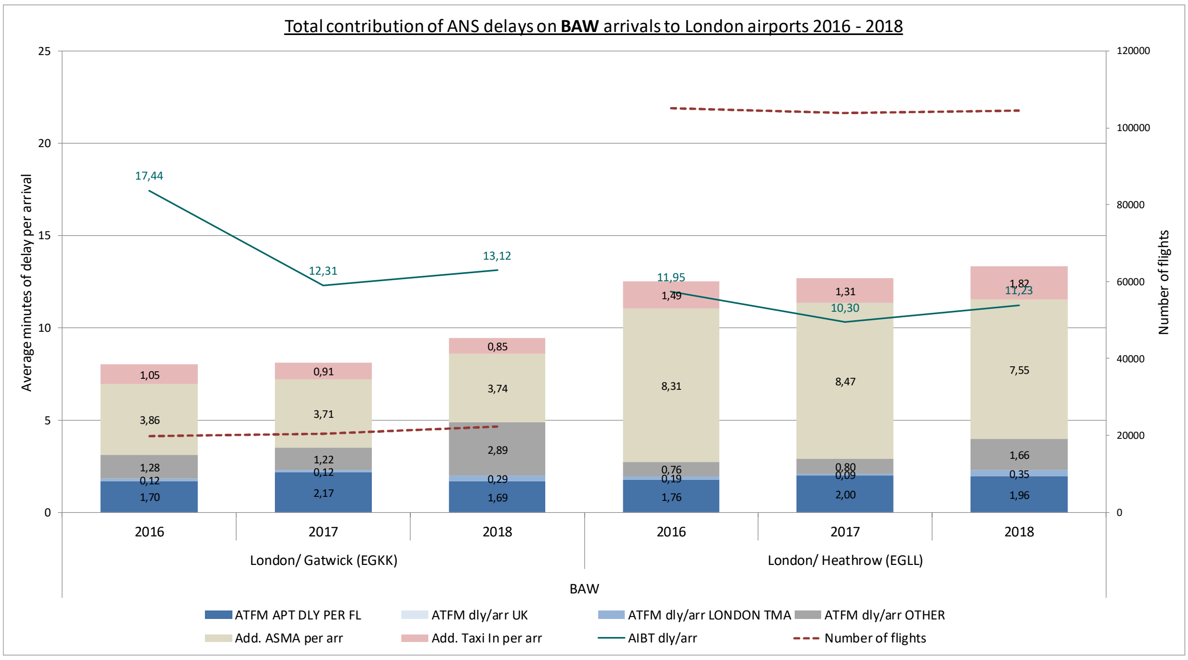


Figure 6-4: Punctuality and ANS-related impact on British Airways arrivals at London airports (2016-18)

EasyJet (c.f. Figure 6-5) is the second largest operator in terms of movements at London airports. They operate mainly from Gatwick, but also have movements at Luton and Stansted. The EasyJet arrivals most affected by ANS related delays are those arriving at Gatwick airport, where they experience higher delays than the British Airways flights. The punctuality for in-block (delay in arrival at the stand) sits, in 2018, above 19 minutes for all three airports, significantly above the ANS infringed delays, which suggests late departures from origin and reactionary delays.

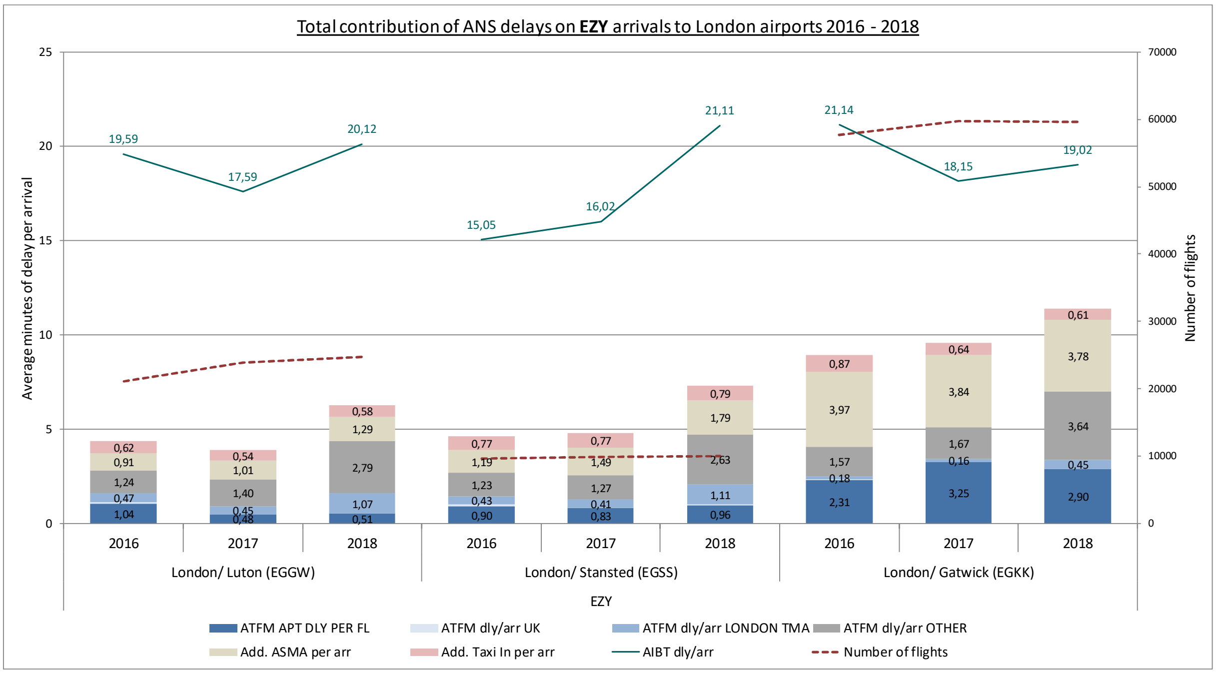


Figure 6-5: Punctuality and ANS-related impact on EasyJet arrivals at London airports (2016-18)

Ryanair (c.f. Figure 6-6) mostly operates to/from Stansted airport, with lesser activity at Gatwick and Luton airports. The in-block punctuality at Gatwick, where Ryanair arrivals experience the highest delays, is in line with the total ANS delays. On the other-hand, in 2018, Ryanair's in-block punctuality at Stansted is above 20 minutes of delay, more than double the ANS delays, and a drastic increase on 2017. These results are very similar to the situation for EasyJet at Stansted. For both of them, the increase in delays at Stansted in 2018 versus 2017 is primarily due to ATFM regulations in the European network and the London TMA.

