



**PRR 2016**

# **Performance Review Report**

An Assessment of Air Traffic Management in Europe  
during the Calendar Year 2016

**Performance Review Commission**

June 2017

## Background

This report has been produced by the Performance Review Commission (PRC). The PRC was established by the Permanent Commission of EUROCONTROL in accordance with the ECAC Institutional Strategy 1997. One objective of this strategy is "to introduce a strong, transparent and independent performance review and target setting system to facilitate more effective management of the European ATM system, encourage mutual accountability for system performance..."

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## FOREWORD by the PRC Chairman



For almost 20 years, the independent Performance Review Commission (PRC) has been measuring pan-European ATM performance and making recommendations for improvements. The EUROCONTROL performance review scheme, which began in 1998, was a world-first at the time. Since then, elements have been adopted by ICAO and applied by States worldwide including China, Brazil and Singapore.

Closer to home, the European Commission built on the solid body of work produced by the PRC by establishing a performance scheme for the Single European Sky (SES).

The Commission designated the PRC, supported by the Performance Review Unit (PRU), as the first Performance Review Body (PRB) of the Single European Sky. This designation ended on 31 December 2016.

Thus, from 2017 onwards, the PRB will be a separate group designated by the European Commission.

To ensure that there are no overlaps between the PRC's tasks and those of the PRB, the PRC has agreed to a joint proposal made by EUROCONTROL and the European Commission on how the PRC's future tasks could complement those of the PRB and avoid duplication.

The PRC held a series of meetings with stakeholders in 2016 to listen to their needs and requirements. The purpose was to establish whether the usefulness of the PRC's main products – the annual Performance Review Report and the annual ATM Cost-effectiveness (ACE) Benchmarking report – could be further improved.

The dialogue with stakeholders has been effective and constructive and the PRC thanks all stakeholders concerned.

The PRC has listened and taken action. From now on, there will be improved PRC reporting. With the PRU in support, the PRC will continue to develop its web presence and publish short quarterly reviews, so that high level performance information is available more quickly. This will also help to slim-down the PRR and ACE reports, as a lot of information will become available online.

I hope that you find this approach, and this new-look PRR, even more useful for your requirements.

Should you wish to contact the PRC, you can find contact details on the inside-back cover of this report.

Pleasant reading!

A handwritten signature in black ink, reading 'Ralph Riedle'. The signature is written in a cursive, flowing style.

Ralph Riedle

Chairman

Performance Review Commission

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### SUMMARY

This report of the Performance Review Commission analyses the performance of the European Air Traffic Management System in 2016 under the Key Performance Areas of Safety, Capacity, Environment and Cost-efficiency.

### Keywords

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This report assesses the performance of Air Navigation Services (ANS) in the EUROCONTROL area for the calendar year 2016 for all key performance areas, except for cost-efficiency, which analyses performance in 2015 as this is the latest year for which actual financial data are available.



In 2016, air traffic in the EUROCONTROL area (ESRA08) continued to increase for the third year in a row. On average, the number of controlled flights increased by 2.4% compared to 2015. The main driver of the observed growth in 2016 was the growth in the intra-European low cost traffic segment. As in previous years, passenger numbers grew at a higher rate than traffic (+5.1% vs. 2015).

In 2016, annual traffic reached the pre-economic crisis level of 2008 and the third quarter in 2016 was the highest on record. Of the 39 Air Navigation Service Providers (ANSPs) included in the analysis, 25 showed an increase in traffic compared to 14 ANSPs which showed a decline in 2016. In absolute terms, ENAIRE (Spain), NATS (UK) and DSNA (France) experienced the highest year on year growth in 2016. DHMI (Turkey), UKSATSE (Ukraine) and ROMATSA (Romania) reported the highest absolute decrease in 2016.

The substantial traffic increase in some areas contributed to a decrease in overall service quality. The share of flights arriving within 15 minutes of their scheduled time decreased by 1.6 percent points to reach 81.5% in 2016.



Safety is the primary objective of ANS and overall safety levels in the EUROCONTROL area remain high. There was only one reported air traffic accident with direct ANS contribution in 2015, which is the latest year for which validated data are available.

In the EUROCONTROL area in 2016 the number of all key risk occurrence types (Separation minima infringements (SMIs), Runway incursions (RIs), Unauthorised Penetrations of Airspace (UPAs), and ATM Specific Occurrences) had increased. Overall, there were 15 SMIs and 28 UPAs per hundred thousand controlled flight hours in the airspace and less than one (0.9) RIs per ten thousand movements at airports reported in 2016.

The quality and completeness of safety data reported to EUROCONTROL increased over the past years but with scope for further improvement, particularly in terms of severity classification. Although this has been pointed out by the PRC on several occasions, 24% of the reported occurrences were still not severity classified in 2016, which is considerable increase comparing to 2015 (13%).

The PRC review of the implementation status of the Acceptable Level of Safety Performance (ALoSP) concept in EUROCONTROL Member States clearly suggested that there is a need for common definitions and guidance material in order to ensure a harmonised approach in the EUROCONTROL area.



The PRC's concern about over conservative capacity planning and the risk of performance deterioration when traffic grows again has been voiced on several occasions. In 2016, total en-route ATFM delays increased by 21% compared to 2015 and the share of flights affected by en-route ATFM delays increased from 3.9% to 4.8% in 2016.

ATC Capacity/Staffing related constraints remained by far the main driver of en-route ATFM delays (55.3%), followed by weather-related constraints (18.3%), ATC disruptions/ industrial actions (12.3%)

and Event related constraints (9.1%) which also include delays due to ATC system upgrades.

Three quarters of the en-route ATFM delays were generated by four air navigation service providers: DSN (41.6%), DFS (13.0%), Maastricht (11.4%) and ENAIRE (9%). The vast majority of Area Control Centres (ACCs) performed well in 2016, with notable improvements at Lisbon, Athens, and Zagreb ACCs. The most constraining ACCs in 2016 were Brest, Nicosia, Bordeaux, Brussels, Barcelona, Prestwick, Maastricht UAC, Warsaw, Canarias, Karlsruhe UAC and Marseille. Together, they accounted for 70.1% of all en-route ATFM delays but only 30.1% of total flight hours controlled in the EUROCONTROL area.

The reasons for the constraints varied by ACC and were in some cases exacerbated by the higher than expected traffic growth. In view of the number of planned major project implementations over the next years it is important to reiterate the message from last year's PRR that ANSPs need to effectively coordinate the planning and implementation of all changes to the ATM system that could adversely affect operations with the Network Manager.

Horizontal en-route flight efficiency in the EUROCONTROL area decreased slightly from 97.3% to 97.1% in 2016, after a continuous improvement over the past years.

The effects of ATC industrial action on specific days in 2016 are clearly visible but the overall impact on system wide flight efficiency remains within 0.03% points.

Despite a slight decrease in flight efficiency at system level in 2016, the benefits of Free Route Airspace (FRA) implementation and related reductions in fuel burn, emissions and costs are clearly visible in a number of Member States. On average, flight efficiency is 1.6% points better in Member States where FRA is fully implemented all day, and actual flown trajectories are notably closer to the filed flight plans.

Complementary to horizontal flight efficiency, an initial evaluation of vertical en-route flight efficiency in this year's PRR enabled clear differences on specific airport pairs to be identified. Work is in progress to better quantify the measured inefficiencies in terms of fuel burn and CO<sub>2</sub> emissions in the future.

Closer civil-military cooperation and coordination is an important enabler to improve capacity and flight efficiency performance. Some areas for further improvement identified in a PRC survey relate to the lack of impact assessment in terms of capacity and route options for restricted/segregated airspace and the absence of clear strategic objectives.



The analysis of the top 30 airports in terms of traffic showed that ten airports (Amsterdam, Istanbul Ataturk, London Gatwick, Stockholm Arlanda, Istanbul Sabiha Gökçen, Dublin, Berlin Tegel, Geneva, Lisbon and Warsaw) reported their highest traffic level on record, surpassing the levels observed before the economic crisis starting in 2008. Amsterdam reported a 5.9% increase in traffic in 2016 which made it the airport with the most commercial movements in Europe in 2016.

The two Istanbul airports, which reported a remarkable traffic growth over the past years, were affected by the situation in Turkey, resulting in a notable slowdown in traffic growth. Of the top 30 airports, six showed a traffic decrease in 2016 with the highest decrease observed for Brussels airport (-6.8% vs 2015) as a result of the reduced capacity following the terrorist attacks in March 2016.

The substantial traffic increase at some airports contributed to higher levels of operational inefficiency and resulted in somewhat higher additional times during descent and in the taxi-out phase compared to 2015.



Average airport arrival ATFM delay and additional holding (ASMA) time decreased slightly in 2016 at the top 30 airports but were still heavily concentrated among a few airports. Five airports (Istanbul Sabiha Gökçen, Istanbul Ataturk, Amsterdam, London Heathrow, and London Gatwick) accounted for 59% of the airport arrival ATFM delay reported for the top 30 airports. The situation in Istanbul is expected to improve with the opening of the first phase of the new Istanbul Airport which is scheduled for 2017/2018. Airport arrival ATFM performance at Amsterdam and the two London airports (LHR, LGW) was to a large extent affected by weather which required the available capacity to be reduced.