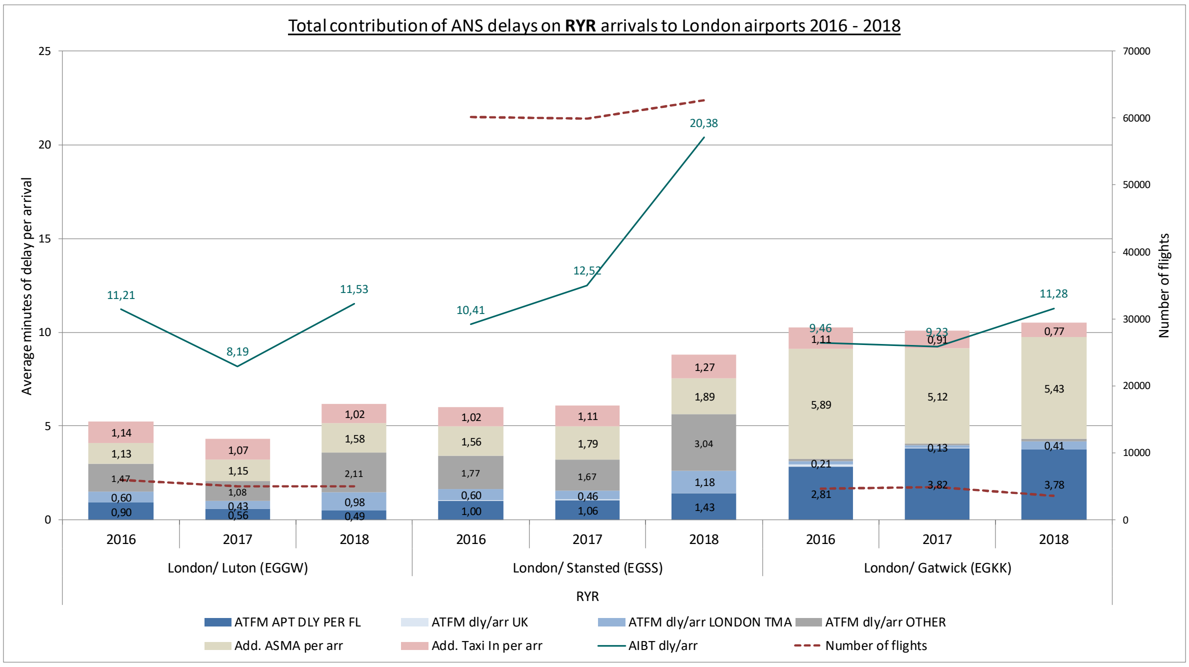


Figure 6-6: Punctuality and ANS-related impact on Ryanair arrivals at London airports (2016-18)

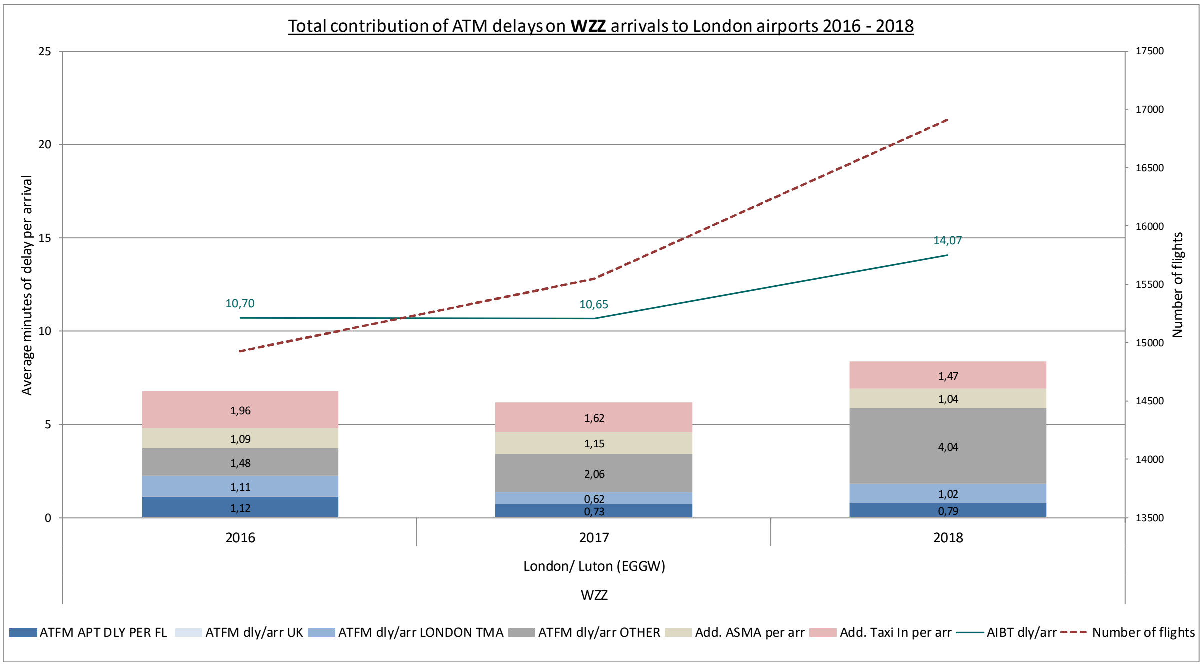


Figure 6-7: Punctuality and ANS-related impact on Wizz Air arrivals at London airports 2016-18)

Wizz Air operates to/from Luton and the biggest contributor to its ANS related delays (within these categories), as with Ryanair and EasyJet, is ATFM delays from outside the UK.

Once more, the in-block punctuality is not justified simply by the ANS delays, so other reasons (late departures) are also contributing to these results.

6.3 Summary of estimated total impact on London bound flights

6.3.1 Observations - estimated total impact on London bound flights

a) In general, arrivals into Heathrow experienced the highest levels of combined ANS delays: primarily due to holding and to a lesser extent due to arrival ATFM regulations.

b) Gatwick, Luton and Stansted are seasonal airports. In July 2018, arrivals into these airports experienced more than 10 minutes of ANS related delays per arrival; even higher than those at Heathrow during the same period.

c) ANS delays affecting arrivals into Gatwick are the second highest after Heathrow and are affected by a combination of arrival ATFM delays, en-route delays originating in the rest of European airspace, and airborne holdings.

d) The situation for arrivals into Luton and Stansted has significantly deteriorated in the last year. Even though the greatest proportion of ANS delay is from elsewhere in the European network, regulations originating within the London TMA played a significant part.

e) Overall, British Airways arrivals into London Heathrow receive the highest ANS delays per arrival, followed by EasyJet and Ryanair arrivals into London Gatwick.

f) Although ANS delays for Ryanair and EasyJet at Stansted and Luton increased in 2018, they remain below the observed levels of delay for the same airlines at Gatwick.