London Heathrow, Istanbul Ataturk and Istanbul Sabiha Gökçen all show up with continuously high arrival throughput close to the peak declared arrival capacity. Although this maximises the use of capacity, the high intensity operation close to maximum capacity can result in high delays and possibly cancellations when there is a mismatch between scheduled demand and the capacity that can be made available.

The group of smaller Greek airports reported in last year's report continued to generate high ATFM delays in 2016. The issue appears to be linked to scheduling and variability. It needs to be addressed proactively in order to avoid a repetition of high delays also in summer 2017. The PRC will be monitoring the situation which has persisted now for several years.

Whereas A-CDM implementation is considered to be an enabler to improve situation awareness and performance, it is important to ensure that the available information is used to improve local processes. A-CDM can also help to improve the data quality which is presently an issue for the measurement of ATC pre-departure delays.

Vertical flight efficiency in climbs and descents at the top 30 airports has been added as a new metric in this year's report. On average, inefficiencies were more than 6 times higher in descent than in climb with notable differences by airport.



In 2015, which is the latest year for which actual financial data are available, the en-route ANS unit costs of the Pan-European system amounted to 49.2 €<sub>2009</sub> per service unit (TSU). This is -2.4% lower than in 2014 since in 2015 the number of TSUs rose faster (+3.9%) than en-route ANS costs (+1.5%). En-route unit costs are expected to reduce by -1.8% p.a. over the 2015-2019 period and reach a value of 45.8 €<sub>2009</sub>. If these plans materialise, the en-route unit costs in 2019 will be some -24% lower than in 2009, implying substantial cost-efficiency improvements during this 10 year period.

In 2015, European terminal ANS unit costs amounted to 171.6 €<sub>2009</sub> per terminal service unit (TNSU) and are expected to decrease by -2.1% p.a. until 2019. This performance improvement reflects the fact that total terminal ANS costs are planned to reduce by -0.7% p.a. while TNSUs are expected to increase by +1.4% p.a. between 2015 and 2019.

Detailed ANSPs benchmarking analysis indicates that in 2015 gate-to-gate ATM/CNS provision costs slightly increased by +0.5% and amounted to some €8.1 Billion at Pan-European system level. At the same time traffic, expressed in terms of composite flight hours, rose by +1.7%. As a result, gate-to-gate unit ATM/CNS provision costs reduced in 2015 (-1.2% vs 2014).

In order to also consider the service quality provided by ANSPs, the gate-to-gate economic performance combines ATM/CNS provision costs and the cost of ATFM delays.

Although unit ATM/CNS provision costs decreased in 2015, unit economic costs increased by +3.2% to reach €501 per composite flight-hour reflecting a substantial increase in the unit costs of ATFM delays (+38.8% vs. 2014).

In fact, the trend of decreasing ATFM delays observed in previous years stopped in 2013, when a new cycle characterised by higher delays started.

The analysis provided in the operational en-route ANS performance chapter of this report indicates that this trend continued in 2016 since en-route ATFM delays were +20.9% higher than in 2015.

This implies that in 2016, the unit costs of delays will be significantly higher than in 2015 and will negatively affect ANSPs economic cost-effectiveness.

## PRC Recommendations 2016

Recommendation	Rationale for the recommendation
REC 1) The Provisional Council is invited <b>to request</b> States to task their airport operators to provide data on operations at the top thirty (30) airports in accordance with the required quality standards to ensure a harmonised approach towards ANS performance review.	<i>Although overall data quality has improved continuously over the past years, there is scope for further improvement in terms of completeness (data for a number of key airports like Istanbul are still not available) and quality (airport delay coding or data is not provided in the right format).</i>
REC 2) The Provisional Council is invited to request Member States and their ANSPs to support the PRC study to investigate the impact of the various pension schemes on EUROCONTROL Member States costs.	<i>Employment costs can be significantly affected by pension arrangements. This issue requires the utmost attention given the long term consequences of pensions-related decisions and their magnitude in the cost bases and impact on unit costs.</i>



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## 1 Introduction and context

### 1.1 About this report

[Air Navigation Services \(ANS\)](#) are essential for the safety, efficiency and sustainability of civil and military aviation, and to meet wider economic, social and environmental policy objectives.

The purpose of the independent Performance Review Commission (PRC) is “*to ensure the effective management of the European Air Traffic Management system through a strong, transparent and independent performance review*”, per Article 1 of its Terms of Reference [Ref. 1]. More information about the PRC is given on the inside cover page of this report.

This Performance Review Report (PRR 2016) has been produced by the PRC with its supporting unit the Performance Review Unit (PRU). Its goal is to provide policy makers and ANS stakeholders with objective information and independent advice concerning the performance of European ANS in 2016, based on analysis, consultation and information provided by relevant parties. It also gives some information on other PRC activities in 2016.

As in previous years, stakeholders were given an opportunity to comment on PRR 2016 before it was finalised. The PRC sent the draft final Report to stakeholders, and posted it on the EUROCONTROL internet site, for consultation and comment from 17 March – 07 April 2017.

On the basis of PRR 2016, the PRC will provide independent advice on ANS performance and propose recommendations to the EUROCONTROL States.

The PRC’s recommendations can be found in the Executive Summary.

#### 1.1.1 Further PRC work

In addition to the PRR which provides an independent holistic view of ANS performance in all EUROCONTROL Member States across all key performance areas, the PRC work focuses on tasks complementary to those of the Performance Review Body of the Single European Sky performance scheme. They include:

- production of annual [ATM cost-effectiveness \(ACE\) Benchmarking reports](#) which present yearly factual data and analysis on cost-effectiveness and productivity for Air Navigation Service Providers (ANSPs) in Europe;
- involvement in international benchmarking studies to foster discussions on how to improve the air navigation system for the benefit of all users and to support the International Civil Aviation Organization (ICAO) in establishing common principles and related guidance material for ANS performance benchmarking;
- provision of in-depth analysis and independent ad-hoc studies on ATM performance either on the PRC’s own initiative or at the request of interested parties;
- basic R&D into the development of performance measurement;
- investigation of how performance could be best described/measured in the long-term;
- development of possible future performance indicators and metrics; and,
- identification of future improvements in performance.

In order to allow easier access and to make information available more quickly, the PRC has developed its online reporting tools.

More information on the PRC quarterly online ANS performance review as well as information on studies, performance methodologies and data for monitoring ANS performance in the EUROCONTROL area is available online at: <http://www.ansperformance.eu/prcq>.

### 1.1.2 Report scope and structure

Unless otherwise indicated, PRR 2016 relates to the calendar year 2016 and refers to ANS performance in the airspace controlled by the 41 Member States of EUROCONTROL (see Figure 1-1), here referred to as “[EUROCONTROL area](#)”.

In 2016, EUROCONTROL signed agreements with Israel and Morocco with a view to fully integrating the two States into the agency’s working structures and also to include them in future performance reviews.

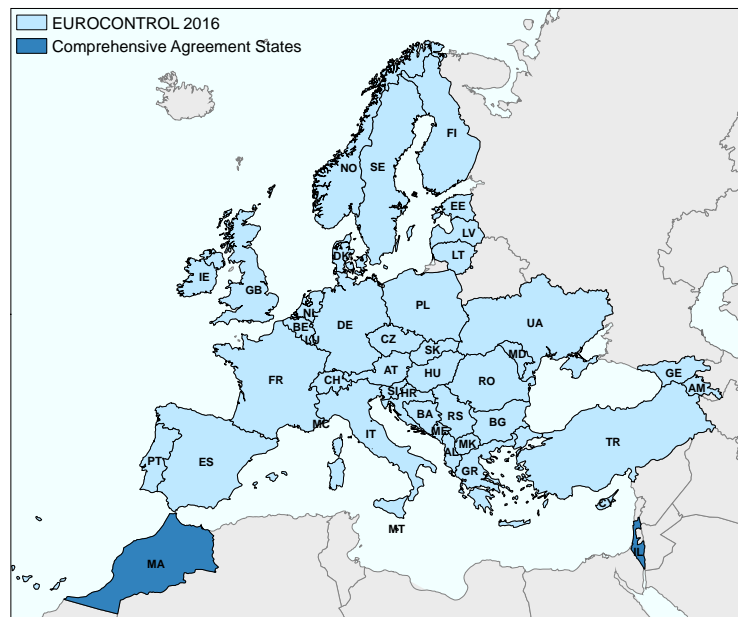


Figure 1-1: EUROCONTROL States (2016)

PRR 2016 addresses the Key Performance Areas: Capacity, Cost Effectiveness, Efficiency, Environmental sustainability and Safety.

It is organised in five chapters:

- **Chapter 1- Introduction and context:** General context including a high level review of air traffic demand and punctuality trends in the EUROCONTROL area.
- **Chapter 2 – Safety:** Review of Safety ANS performance in terms of accidents, ATM-related incidents and the level of safety occurrence reporting in the EUROCONTROL area.
- **Chapter 3 - En-route ANS performance:** Review of operational en-route ANS performance (ATFM delays, en-route flight efficiency), including a detailed review of the most constraining ACCs in 2016.
- **Chapter 4 - ANS performance @ airports:** Review of the operational ANS Performance of the top 30 airports in terms of traffic in 2016.
- **Chapter 5 - ANS Cost-efficiency:** Analysis of ANS cost-efficiency performance in 2015 (the latest year for which actual financial data were available) and performance outlook, where possible.



Although there is no dedicated Environmental chapter in this year’s PRR, the PRC acknowledges that sustainable development is an important political, economic and societal issue and the aviation industry has a responsibility to minimise its global and local environmental impact.

In PRR 2016, the environmental component of ANS performance is addressed indirectly in Chapters 3 and 4 as it is closely linked to operational performance (ANS-related inefficiencies in terms of fuel and CO<sub>2</sub> emissions).

The environmental impact of ANS performance can generally be divided into the impact on: (1) global climate, (2) local air quality, and (3) noise at airports. The PRC is presently evaluating possibilities how to better address the ANS-related contribution towards environmental sustainability in future publications.



## 1.2 European air transport key indices

On average, air traffic in the EUROCONTROL area ([ESRA08](#)) continued to increase for the third year in a row in 2016 and reached the pre-economic crisis level of 2008.

At system level, air traffic increased by 2.4% which corresponds to an additional 681 flights per day on average.

The observed growth corresponds to the baseline forecast scenario (+2.4%) predicted for the ESRA08 area in the STATFOR 7-year forecast - Feb. 2016 [Ref. 2].

Figure 1-3 shows the change compared to 2015 in terms of flight type, traffic segment, flight distance and flight hours.

The main driver of the observed 2.4% traffic growth in 2016 was the growth in the intra-European low cost traffic segment ([STATFOR](#) definition).

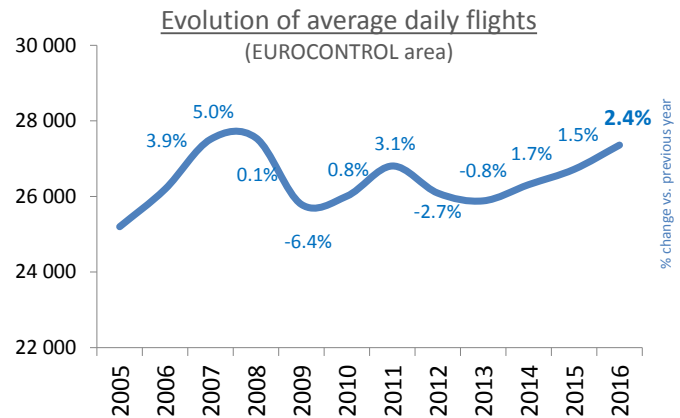
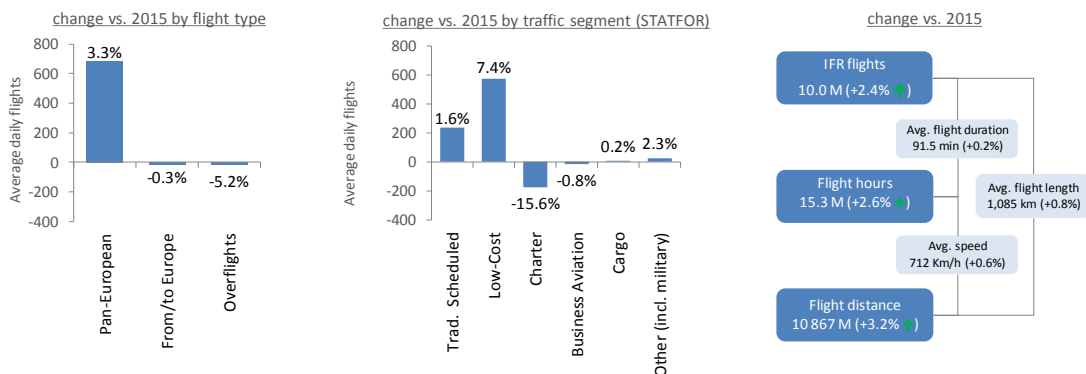


Figure 1-2: Evolution of average daily flights



Source: STATFOR

Figure 1-3: Year on year change versus 2015

Flight hours (+2.6% vs 2015) and distance (+3.2%) grew at a higher rate than flights in the EUROCONTROL area which suggests an increase in average flight distance and also in average speed in 2016.

Peak traffic load continued to rise at a higher rate than average traffic in 2016 and the 3rd quarter in 2016 was the highest on record.

September 9<sup>th</sup> 2016 was the peak day in 2016 with 34,024 flights. It was also the 2nd highest on record (27 June 2008).

The highest growth compared to 2015 was observed in Portugal (+10.5%), Ireland (7.5%), Spain (+7.5%) and Poland (+7.3%).

The most notable traffic decreases in 2016 were in Ukraine (-9.0%), Moldova (-8.3%), Armenia (-7.8%) and Albania (-7.8%).

Traffic growth at [Area Control Centre \(ACC\)](#) level is analysed in more detail in Chapter 4.

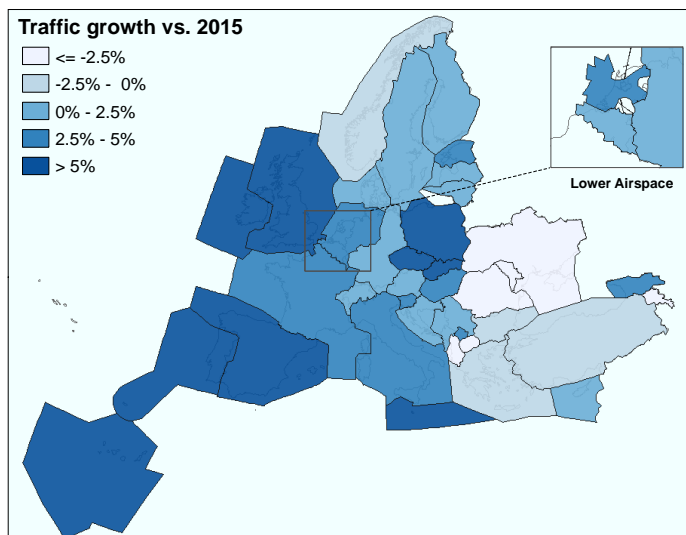


Figure 1-4: Traffic growth by Air Navigation Service Provider

Although the relationship between “traffic complexity” and ANS performance in general is not straightforward, complexity is generally a factor to be taken into account when analysing ANS performance. High density can lead to a better utilisation of resources but a high structural complexity entails higher ATCO workload and potentially less traffic.

The annual complexity score shown in Figure 1-5 combines traffic density (concentration of traffic in space and time) and the intensity of potential interactions between traffic (structural complexity).

In the EUROCONTROL area the complexity score increased further in 2016 and reached 6.9 minutes of potential interactions with other aircraft per flight hour in the airspace.

As can be expected, the highest complexity scores are observed in the core area with scores notably higher than the EUROCONTROL area average. In Figure 1-5, the complexity score is shown as an annual average and, subject to the level of seasonality in the area, the complexity score may be notably higher during peak months. More information on the methodology and more granular data are available from the [ANS performance data portal](#).

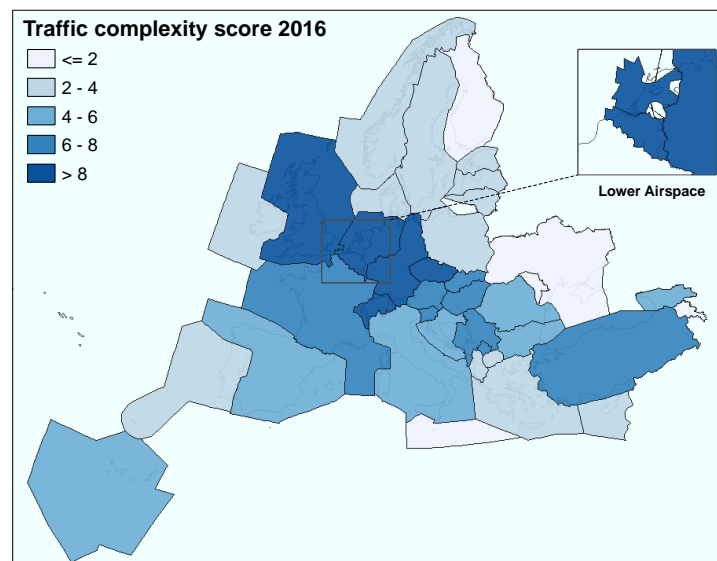


Figure 1-5: Traffic complexity score (2016)

Traffic variability can also affect performance if not addressed with appropriate measures. It can be characterised as temporal (seasonal, daily, hourly) and spatial (location of traffic in an airspace) variability. Figure 1-6 provides an indication of the seasonality by comparing the peak week to the average week in 2016.