6.3.2 Finding - estimated total impact on London bound flights

I. Although the impact of ANS related inefficiencies increased in 2018, above the levels experienced in 2016 and 2017, the overall impact of ANS related inefficiencies for arrivals into Stansted and Luton remains lower than at Heathrow and Gatwick.

7 Complementary analysis: Turn-round times

The study of the scheduled turn-round times (TTT) versus achieved ones intends to show if the turnaround operation at an airport is absorbing or generating delay (adding more delay to the next departure than exclusively the one resulting from the late arrival)
The analysis is focused on Medium Jet aircraft of the four main operators at London airports and it measures the average time between In-block and Off-block times[14] (scheduled and actual).

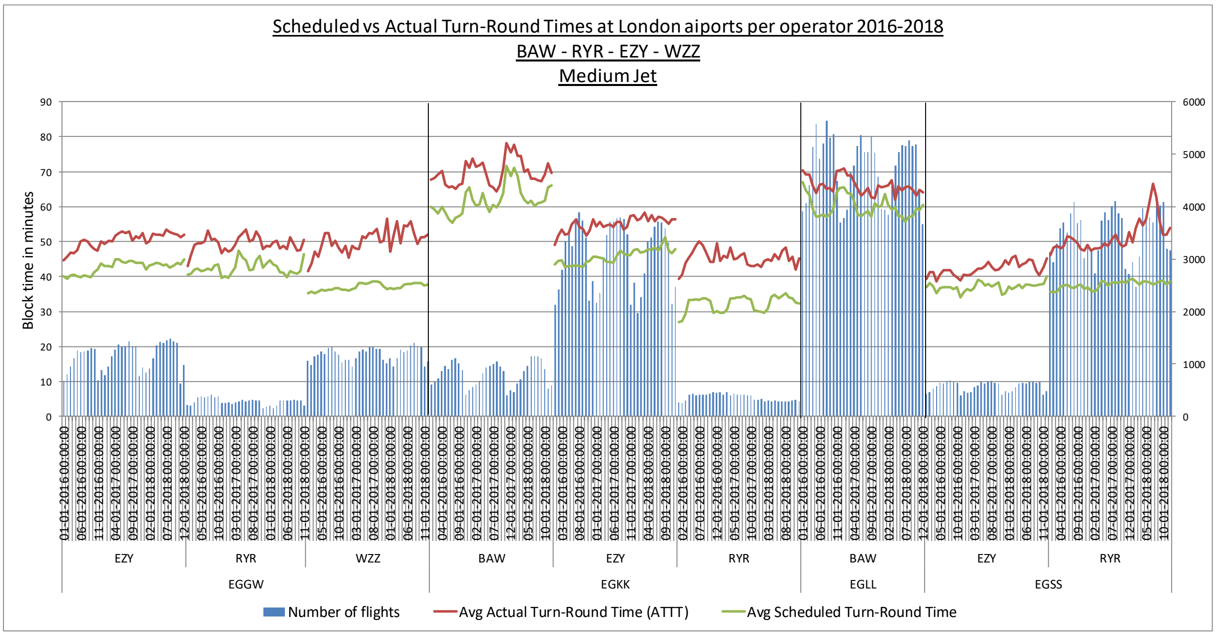


Figure 7-1: Actual and scheduled Turn-round times at London airports by airline (Medium Jets)

For every airline and every airport, and according to the data submitted via de Airport Operator Data Flow, average ATTT is always higher than the planned, which means there is no recovery from the delays of the arrivals (In-block), but even more delay added in the Off-block. The highest differences between these scheduled and the achieved can be observed in those cases where the planning is very tight (i.e. Ryanair in Gatwick and Wizz Air in Luton).

The longest scheduled turn-round times are those from British Airways. In Heathrow the planned turn-round times are around 60 minutes per flight, which makes sense given the hub-and-spoke model and the need to guarantee connections. At Gatwick, BAW has significantly increased its planned turn-round times in the last 2 years reaching up to almost 80 minutes in winter 17-18. Despite the long planned block times, the resulting actual turn-round times are still around 5 to 10 minutes longer.

The rest of airlines, flying point to point, have shorter planned turn-round times.

[14] Actual Turnaround Time (ATTT): Time difference between the Actual off-block time (AOBT) minus the Actual in-block time (AIBT)
Actual Off-block Time (AOBT): The time the aircraft pushes back / vacates the parking position.
Actual In-block Time (AIBT): The actual date and time when the parking brakes have been engaged at the parking position.
Scheduled Turnaround Time (STTT): Time difference between the Scheduled off-block time (SOBT) minus the Scheduled in-block time (SIBT)
Scheduled Off-block Time (SOBT): The time that an aircraft is scheduled to depart from its parking position.
Scheduled Off-block Time (SIBT): The time that an aircraft is scheduled to arrive at its first parking position.

At Luton, EasyJet and Ryanair plan 40 to 45 minutes, while Wizz Air plans only 35 to 39 min. However, the actual turn-round times are for all three around the 50 minutes, and in fact for Wizz Air in 2018 even up to 55 minutes.

In Stansted Ryanair and EasyJet plan slightly shorter times than at Luton (35 to 40 min) but the achieved turn-round times differ between the two airlines.
The worst results in terms of actual turn-round times versus planned are those observed for Ryanair at Stansted in summer 2018 with around 25 minutes difference, while EasyJet at the same airport registers a delay in the turn-round of 10 minutes.

It is interesting to see how EasyJet and Ryanair, who plan similar times at Stansted (35 to 40 min) and Luton (40 to 45 minutes), have very different scheduled turn-round times in Gatwick (RYR: 30 to 35 min; EZY: 45 to 50 min)

8 Conclusions

8.1 Overview

This report studies the provision of air traffic management within the London TMA and at London airports. It provides a review of the coding and reporting of ATFM delays within London TMA and at the London airports. Additionally, the analysis includes the aggregation of additional inflight traffic flow measures (additional times during arrival phase and during surface movement at airports), to give a more enhanced perspective on the airspace user experience.

This report has been drafted to support the UK CAA in their on-going investigation based on the specific Terms of Reference agreed between EUROCONTROL and the UK Civil Aviation Authority (UK CAA) for this report.

The report represents a data driven and factual study including expert judgement. The data is derived from information available to the EUROCONTROL Performance Review Unit (PRU) and the expert judgement derives from both the experience of ATM and airport operations within the PRU, and the published opinions of the EUROCONTROL Performance Review Commission.

As far as practical, comparison with other European service providers, control centres, and airports have been made based on the regular performance monitoring performed by the PRU, either through the Performance Review System of EUROCONTROL, or to support the European Commission in the functioning of the SES Performance Scheme.

8.2 Main Findings

Traffic characteristics (long haul, short haul); airline business model (low cost, traditional); infrastructure (multiple, single runway) and traffic demand are heterogeneous across the London airports.