High seasonality is traditionally observed for the classical holiday destinations in the South.

If traffic is highly variable and there is limited flexibility to adjust the capacity provision according to actual traffic demand, the result may be poor service quality or an underutilisation of resources.

If addressed proactively, traffic variability can be mitigated or resolved to a certain degree by utilising previous experience. If demand is higher at weekends than during weekdays, then it is possible to roster staffing levels to suit.

Similarly, if demand is higher during certain periods, for example July and August, then it is possible to make more operational staff available by reducing ancillary tasks performed by ATCOs during the peak period.

Hence, traffic variability and complexity is therefore a factor that needs to be carefully managed as it may have an impact on productivity, cost-efficiency, and the service quality provided by air navigation service providers.

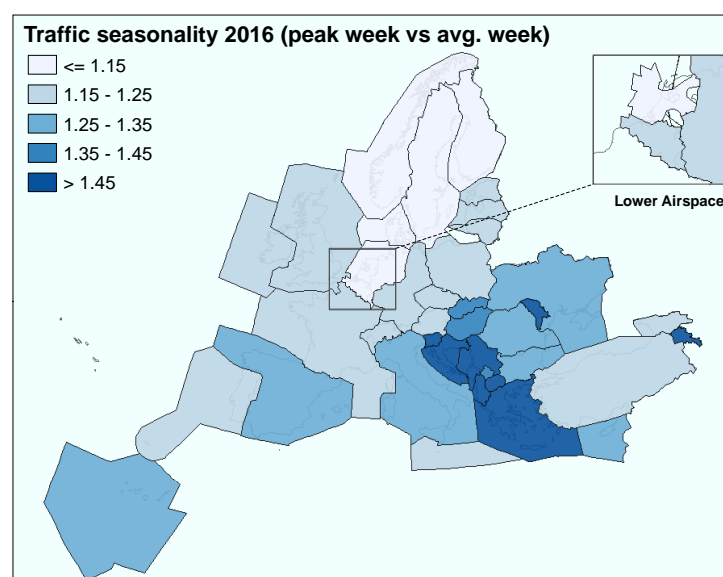


Figure 1-6: Traffic seasonality (2016)

Figure 1-7 shows the evolution of European IFR flights ([ESRA08](#))<sup>1</sup> since 1990 together with selected traffic forecasts<sup>2</sup>.

The (Feb. 2017) [STATFOR](#) 7-year forecast [Ref. 3] has been revised upwards and predicts European flights (ESRA08) to grow by 2.8% in 2017 (Low: 1.4%; High 4.1%).

The average annual growth rate (AAGR) between 2015 and 2023 is forecast to be at 1.9% (Low: 0.5%; High 3.4%).

Despite the stagnation following the economic crisis, air traffic demand in Europe is expected to reach 11.6 million flights by 2023 which is 14% more than in 2016.

Figure 1-8 shows the evolution of European air traffic indices<sup>3</sup> between 2008, the year (with the highest recorded traffic levels before the start of the economic crisis) and 2016.

The trend already observed over the past years continued also in 2016. Average distance and take-off weight grew at a higher rate than the number of flights leading also to a higher growth of en-route service units<sup>4</sup>.

The high passenger load factors reported over the past years also continued in 2016 and passenger numbers continued to outpace the growth in flights.

The continued traffic growth over the past three years contributed to a decline of service quality.

The share of arrivals within 15 minutes of scheduled

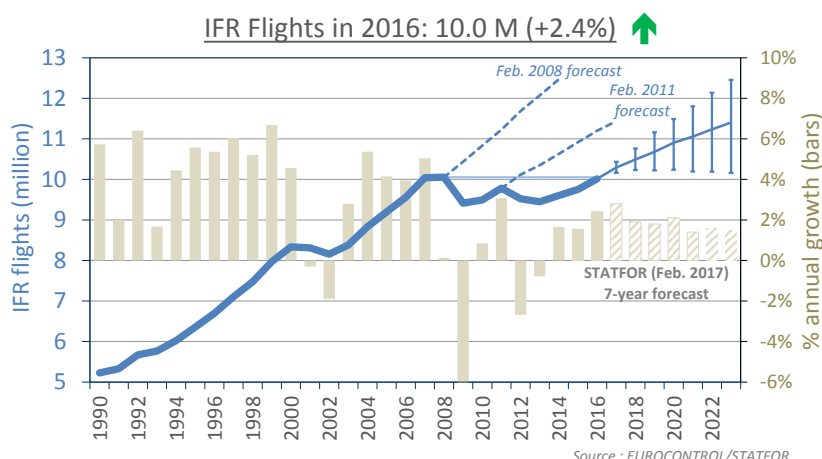


Figure 1-7: Evolution of European IFR flights (1990-2022)

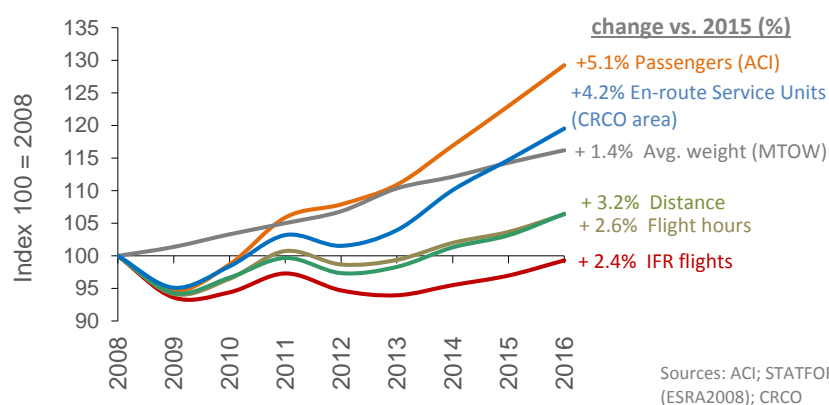


Figure 1-8: European air traffic indices (2008-2016)

#### Share of arrivals within 15 min of scheduled time

80.5% of arrival were punctual (-1.6% pt. vs 2015)

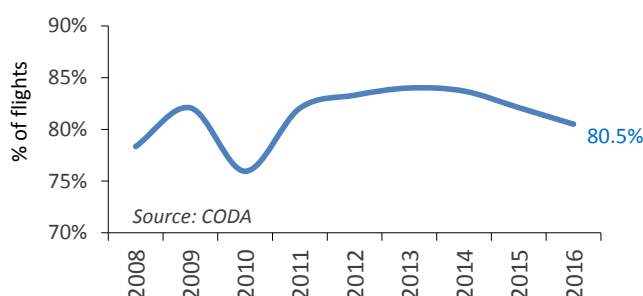


Figure 1-9: Evolution of arrival punctuality

<sup>1</sup> European Statistical Reference Area defined by the EUROCONTROL Statistics and Forecast Service (STATFOR).

<sup>2</sup> STATFOR 2008 forecast (before the economic crisis), STATFOR 2011 forecast (before the start of the SES performance scheme), and the latest available STATFOR Feb. 2017 forecast.

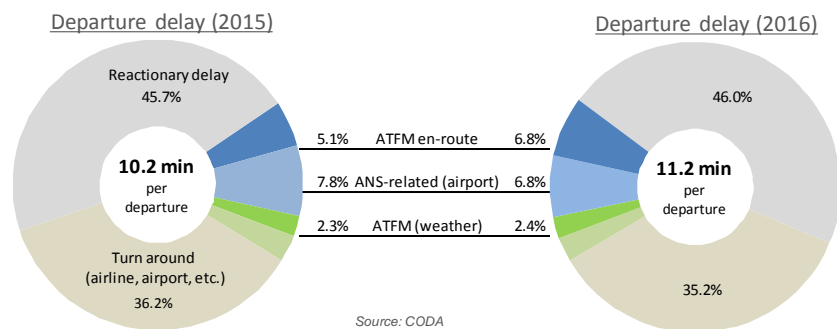
<sup>3</sup> Note that the individual indices can refer to slightly different geographical areas.

<sup>4</sup> Used for charging purposes based on aircraft weight factor and distance factor.

time decreased for the third consecutive year. In 2016, 80.5% of arrivals were punctual, a decrease of 1.6% points compared to 2015.

Average departure delay per flight increased from 10.2 minutes to 11.2 minutes per departure in 2016.

Reactionary delay originating from previous flight legs continued to be the main delay cause followed by turn around delays.



**Figure 1-10: ANS contribution towards departure total departure delays**

The network sensitivity<sup>5</sup> to primary delays increased from 0.84 to 0.85 leading to an increase in reactionary delays in relative terms in 2016.

The ANS contribution increased due to en-route traffic flow measures and ATFM weather related delays in 2016 but decreased for airport ANS related performance. A thorough analysis of non-ANS related delay causes is beyond the scope of this report. A more detailed analysis of departure delays reported by airlines is available from the [Central Office for Delay Analysis \(CODA\)](http://www.eurocontrol.int/coda)<sup>6</sup>.