Accordingly, there is variation in the application and type of ATM techniques used to effectively manage traffic flows.

The ATFM processes followed by ATC, including delay coding and attribution, are consistent with the current guidelines as published by EUROCONTROL in the ATFCM manual.

The EUROCONTROL Performance Review Commission has identified that the current ATFCM process should be strengthened by developing and adopting strict procedures instead of the current guidelines that lead to inconsistencies and opacity in monitoring capacity performance.

The analyses performed in this report did not reveal any evidence of difference in treatment between airspace users operating at different airports within the London multi-airport system.

8.2.1 PRU findings on en-route capacity performance

(Chapter 4)

- It would improve transparency to external stakeholders and improve compliance with EU Regulation No 677/2011 if NERL would provide the Network Manager with the dynamic update of actual sector configurations deployed. (This would also eliminate anomalies regarding 'conjoint airspace'.) This does not need to affect current operational arrangements or responsibilities.
- Recalling that sectors are being regulated at capacity levels above the published declared capacity, which could indicate the potential to increase the published declared capacities, the PRU recalls PRC recommendation (f) in PRR2015, endorsed by the Provisional Council of EUROCONTROL, that requested Member States *to task ANSPs to review sector capacities, both with and without airspace restrictions, to increase network performance*.
- In view of the evidence that sectors were regulated at capacity levels below the declared capacity but attributing the delays to ATC capacity, instead of identifying the constraint preventing full deployment of capacity; that ATFM delays in collapsed sectors were attributed to ATC capacity, the PRU recalls PRC recommendation c) from PRR2017, and in particular the rationale containing PRC proposals for ATFM delay attribution:

> *The ATFM delay attribution process should be based on the following principles:*
>
> *The primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or airspace management);*
>
> *Attribution of delays to external causes (e.g. weather or 3rd party strike) should only be used in cases where no ANSP-internal capacity constraints prevent the deployment of maximum capacity;*
>
> *Attribution of delays to ATC capacity should not be used for collapsed sectors or when the regulated capacity is less than the maximum declared capacity of the sector.*

- It is noted that the ATFCM process does not contain rules for attributing ATFM delay, but only 'guidelines'.
- It is noted that the NATS internal guidance on delay attribution principles refers to the planned sector configuration rather than the sector configuration required to satisfy the traffic demand.
- It is noted that previous PRC reviews of capacity performance at other ANSPs raised exactly the same issues and prompted the PRC to make recommendations to strengthen the ATFCM process. NERL is not exceptional by any means in how they attribute ATFM delay.
- As part of the SES Performance Scheme, the UK has implemented an incentive scheme for capacity performance. This incentive scheme excludes certain ATFM delays based on the attributed delay codes – typically explained as non-controllable by the ANSP. Where Member States have implemented incentive schemes for capacity performance which excludes certain ATFM delays, according to the attributed delay code, there might be benefits from considering a verification process for the attribution of ATFM delay.

8.2.2 PRU Findings on London airport capacity

(Chapter 5)

I. PRU does not find any evidence of wrong regulation reason attribution at Stansted, but there is a clear regulation pattern in the mornings, coinciding with the highest peaks in demand, that suggests that the resilience of the airport to accommodate its schedule is very low.

8.2.3 PRU Findings on estimated total impact on London bound flights

(Chapter 6)

I. Although the impact of ANS related inefficiencies increased in 2018, above the levels experienced in 2016 and 2017, the overall impact of ANS related inefficiencies for arrivals into Stansted and Luton remains consistently lower than at Heathrow and Gatwick.

8.3 Addressing the UK CAA Questions

This report provides input to the UK CAA investigation team with a view to address the following questions:

1. Understand the processes by which NERL records, categorises, and reports delays.

This report is based on factual analysis of data recorded by the Network Manager and subsequently provided to the PRU. The data is produced through the process of ATFCM for the entire network, for which the Network Manager has a central role and specific responsibilities.

The review shows that the manner in which NERL categorises delays is in accordance with the existing ATFCM guidelines and is consistent with other ANSPs throughout the network.

2. Understand whether those processes are robust and follow existing best practice guidance.

Whilst noting that the delays are categorised in accordance with the existing ATFCM guidelines, it is important to recall that, in 2017, the Provisional Council of EUROCONTROL, noting the concerns raised by the PRC, requested the Director General of EUROCONTROL and the Member States to strengthen the ATFCM process by developing and adopting strict procedures for attributing ATFM delay causes instead of the current guidelines that lead to inconsistencies and opacity in monitoring capacity performance.

3. Have (ATFM) delays in practice been recorded appropriately for the London Approach Service in relation to Stansted?

As previously stated, the ATFM delays used in this analysis are those recorded by the Network Manager. In accordance with the ATFCM process, when requested by the UK FMP (due to an imbalance between available ATC capacity and traffic demand), the Network Manager will apply an ATFM regulation to flights intending to fly within a specific portion of airspace. The ATFM regulation contains the geographical location and the reason (delay code) for the capacity constraint.

The responsibility for defining both the geographical location and the reason for the delay lies with the ATFM unit requesting the regulation (UK FMP), not the Network Manager. The Network Manager is responsible for calculating the amount of delay caused by the application of the ATFM regulation.

The report has raised anomalies in attributing delays to ‘conjoint airspace’, which although being made for acceptable operational reasons, reduce transparency for post-operations analysis. This could be significantly improved if the ANSP provides NM with the actual sector configurations, to permit cross-referencing of regulations against open sectors.

4. What are the underlying causes and contributory factors to ATFM delays in the London area?

This report is based on a factual analysis of the reported ATFM delay within the London TMA. Comments on the attributed causes and contributory factors are presented throughout this report as and when they arise.

The general behaviour is consistent with the ATFM operations observed in other ANSPs across Europe, in that whilst specific reasons for capacity constraints may arise from time to time (such as adverse weather, or non-availability of staff), increasing levels of traffic will amplify any capacity constraints.

Furthermore, capacity constraints applied for internal ANSP reasons, for example the operation of collapsed sectors, due to non-availability of staff (planned or unplanned), can adversely impact airspace users if traffic demand exceeds the deployed capacity.

5. Interrelation and impacts of other forms of delay on NERL attributable ATFM delays in the London area, and vice-versa.

This report analysed the en-route and arrival ATFM delay observed for London TMA and London airports. Other forms of temporal inefficiencies (i.e. additional ASMA time, additional taxi-in and taxi-out times) have also been analysed. In general, the different components are cumulative from an individual flight perspective.

The estimated total impact on London bound flights is summarised in section 6.3

6. Likelihood of likely consumer harm (including additional costs borne by airlines and airports) arising from NERL attributable delay in the London approach area (including reactionary delay) and put in the context of total flight delay and ATFM delay in other comparable airspace sectors.