After this outline of key air transport trends in the EUROCONTROL area, the following chapters will provide a detailed analysis of ANS performance in the areas of Safety (Chapter 2), Operational ANS en-route performance (Chapter 3), ANS performance at airports (Chapter 4) and ANS Cost-efficiency (Chapter 5).

<sup>5</sup> Reactionary delay for each minute of primary delay.

<sup>6</sup> The Central Office for Delay Analysis (CODA) publishes detailed monthly, quarterly, and annual reports on more delay categories (see <http://www.eurocontrol.int/coda>).



## 2 Safety

SYSTEM TREND (AST REPORTING)	2015	2016(P)	Trend	% change
<b>Accidents and incidents</b>				
<i>Total number of reported Accidents with ATM Contribution</i>	1	0	↓	-100
<i>Total number of reported Severity A+B</i>	728	727	↓	~0.0
<i>Total number of reported ATM incidents</i>	23 654	24 943	↑	5.4
<i>Occurrences not severity classified</i>	13%	24%	↑	89.3
<b>Separation Minima Infringements (SMI)</b>				
<i>Total number reported</i>	2 338	2 421	↑	3.6
<i>Total number of reported Severity A+B</i>	241	302	↑	25.3
<b>Runway incursions (RI)</b>				
<i>Total number reported</i>	1 397	1 624	↑	16.2
<i>Total number of reported Severity A+B</i>	94	97	↑	3.2
<b>Unauthorised penetration of airspace (UPA)</b>				
<i>Total number reported</i>	4 392	4 638	↑	5.6
<i>Total number of reported Severity A+B</i>	88	77	↓	-12.5
<b>ATM Specific Occurrences</b>				
<i>Total number reported</i>	16 648	17 653	↑	6.0
<i>Total number of reported Severity AA+A+B</i>	453	322	↓	-30.5

### 2.1 Introduction

This chapter reviews the Air Navigation Services (ANS) safety performance of the EUROCONTROL Member States between 2007 and 2016 (note that 2016 data is only preliminary).

Sections 2.2 and 2.3 in this Chapter show the trends in ANS-related accidents and incidents in the EUROCONTROL area. Section 2.4 provides an analysis of the current status of safety data reporting and investigation in EUROCONTROL Member States while Section 2.5 addresses acceptable Levels of Safety Performance (ALoSP).

The review of ANS safety performance in this chapter is based on accident and incidents data reported to EUROCONTROL via the [Annual Summary Template \(AST\)](#) reporting mechanism and complemented with additional sources of information when necessary.

Since 1997, the PRC has used data from the AST reporting mechanism for the analysis of accidents and incidents. Complementary to the AST data, from 2013 to 2016, the PRC has also analysed safety data using the European Central Repository (ECR) safety occurrence database, on a trial basis. However, in this year's report, the review of ANS safety performance is again entirely based on data reported via the AST reporting mechanism as it is presently considered to be complete as it covers all Member States.

### 2.2 Accidents

Safety is clearly the primary objective of ANS. However, not all accidents can be prevented by ANS and there are a number of accidents without ANS involvement.

Figure 2-1 shows the total number of air traffic accidents in the **EUROCONTROL area** between 2011 and 2016, based on AST data submitted by the EUROCONTROL Member States. The data was cross checked and supplemented with the available information from the ICAO Accident/Incident Data Reporting (ADREP).

The analysis covers accidents involving aircraft above 2,250 kg Maximum Take-Off Weight (MTOW), irrespective of whether the ATM domain contributed to the event or not.

In 2016, based on preliminary data, there were 67 accidents in the EUROCONTROL area (over 35% decrease comparing to 2015) out of which 15 were fatal. This represents approximately 22% of the total accidents.

The majority of ANS-related accidents between 2014 and 2016 were related to 'Collisions on the ground between aircraft and vehicle/person/obstruction' and Controlled Flight into Terrain (CFIT).

Almost three quarters of the reported accidents were put in the category 'Other' hence the real picture might be different if these were coded differently.

To improve this situation in the future, the EUROCONTROL DPS/SSR Safety Analysis Team will provide further support to Member States in order to improve the quality of accident coding in the national databases.

#### Total air traffic accidents - fixed wing, weight >2250kg MTOW) (EUROCONTROL area)

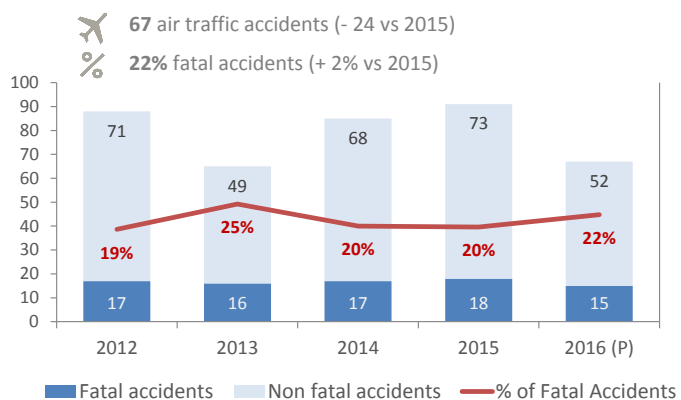


Figure 2-1: Accidents in EUROCONTROL area (2012-16P)

#### Risk Distribution in the EUROCONTROL area (2012-2016P)

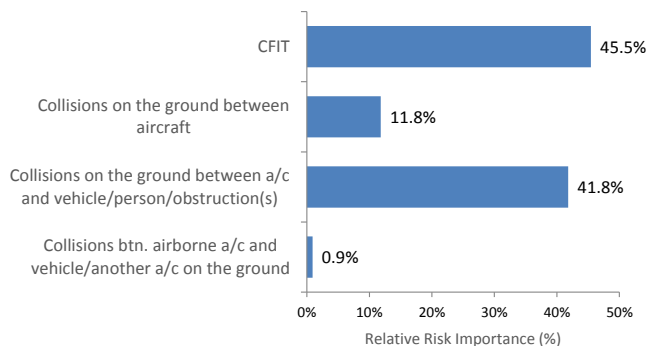


Figure 2-2: Accidents risk distribution (2012-16P)

### 2.2.1 Air traffic accidents with ATM Contribution

There was only one reported accident with direct ATM contribution in 2015, which was a non-fatal ground collision.

In 2016 (based on preliminary data) there were no reported accidents with direct<sup>7</sup> or indirect<sup>8</sup> ATM contribution.

### 2.3 Incidents

This section provides a review of ATM-related incidents, reported through the EUROCONTROL AST reporting mechanism. The PRC has made use of, with gratitude,

#### Accidents with ATM contribution - fixed wing, weight >2250kg MTOW) (EUROCONTROL area)

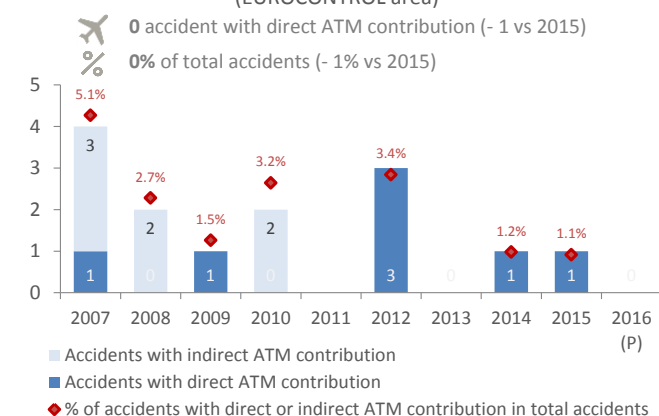


Figure 2-3: Accidents with ATM contribution in the EUROCONTROL area (2007-16P)

<sup>7</sup> Where at least one ATM event or item was judged to be DIRECTLY in the causal chain of events leading to an accident or incident. Without that ATM event, it is considered that the occurrence would not have happened.

<sup>8</sup> Where no ATM event or item was judged to be DIRECTLY in the causal chain of events leading to an accident or incident, but where at least one ATM event potentially increased the level of risk or played a role in the emergence of the occurrence encountered by the aircraft. Without such ATM event, it is considered that the accident or incident might still have happened.



the data provided by the EUROCONTROL DPS/SSR Unit and EUROCONTROL Safety Regulation Commission (SRC) Annual and intermediate Reports [Ref. 4]. As opposed to the accident analysis, there is no MTOW limit (2,250 kg) for the ATM-related incidents.

The analysis concentrates on the several key risk occurrence types, namely: separation minima infringements (SMIs), runway incursions (RIs), airspace infringements (AIs)/unauthorised penetrations of airspace (UPAs), and ATM Specific Occurrences (ATM-S).