This report is not in the position to quantify the associated costs to airspace users or airports.

The performance observed at London TC is good relative to comparable ACCs.

7. Understand key constraints faced by the provision of London Approach Service to aircraft using Stansted and Luton airport and what actions might be able to address those constraints in the future.

This report highlighted the interplay between the ANS, airports, and airspace users, and how the efficient use of resources is a shared responsibility amongst all parties. The assessment of the impact on airspace users shows that ANS is not the sole factor to be addressed.

This report documents a substantial growth of air traffic within the London multi-airport system, particularly at Stansted and Luton.

The observations point at a general requirement to minimise the need for ATFM measures to be put in place, to ensure the safe and efficient flow of air traffic. The ultimate goal is better modulation of the air traffic demand in light of the available resources across the involved stakeholders.

It is acknowledged that NERL, like any other ANSP, should provide the capacity required for the provision of air traffic services to satisfy peak demand. However, the action on the ANSP does not live in isolation. It needs to be properly balanced with the resources on the airport side, both airside and landside, and the airspace user operations.

8.4 PRU Recommendations

The findings of this report are based on the performance data analyses presented for the air navigation service provision within the London Approach Area and airports.

Promote higher level of transparency by providing sector opening times

NERL currently manages capacity and demand autonomously and does not provide sector opening times to the Network Manager. While this practice is permissible under the existing ATFCM practices it reduces transparency on the actual operational practice of service provision. It would improve transparency to external stakeholders, and demonstrate compliance with EU Regulation No 677/2011, if NERL would provide the Network Manager with the dynamic update of actual sector configurations deployed. This does not need to affect current operational arrangements or responsibilities

Other air traffic control centres in Europe that also operate to a similar level of autonomy, in monitoring and balancing capacity and demand, share the sector opening times with the Network Manager.

It is recommended that NERL follows this practice.

Establish a mechanism to verify the ATFM delay code attribution

As part of the SES Performance Scheme, the UK has implemented an incentive scheme for capacity performance. This incentive scheme excludes certain ATFM delays based on the attributed delay codes – typically explained as non-controllable by the ANSP.

Where Member States have implemented incentive schemes for capacity performance which excludes certain ATFM delays, according to the attributed delay code, there might be benefits from considering a verification process for the attribution of ATFM delay.

PRC recommendation c) from PRR2017 provides guidance on the principles of the ATFM delay attribution:

> The primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or airspace management);
>
> Attribution of delays to external causes (e.g. weather or 3rd party strike) should only be used in cases where no ANSP-internal capacity constraints prevent the deployment of maximum capacity;
>
> Attribution of delays to ATC capacity should not be used for collapsed sectors or when the regulated capacity is less than the maximum declared capacity of the sector.

It is recommended to implement these principles consistently and establish an independent verification process for the delay attribution.

Engage with airspace users and airports to de-conflict arrival/departure peaks and consequent congestion

Recurrent congestion at specific times at Stansted suggests that a collaborative process between the parties involved (i.e. ANSP, airspace user, airports) can help to mitigate the effect and reduce the need to modulate the air traffic through ATFM delay or additional time in the terminal airspace.

It is recommended to initiate a wider collaborative process to balance the interests of ANSP, airspace user, and the airport operator.

This page is intentionally left blank

Annex 1: Network Operations Plan (2018-2019/22)

London TC

UNITED KINGDOM — LONDON TC

Traffic forecast

ACC	Growth	2018	2019	2020	2021	2022
London TC	H	2.3%	4.3%	8.2%	11.2%	13.6%
	B	1.5%	2.7%	4.1%	5.4%	6.3%
	L	0.7%	1.3%	1.2%	1.6%	1.9%
	Shortest Routes: No significant impact					

% growth per ACC v. 2017, based on the EUROCONTROL Seven-Year Forecast (February 2018)

Shortest routes: With part of Ukraine, Libya, Iraq and Syria airspaces closed or not used by the airspace users

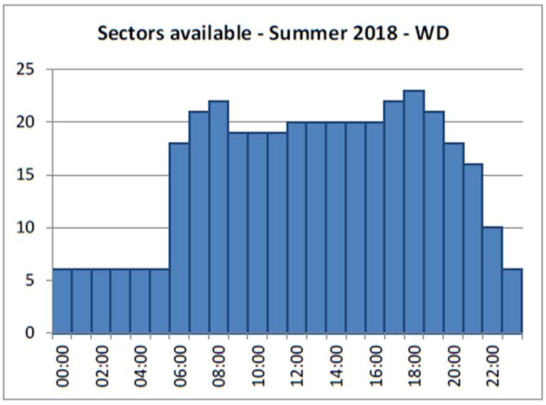
Planned capacity enhancement measures

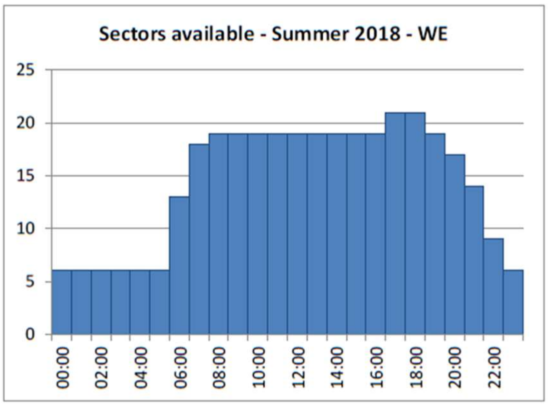
Summer Capacity Plan					
	2018	2019	2020	2021	2022
Free Route Airspace					
Airspace Management Advanced FUA					
Airport & TMA Network Integration					
Cooperative Traffic Management	Improved ATFCM, including STAM				
Airspace	RP2/RP3 Airspace Development Programme				
Procedures	Developing Queue Management programme				
Staffing	Flexible use of existing staff				
	On-going recruitment to maintain agreed business service levels				
Technical	EXCDS Implementation			Transition to new controller working positions	
				iTEC introduction (Winter 20/21)	
Capacity	Adaptation of sector configurations to demand				
	Traffic Management Improvements				
	Complexity reduction and improved traffic presentation between sectors / ANSPs				
Significant Events			TC Training for new controller working position		
	TC training for EXCDS				
Max sectors	44 27 ENR +17 APP	44 27 ENR +17 APP	44 27 ENR +17 APP	44 27 ENR +17 APP	44 27 ENR +17 APP
Planned Annual Capacity Increase	2%	1%	1%	2%	1%
Reference profile Annual % Increase	0%	0%	N/A	N/A	N/A
Difference Capacity Plan v. Reference Profile	2.0%	2.6%	N/A	N/A	N/A
Annual Reference Value (min)	0.10	0.10	N/A	N/A	N/A
Annual en-route delay forecast (min)	0.13	0.06	0.07	0.08	0.06
Summer reference value (min)	0.10	0.10	N/A	N/A	N/A
Summer en-route delay forecast (min)	0.18	0.11	0.11	0.10	0.10
Additional information	Swanwick RP2/RP3 airspace programme will deliver various modules throughout the period, capacity increase values will be confirmed in project definition. Major Project Transition to Electronic Platform in TC 2017/2018. Up to 23 ENR sectors are planned to be open in Summer 2018 with a maximum of 27 possible if required.				