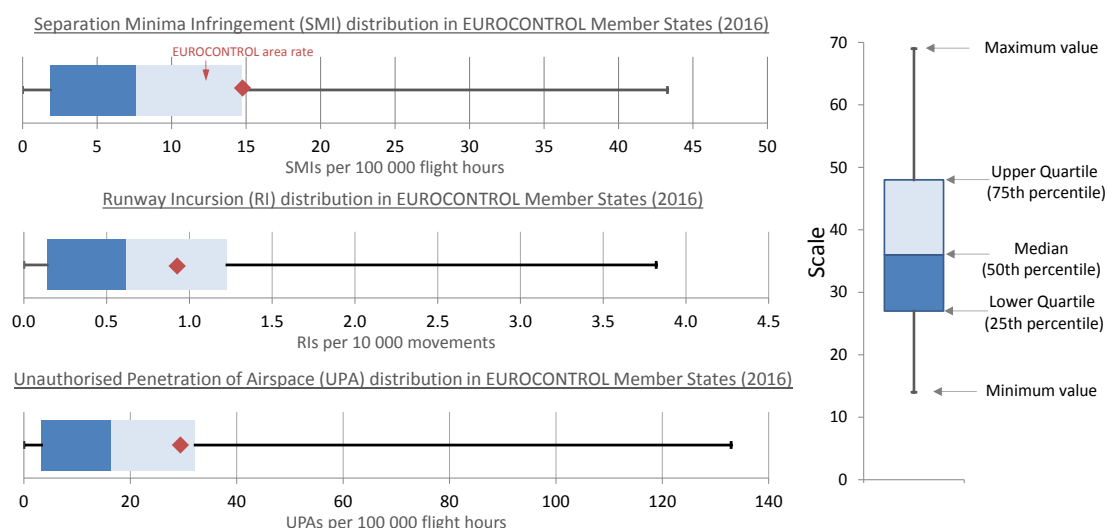
Overall, based on the AST reports submitted by 39 EUROCONTROL Member States, there was a 5.4% increase in the total number of incidents reported in comparison with 2015.

Table 2-1 shows the EUROCONTROL area overall occurrence rates (as reported by all 39 reporting States) for SMI, RI and UPAs in 2016.

**Table 2-1: Occurrence rates (SMI, RI, UPA) in the EUROCONTROL area (2016)**

2016	Rate of SMIs (per 100,000 flight hours)	Rate of RIs (per 10,000 movements)	Rate of UPAs (per 100,000 flight hours)
EUROCONTROL Area	15	0.9	28

Figure 2-4 shows the underlying distribution of occurrence rates of all 39 reporting EUROCONTROL Member States for three categories of occurrences SMI, RI and UPAs compared to the EUROCONTROL area overall rate.



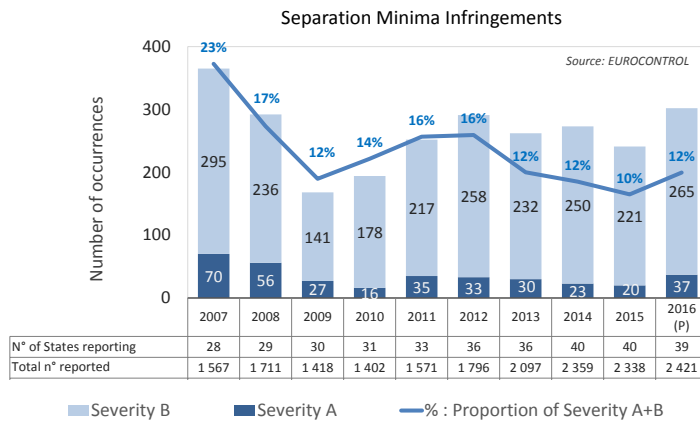
**Figure 2-4: Occurrence rates EUROCONTROL area (2016)**

In 2016 (based on preliminary data), the EUROCONTROL area SMI rate was approximately 15 SMI per 100 000 flight hours (the same as in 2015) with a few States having a very high SMI occurrence rate (4 States are above the 90<sup>th</sup> percentile). A similar picture can be observed for RIs and UPAs. The distribution is skewed with a small number of States with high occurrence rates compared to the rest of the States.

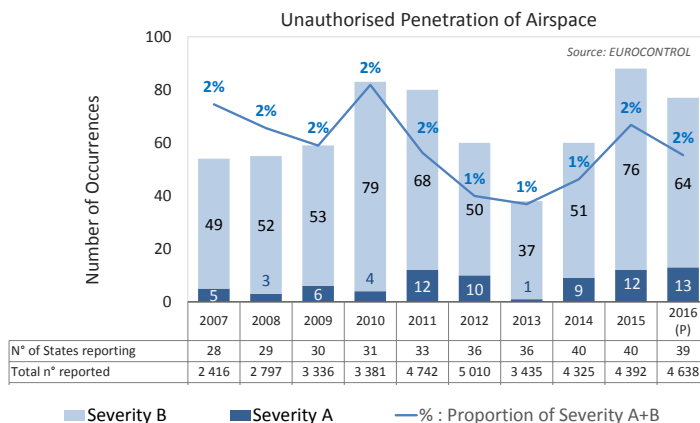
At EUROCONTROL level, there was less than 1 reported RI per 10,000 movements in 2016 (slight increase from 0.8 in 2015 to 0.9 in 2016). For UPAs, the occurrence rate was approximately 28 reported UPAs per 100,000 flight hours in 2016 (the same as in 2015).

However, similarly to the rate of SMIs, the rate of UPAs shows substantial differences among Member States; and few States have extremely high UPA rates (2 States are above 90<sup>th</sup> percentile).

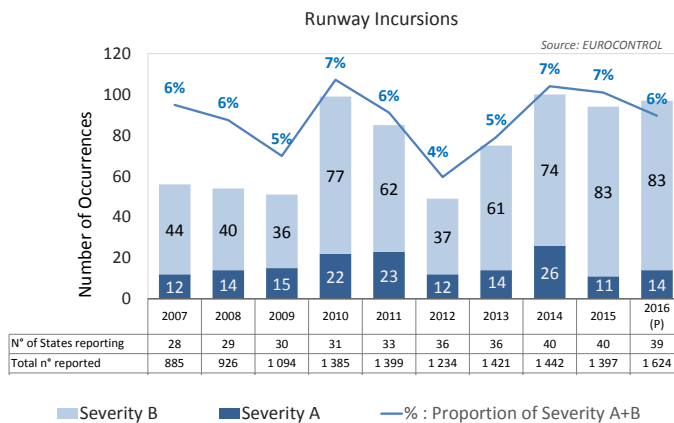
The next four figures illustrate the trends of SMI, RI, UPAs, and ATM-S occurrences in the period 2007-2016 (preliminary), detailing the evolution of the number of reporting States, the total number of occurrences reported per each category and especially the evolution of risk-bearing (Severity AA/A and Severity B) occurrences in each figure.



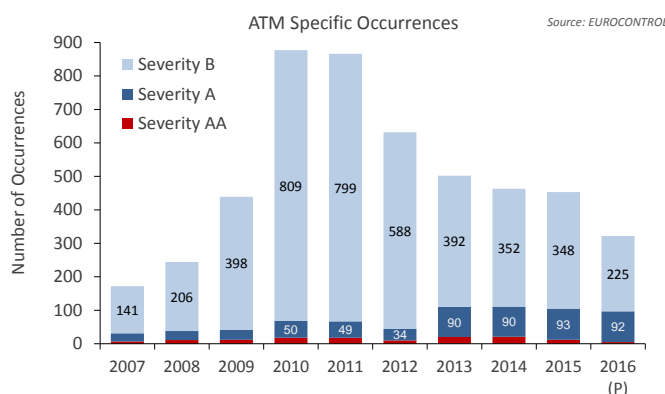
**Figure 2-5: Reported high-risk SMIs (EUROCONTROL)**



**Figure 2-6: Reported high-risk UPAs (EUROCONTROL)**



**Figure 2-7: Reported high-risk RIs (EUROCONTROL)**



**Figure 2-8: Reported high-risk ATM Spec. Occurrences (EUROCONTROL)**

With an increase in traffic, the number of reported risk bearing SMIs (Severity A+B) increased in 2016 from 241 to 302.

Overall, 12% of all SMI occurrences reported in 2016 were categorised as risk bearing occurrences which is 2% more than in 2015.

The number of risk bearing UPA occurrences (Severity A+B) decreased from 88 to 77 in 2016.

Nevertheless, the share of risk bearing UPA occurrences in the total reported UPAs increased stayed the same at 2% in 2016.

The reported risk bearing RIs (Severity A+B) increased slightly from 94 to 97 in 2016.

However, at the same time, the share of risk bearing RIs decreased to 6% of the total reported RI occurrences in 2016.

The total number of risk bearing ATM specific occurrences decreased significantly from 453 to 322 in 2016 (-30.5%).

At the same time, the total number of reported ATM Specific Occurrences increased by 6% in 2016.

## 2.4 Reporting and Investigation

This section provides a review of the quality and completeness of ATM-related occurrences (operational and ATM specific occurrences) reported through the AST mechanism, updated in March 2017 based on the preliminary 2016 data.

### 2.4.1 Total number of reported occurrences

The preliminary 2016 data were received from 39 EUROCONTROL Member States (one State did not submit data in this year cycle).

The number of reported occurrences increased by 5.4% in 2016.