The delay forecast excludes delays for disruptions such as industrial actions and technical failures.

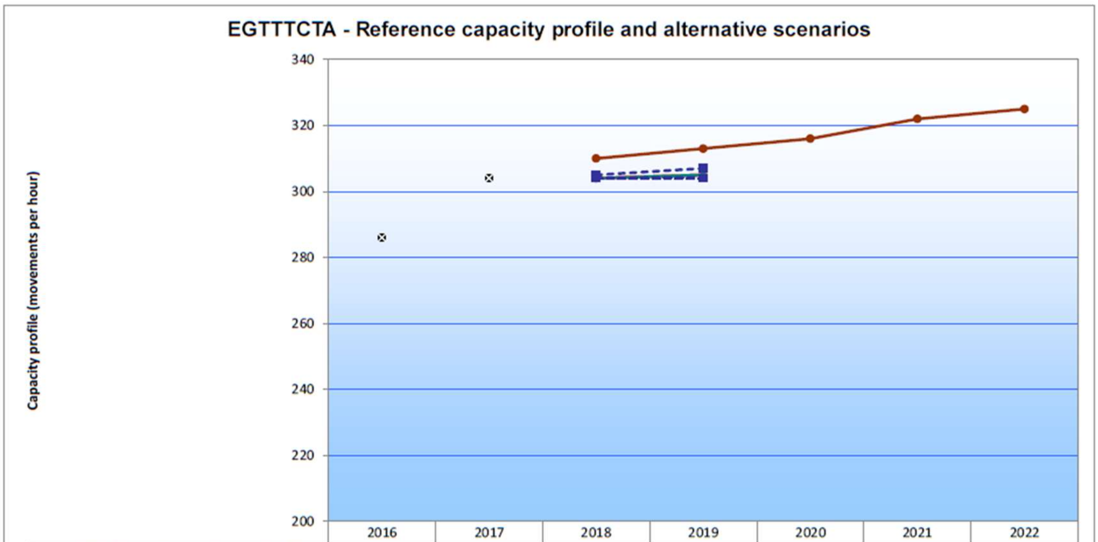
06/03/2018 375

Sectors available - Summer 2018





Capacity Baseline and Requirements



	2016	2017	2018	2019	2020	2021	2022
2018-2019 Reference Capacity Profile			304	305			
Capacity Profile - Shortest Routes (Open)			304	305			
Capacity Profile - Current Routes			304	305			
Capacity Profile - High			305	307			
Capacity Profile - Low			304	304			
Capacity Baseline	286	304					
2018 - 2022 Plan			310	313	316	322	325

Expected Performance

No capacity issues are expected over the planning period in London TC.

Annex 2 – background information

Air Navigation Services

This report supports the UK CAA investigation with a view to assess the questions raised. To link considerations of how traffic flows are managed and the impact or magnitude experienced by airspace users, it is important to understand the interplay between air traffic management (ATM) and air traffic service provision (ATS). Both are part of the air navigation services (ANS) provided and used by airspace users.

The term air navigation services includes air traffic management (ATM), communications, navigation and surveillance systems (CNS), meteorological services for air navigation (MET), search and rescue (SAR) and aeronautical information services (AIS). These services are provided to air traffic during all phases of flight (e.g. planning, execution) and operations (approach, aerodrome and en-route). Figure 0-1 depicts and highlights the service categorisation relevant for this study.

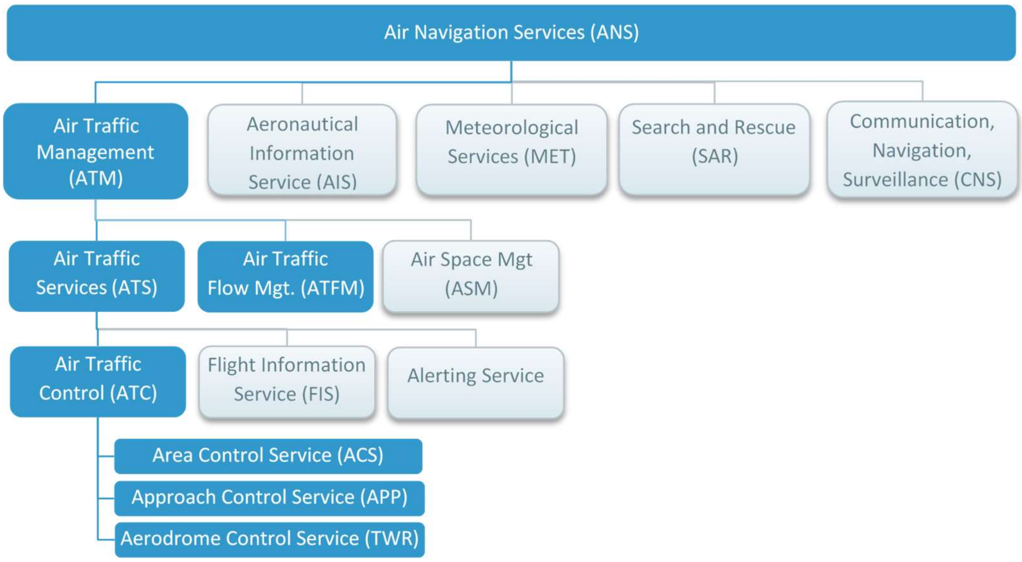


Figure 0-1: Air Navigation Services (ANS)

The term Air Traffic Management (ATM) is generally accepted as covering all activities involved in ensuring and meeting the overall goal: "to ensure the safe, orderly and expeditious flow of air traffic". The term comprises Air Traffic Services (ATS), Air Traffic Flow Management (ATFM), and Airspace Management (ASM).

The key characteristic of air traffic services (ATS) is the provision of control services (ATC) for the purpose of safety, i.e. providing separation (preventing collisions between aircraft and aircraft and obstructions or obstacles), and synchronisation of air traffic (maintaining and expediting the orderly flow). Air traffic services are provided by air traffic controllers and can be generalised to interactions between controllers and aircrews, and controllers of adjacent airspaces.

The focus of air traffic flow management (ATFM, within the European context also frequently coined air traffic flow and capacity management [ATFCM]) is the contribution to the overall goal by ensuring a balance between capacity and demand (i.e. ensuring no safety critical overload by demand). The principal means to manage the capacity/demand balance is through dispositioning flights in time (i.e. ATFM delay) or space (i.e. re-routing). ATFM is a collaborative process entailing interactions between the respective flow management function of an air navigation service providers, the European Network Manager, and/or airspace users.

Accordingly, traffic management initiatives can result in a refined flight plan (i.e. re-routing) or delayed departure (i.e. ATFM delay). These pre-departure measures are referred to as “regulations” signalling the management (regulation) of the air traffic flow. ATFM delays result in a calculated take off time (CTOT). Airspace users subject to a regulation are expected to adhere to the CTOT within a certain tolerance window. This ensures that the targeted modulation of demand materialises along the route of flight.

Note: ATFM delay is assigned to the most penalising regulation. In the event of two or more separate regulations affecting a flight only the most penalising regulation would appear in the data.

Air Traffic Flow Management (ATFM) in the United Kingdom

Extracted from UK AIP ENR Section 1.1 – 1.4 & 3.1 – 3.4

1.1 Air Traffic Flow Management is a service established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring [Area Control Centre] ACC capacity is utilised to the maximum extent possible and the traffic volume is compatible with the capacities declared by the appropriate ATC authority.

1.2 A Centralised Air Traffic Flow Management (ATFM) service is established within the ICAO (EUR) Region to optimise the use of air traffic system capacity. The EUROCONTROL Network Management Directorate (NMD) in Brussels provides this service in conjunction with Flow Management Positions (FMPs) established at each ACC.

1.3 The NMD includes the Flow Management Division (FMD), responsible for the planning, co-ordination and implementation of ATFM measures within the FMD ATFM area and the Flight Data Operations Division (FDOD), responsible for collecting, maintaining and providing data on all flight operations and the air navigation infrastructure. FDOD includes the Integrated Flight Planning System (IFPS).

1.4 A description of the ATFM area and information on the Network Operations Systems can be found in the Network Operations Handbook[15].

3.1 The emphasis for ATFM measures is changing from regulation (delaying aircraft on the ground) towards capacity management. Only when no other option is available will a regulation be applied and delays issued (Slot Allocation).

3.2 Alternative ATFM measures include the re-routing of aircraft both strategically and tactically. Permanent Strategic routing requirements are published in the Route Availability Document (RAD). The RAD enables ATC to maximise capacity by defining restrictions that prevent disruption to the organised system of major traffic flows through congested areas.

3.3 In addition, routing 'scenarios' may be applied by the NMD to help resolve particular problems on particular days. These involve recommended or mandatory routes for particular groups of flights or selected individual flights. Re-routes for groups of flights will be published by the NMD in an AIM (Air Traffic Flow and Capacity Management Information Message) or ANM (ATFM Notification Message).

3.4 Re-routing may include restricting the level of an aircraft to keep it out of a particular ATC sector. This is known as level capping. Level capping scenarios are published for groups of aircraft.

[15] https://www.eurocontrol.int/publication-type/network-operations-handbook

Generic organisation of Air Navigation Services

Under Article 1 of the ICAO Chicago Convention, States have the sovereignty over the airspace above their territory. However, States are also required to establish the provision of air navigation services within their airspace. The dimension of the national airspace and its organisation into Flight Information Regions (FIR) is published in the respective Aeronautical Information Publication (AIP). Today's operational concept entails that air traffic services are provided by one organisation (i.e. air navigation service provider [ANSP]) within a specific area of responsibility[16] (AOR). The further breakdown of the FIR into AORs and their assignment is outside the scope of this report.

Dependent on the local specifics, the service provider in coordination with the national supervisory authority define operational sectors to organise the service provision and accommodate the demand. The following Figure 0-2 depicts a conceptual airspace schematic. This organisation can be directly mapped to the air traffic control services provided:

- control zone (CTR) - aerodrome control service
- approach unit (APP) – approach control service
- area control service by an area control centre.

For practical reasons, aforementioned units may be collocated. There is also commonly a separation between upper area control and (lower) area control. Paying attention to the nature of air traffic around major aerodromes, a designated area of the airspace is referred to as Terminal Control Area (TCA) or Terminal Maneuvering Area (TMA). Within the respective airspaces, sectors are identified to handle the traffic. Dependent on the nature of the traffic flow, time of the day / demand situation, and operational specifics, sectors may be "collapsed" (i.e. two or more elementary sectors are combined).

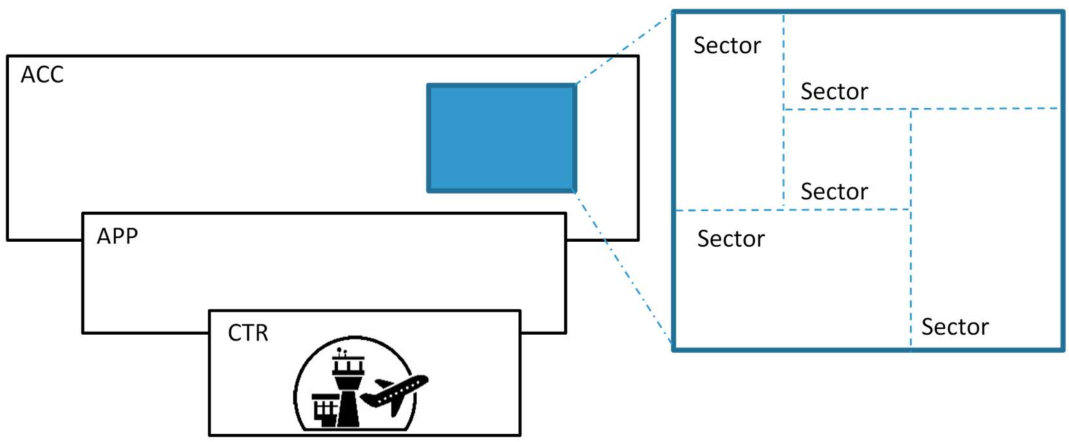


Figure 0-2: Conceptual Airspace Organisation

ATFM regulations are generally coded and linked to locations. Such locations are typically linked to the sectorisation of a control area.

[16] Depending on the concept of operations and for typically operational air traffic (e.g. military flights) it is possible that the latter traffic is controlled by another control unit within the same volume of airspace. This is however of no relevance for this report.

London Approach Service

The Oberon report [2], compiled by UKCAA, does not focus on actual portions of airspace, but instead concentrates on the air traffic control service provided. It identifies the London Approach Service as an air traffic control service provided by NERL. It further breaks this down into Area service, which operates the general airspace within the London Terminal Control Area and Approach Service, which operates into each of the airports of the London Approach.

The Oberon report states (Figure 1: page 27) that there are typically 2 operational positions for ATC, up to a maximum of 3 operating positions, allocated for Stansted Approach.