Nevertheless, the available data does not allow conclusions to be drawn if the observed year-on-year change represents a genuine safety performance variation or if it is due to different reporting levels.

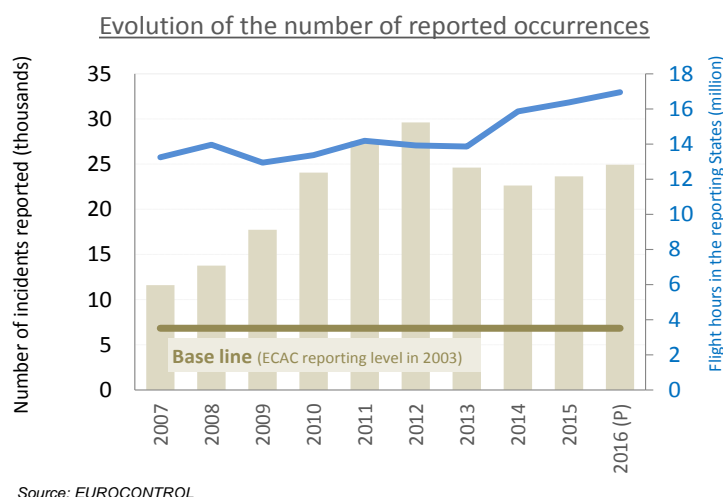


Figure 2-9: Reported occurrences (2007-2016P)

### 2.4.2 Unclassified or undetermined occurrences

Figure 2-10 shows the number of ATM-related incidents not severity classified or with severity classification not determined (Severity D) for different occurrences categories. The analysis is based on the data submitted via AST in April 2016, covering the reporting year 2015 (final) and 2016 (preliminary).

In 2015, 13% of reported occurrences were still not severity classified. If the occurrences where the severity is “not determined” are added (i.e. insufficient data provided to fully assess the severity), the percentage rises to just above 18%.

In 2016, based on preliminary data, 24% of reported occurrences were not severity classified, while this percentage rises to almost 30% if “not determined” category (i.e. some data provided but not enough to fully assess the severity) is added.

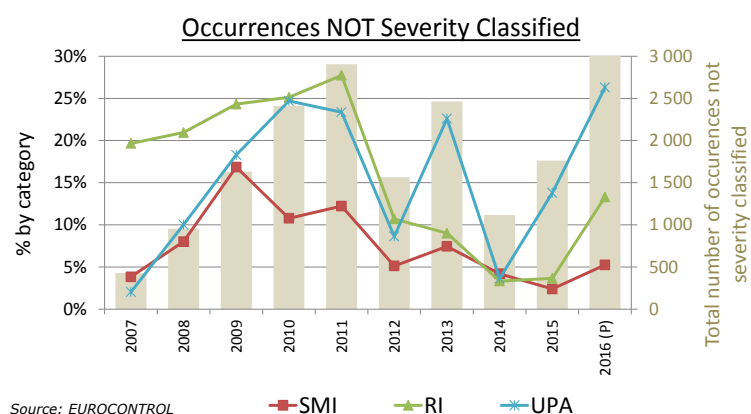


Figure 2-10: Severity not classified or not determined (2007-2016P)

Considering each type of occurrence separately (not just SMIs, RIs and UPAs), the percentage varies between 5% and 70%. If the occurrences where the severity is “not determined” are also included, the range increases to 7% and 75% of total number of reported occurrences in each occurrence category.

A considerable increase of the percentage of occurrences not severity classified for all types of occurrences is visible in 2016 (although to be noted that it is based on preliminary data). Considering the fact that the application of the severity classification based on the Risk Analysis Tool (RAT)

methodology to the reporting of occurrences is a key safety performance indicator of the Single European Sky (SES) Performance Scheme, further actions are needed to ensure the gap is closed.

As already pointed out in several previous reports, the situation needs to be monitored as the quality and completeness of safety data can impact the outcome of the analysis at European and national level, the sustainability of the human reporting system<sup>9</sup> and can also have other potential downstream repercussions such as the inadequate prevention of similar incidents or inadequate sharing and dissemination of lessons learned.

### 2.4.3 Completeness of safety data

Figure 2-11 shows the typical fields that are either left blank or marked *Unknown* in the AST, submitted by the EUROCONTROL Member States. The one of special concern for ATM safety performance is *ATM Contribution* field, which is undetermined in almost 35% of reports (increase from 24% in 2015).

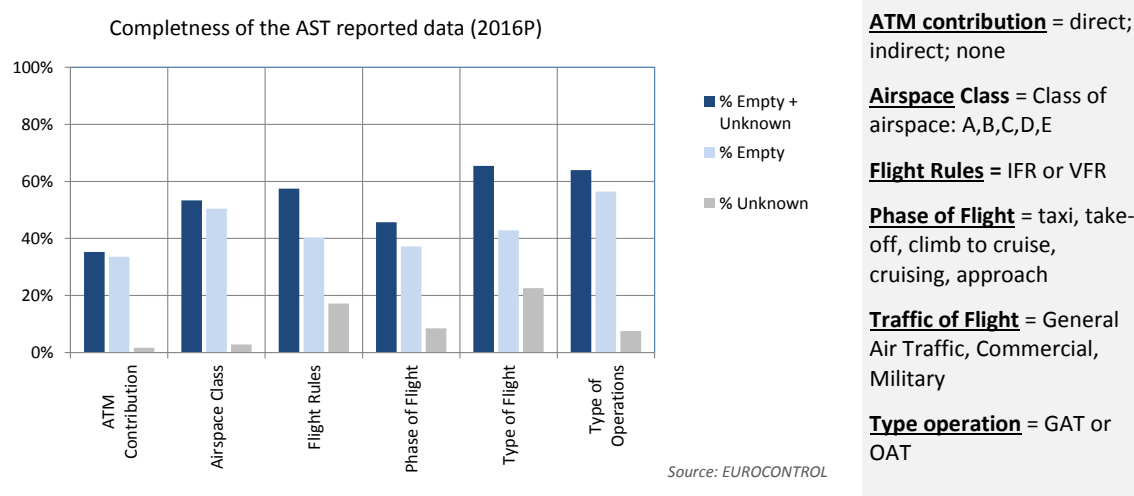


Figure 2-11: Completeness of AST reported data in 2016(P)

It is of concern that a large share of the data required to populate a number of fields is still missing. This lack of completeness of AST data hampers comprehensive safety analysis at European level.

## 2.5 Acceptable Level of Safety Performance (ALoSP)

In last year's PRR (June 2016) [Ref. 5], the PRC raised the concern that the definition and guidance on the development of the [Acceptable Level of Safety Performance \(ALoSP\)](#) concept (as defined by ICAO) is currently not available in Europe.

As the ICAO requirements for ALoSP leave room for interpretation in choosing the best way to implement the concept, the EUROCONTROL Member States could demonstrate leadership in filling such a gap by developing a harmonised approach. A common approach to measuring and managing safety performance will ultimately ensure a harmonised implementation of State Safety Programmes (SSPs) and facilitate the exchange of safety information in the future.

Due to the importance of this issue, and to achieve a deeper and more comprehensive understanding of the ALoSP concept and its implementation among EUROCONTROL Member States, the Provisional Council (PC) of EUROCONTROL, at its 45th Session (June 2016) therefore requested the PRC to review the implementation status of the ALoSP and to report back to the PC/47 (June 2017).

An online survey was distributed to all EUROCONTROL Member States in December 2016 to get a more comprehensive understanding of the ALoSP concept and its implementation in EUROCONTROL

<sup>9</sup> When ATCOs or pilots provide safety reports, if feedback is not provided it can have an adverse impact on the motivation to report.

Member States, in terms of concept definition, scope, and implementation challenges. Emphasis was put on the state level and the concept introduction within SSPs.

A complete response to the ALoSP survey was received from 26 EUROCONTROL Member States, a response rate of 63%. To complement survey responses (responses provided by the states which present their self-assessment) extensive desktop research was carried out to validate the received responses and to acquire missing information wherever possible (collecting information for states that have not responded to the survey or that have omitted certain questions). For six (6) EUROCONTROL Member States it was not possible to determine neither SSP nor ALoSP implementation levels using publicly available information (Albania, Cyprus, Lithuania, Moldavia, Monaco, and Ukraine). Those states were therefore, not included in the results of ALoSP implementation analysis.