The UK Aeronautical Information Publication (AIP) in ENR 2.1, lists and defines the London FIR and various elements of the London TMA wherein service is provided by London Control (NERL). The same section also lists, within the London FIR, various control areas wherein service is provided by other local units, for example London Luton or London Stansted. In general, London Control (NERL) handle traffic above 3500ft and the local units handle traffic below that.

Since the London airspace in general is very complex, with a high density of traffic and multiple airports in close proximity to one another, it is difficult to clearly map the airspace definitions against the associated ATC responsibilities, or ATC operating positions.

In the London TMA, London Control (NERL) will hold traffic and sequence traffic for Stansted (and other airports): tasks which, in a less complex environment, would normally be associated with a dedicated approach unit serving the airport.

To differentiate between the air traffic service provided by London Control (NERL) primarily within the London TMA and the service provided elsewhere in the London FIR, the air traffic control unit providing ATS services primarily within the London TMA is referred to as London Terminal Control Centre (TC). (London Area Control being the remaining unit)

Annex 3 – Airport ICAO Codes

Airport ICAO Code	Country	Airport Name	FAB
EBBR	Belgium	Brussels	FABEC
EDDB	Germany	Berlin/ Schoenefeld	FABEC
EDDF	Germany	Frankfurt	FABEC
EDDH	Germany	Hamburg	FABEC
EDDK	Germany	Cologne-Bonn	FABEC
EDDL	Germany	Dusseldorf	FABEC
EDDM	Germany	Munich	FABEC
EDDS	Germany	Stuttgart	FABEC
EDDT	Germany	Berlin/ Tegel	FABEC
EFHK	Finland	Helsinki/ Vantaa	NEFAB
EGBB	United Kingdom	Birmingham	UK-IRELAND FAB
EGCC	United Kingdom	Manchester	UK-IRELAND FAB
EGGW	United Kingdom	London/ Luton	UK-IRELAND FAB
EGKK	United Kingdom	London/ Gatwick	UK-IRELAND FAB
EGLC	United Kingdom	London/ City	UK-IRELAND FAB
EGLL	United Kingdom	London/ Heathrow	UK-IRELAND FAB
EGPF	United Kingdom	Glasgow	UK-IRELAND FAB
EGPH	United Kingdom	Edinburgh	UK-IRELAND FAB
EGSS	United Kingdom	London/ Stansted	UK-IRELAND FAB
EHAM	Netherlands	Amsterdam/ Schiphol	FABEC
EIDW	Ireland	Dublin	UK-IRELAND FAB
EKCH	Denmark	Copenhagen/ Kastrup	DK-SE FAB
ENBR	Norway	Bergen	NEFAB
ENGM	Norway	Oslo/ Gardermoen	NEFAB
EPWA	Poland	Warszawa/ Chopina	BALTIC FAB
ESSA	Sweden	Stockholm/ Arlanda	DK-SE FAB
EVRA	Latvia	Riga	NEFAB
GCLP	Spain	Gran Canaria	SW FAB
LEAL	Spain	Alicante	SW FAB
LEBL	Spain	Barcelona	SW FAB
LEMD	Spain	Madrid/ Barajas	SW FAB
LEMG	Spain	Málaga	SW FAB
LEPA	Spain	Palma de Mallorca	SW FAB
LFBO	France	Toulouse-Blagnac	FABEC
LFLL	France	Lyon-Saint-Exupéry	FABEC
LFML	France	Marseille-Provence	FABEC
LFMN	France	Nice-Côte d’Azur	FABEC
LFPG	France	Paris-Charles-de-Gaulle	FABEC
LFPO	France	Paris-Orly	FABEC

LFSB	France	Bâle-Mulhouse	FABEC
LGAV	Greece	Athens	BLUE MED FAB
LHBP	Hungary	Budapest/ Ferihegy	FAB CE
LIMC	Italy	Milan/ Malpensa	BLUE MED FAB
LIME	Italy	Bergamo	BLUE MED FAB
LIML	Italy	Milan/ Linate	BLUE MED FAB
LIPZ	Italy	Venice	BLUE MED FAB
LIRF	Italy	Rome/Fiumicino	BLUE MED FAB
LKPR	Czech Republic	Prague	FAB CE
LOWW	Austria	Vienna	FAB CE
LPPR	Portugal	Porto	SW FAB
LPPT	Portugal	Lisbon	SW FAB
LROP	Romania	Bucharest/ Otopeni	DANUBE FAB
LSGG	Switzerland	Geneva	FABEC
LSZH	Switzerland	Zürich	FABEC

References

[1] UK Civil Aviation Authority, „AIR TRAFFIC SERVICES LICENCE FOR NATS (EN ROUTE) PLC," June 2018. [Online]. Available: https://www.caa.co.uk/uploadedFiles/CAA/Content/Standard_Content/Commercial_industry/Airspace/Air_traffic_control/Licences/NERL%20LICENCE%2015%20(Jun%2018).pdf .

[2] UK Civil Aviation Authority, „Project OBERON," [Online]. Available: publicapps.caa.co.uk/docs/33/20170731_Oberon_Report_NonCon_Redacted.pdf.

[3] Performance Review Commission (PRC), „Performance Review Report (PRR) 2018," available for consultation as of 22 March 2019.

[4] EUROCONTROL, Performance Review Unit, „ANS Performance Data Portal," [Online]. Available: http://ansperformance.eu/.

[5] STATFOR, „EUROCONTROL Forecast of Annual Number of IFR Flights (2017 - 2023)," http://www.eurocontrol.int/articles/forecasts, September 2017.

[6] EUROCONTROL, Performance Review Commission, „ATM Cost-Effectiveness (ACE) 2016 Benchmarking Report with 2017-2021 outlook," http://www.eurocontrol.int/publications/, 2018.

[7] EUROCONTROL, Network Manager, „European Network Operations Plan 2018-2022," [Online]. Available: https://www.eurocontrol.int/publications/european-network-operations-plan-2018-2022.

[8] EUROCONTROL, CRCO, „Service Unit Dashboard," [Online]. Available: http://www.eurocontrol.int/ServiceUnits/Dashboard/LongTermEvolution.html .

[9] EUROCONTROL, Network Manager, „European Network Operations Plan 2017-2019/21," [Online]. Available: http://www.eurocontrol.int/publications/european-network-operations-plan-2017-2021.

[10] EUROCONTROL, Performance Review Commission, „ATM Cost-Effectiveness (ACE) 2015 Benchmarking Report with 2016-2020 outlook," http://www.eurocontrol.int/publications/atm-cost-effectiveness-ace-2015-benchmarking-report-2016-2020-outlook, 2017.

[11] N. Manager, ATFCM Users Manual, EUROCONTROL, 2018.