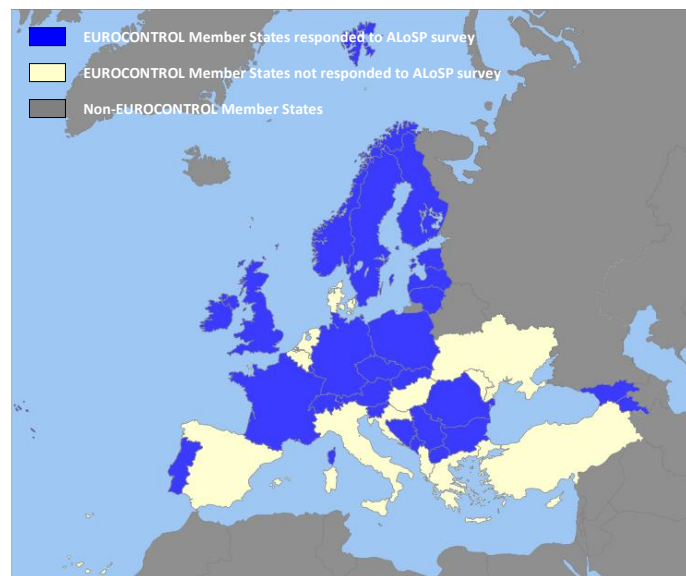


Figure 2-12: Geographical coverage of states responding to the survey

In summary, using all available information (survey responses plus additional desktop analysis) the analysis covered 85% of EUROCONTROL Member States (35 out of 41 states) which is considered to be a representative coverage for the study.

In general, the results of the analysis show that the ALoSP implementation is still an on-going process. Forty (40%) percent of the states (for which information was available) have not established the ALoSP concept, whilst an additional 40% have established it only partially. This means that 80% of EUROCONTROL Member States will still have to work hard to meet the ICAO 2017 target – i.e. to have their SSP and hence ALoSP implemented. In many cases, it was also clear that this target will not be met. The low implementation levels of ALoSP are not surprising, bearing in mind that the overall SSP implementation is still an open issue (SSP being only partially established or have not established at all).

The results of the analysis suggest that even states with an advanced SSP implementation level do not necessarily have a fully established ALoSP in accordance with ICAO requirements. In addition, the analysis also shows that ATS complexity (simply defined) does not necessarily impact the level of ALoSP implementation as originally suspected and that states with mature SSPs have similar problems with the implementation of ALoSP compared to those that are only at the beginning of the process. The maturity of the SSP did not eliminate the basic challenges. In other words, states with different complexities (and size) are facing common implementation challenges and the problems in terms of definition and implementation of ALoSP.

The most common problems and challenges identified during ALoSP implementation were related to the definition of SPIs, their selection for target setting, lack of historical data needed to determine the safety targets and a lack of uniform guidance material on how to do this. Those problems naturally leading to a diverse use of SPIs among the states and to a limited implementation of ALoSP, as the target-setting process is found to be a challenging issue. Naturally, with an increase in the number of SPIs defined within SSPs, target setting was becoming a more challenging issue. This is in line with the ALoSP survey findings that have identified the target-setting process as one of the main challenges in ALoSP implementation.

Lastly, the results of the survey also indicated that there is quite some diversity in the definition of ALoSP across the EUROCONTROL Member States; many states have their own interpretation and have not used ICAO recommendation as guidance. The frequent use of different types of guidance material could point to the need for action to develop uniform documentation containing all

necessary information upon which the ALoSP concept could be effectively built. Overall, the ALoSP concept is still the subject of a lack of clarity. This presents the possibility that the harmonised implementation of the ALoSP concept in EUROCONTROL Member States could be a missed opportunity if a common approach is not introduced and suggested to the states within the next two years.

Overall, it can be concluded that the work on implementation of ALoSP among EUROCONTROL Member States is at its early stages and that its successful continuation will rely on the availability of guidance material that will allow a harmonised implementation. This new harmonised approach of implementation (with a set of proposed indicators and clearly described ways on how to set associated targets, against which performance will be measured) will consequently allow the identification of the real risks in the aviation system in Europe.

Finally, the PRC is of the opinion that a thorough monitoring of ALoSP implementation within Europe should be organised as soon as possible in order to identify challenges in further implementation and provide support to the states, where needed.

The full study on the level of ALoSP implementation in EUROCONTROL Member States which also addresses best practices and recommendations is available online on the [PRC website](#) [Ref. 6].

## 2.6 Conclusions

Despite the continued traffic growth, safety levels in the EUROCONTROL area remained at a constantly high level. There was one reported accident with direct ATM contribution in 2015 and none in 2016, based on preliminary data.

In absolute terms, the number of all key risk occurrence types SMIs, RIs, UPAs, and ATM-S increased in 2016. However, in relative terms the rate of occurrences in the EUROCONTROL area stayed almost the same as in 2015: there were 15 SMIs and 28 UPAs per hundred thousand controlled flight hours in the airspace and less than one (0.9) RIs per ten thousand movements at airports reported in 2016.

The quality and completeness of safety data reported to EUROCONTROL increased over the past years but with scope for further improvement, particularly in terms of severity classification. Although this has been pointed out by the PRC on several occasions, 24% of the reported occurrences were still not severity classified in 2016, which is a considerable increase compared to 2015 (13%).

An acceptable level of safety performance is a crucial part of every SSP. According to ICAO Annex 19, each state shall establish an SSP for the management of safety in the state, in order to achieve an ALoSP in civil aviation. However, effective SSP implementation is a gradual process, and it requires time to mature fully. Factors affecting the time required to establish effective SSPs include the complexity of the air transportation system as well as the maturity of the aviation safety oversight capabilities of the state. Therefore, even the implementation of ALoSP should be considered as a gradual process.

ALoSP survey showed that 80% of EUROCONTROL Member States will have to work hard to meet the ICAO 2017 target. The most common problems and challenges identified during the ALoSP implementation are related to the definition of SPIs, the selection of suitable indicators for target setting, and the lack of historical data needed for setting the targets. Furthermore, the lack of uniform guidance material on how to overcome those challenges was frequently mentioned in the survey carried out by the PRC.

Overall, it can be concluded that the work on implementation of ALoSP among EUROCONTROL Member States is at its early stages and that its successful continuation will rely on the availability of guidance material that will allow a harmonised implementation. This presents the possibility that the harmonised implementation of the ALoSP concept in EUROCONTROL Member States could be a missed opportunity if a common approach is not introduced and suggested to the states within the next two years.





### 3 Operational en-route ANS Performance

SYSTEM TRENDS	2016	Trend	change vs. 2015
IFR flights controlled	10.0M	↑	+2.4%
Capacity			
En-route ATFM delayed flights	4.8%	↑	+0.9 %pt.
Average en-route ATFM delay per flight (min.)	0.86	↑	+0.13 min
Total en-route ATFM delay (min.)	8.7M	↑	+20.9%
Environment/ Efficiency			
Average horizontal en-route efficiency (flight plan)	95.4%	↓	-0.1%pt
Average horizontal en-route efficiency (actual)	97.1%	↓	-0.2%pt.

#### 3.1 Introduction

Despite the slowdown following the economic crisis in 2008, European air traffic is forecast to reach 14.4 million flights by 2035, which is 50% more than in 2012 [Ref. 7]. As the airspace is finite, there is a need to increase the operational efficiency of the air navigation system to be able to accommodate future traffic demand, including new airspace user groups such as Remotely Piloted Aircraft Systems (RPAS).

The ICAO Global Air Navigation Plan (GANP) [Ref. 8] and the European ATM Master Plan both aim at improving the air navigation system through a harmonised set of ATM enhancements which provide operational improvements and which make use of existing avionics capabilities.

Continuous review helps to monitor the impact of enhancement initiatives on performance over time in order to better understand progress and success of the initiatives and to highlight problems in the current system.

This chapter reviews operational en-route ANS performance in the EUROCONTROL area in 2016.

Section 3.2 describes the main changes in air traffic demand by air traffic service provider in 2016 before Section 3.3 analyses ANS-related flight efficiency constraints on airspace users' flight trajectories, including en-route ATFM delays and horizontal and vertical flight efficiency. Civil military cooperation and coordination is addressed in Section 3.4.

The performance indicators used for the analysis in this chapter, expected benefits and supporting initiatives are shown in Table 3-1.

**Table 3-1: Operational en-route ANS performance (Overview)**

	En-route ANS performance
<b>Expected benefits</b>	<ul style="list-style-type: none"> <li>• Reduce delay and fuel burn (CO<sub>2</sub> emissions)</li> <li>• Improve route network design;</li> <li>• Improved route availability (CDRs);</li> <li>• Improved airspace utilisation (civil/military coordination);</li> </ul>
<b>Related indicators in this chapter</b>	<ul style="list-style-type: none"> <li>• En-route ATFM delays;</li> <li>• Horizontal en-route flight efficiency;</li> <li>• Vertical en-route flight efficiency</li> </ul>
<b>Supporting projects/ initiatives</b>	<ul style="list-style-type: none"> <li>• Free route airspace (FRA)</li> <li>• Route network design improvements</li> <li>• Flexible use of airspace (FUA)</li> <li>• Enhanced flow performance through network operational planning</li> </ul>

Through the Global Air Navigation Plan (GANP) [Ref.7], ICAO has established a framework for harmonising airborne and ground-based capabilities. The Aviation System Block Upgrades (ASBUs) comprise packages of capabilities with clearly defined measurable operational improvements,

necessary equipment on the ground and in the air, and associated standards and operational procedures. The focus of the current implementation roadmaps are the ASBU Block 0 and 1 Upgrades.

With a view to operational en-route ANS performance these upgrades include the following modules.

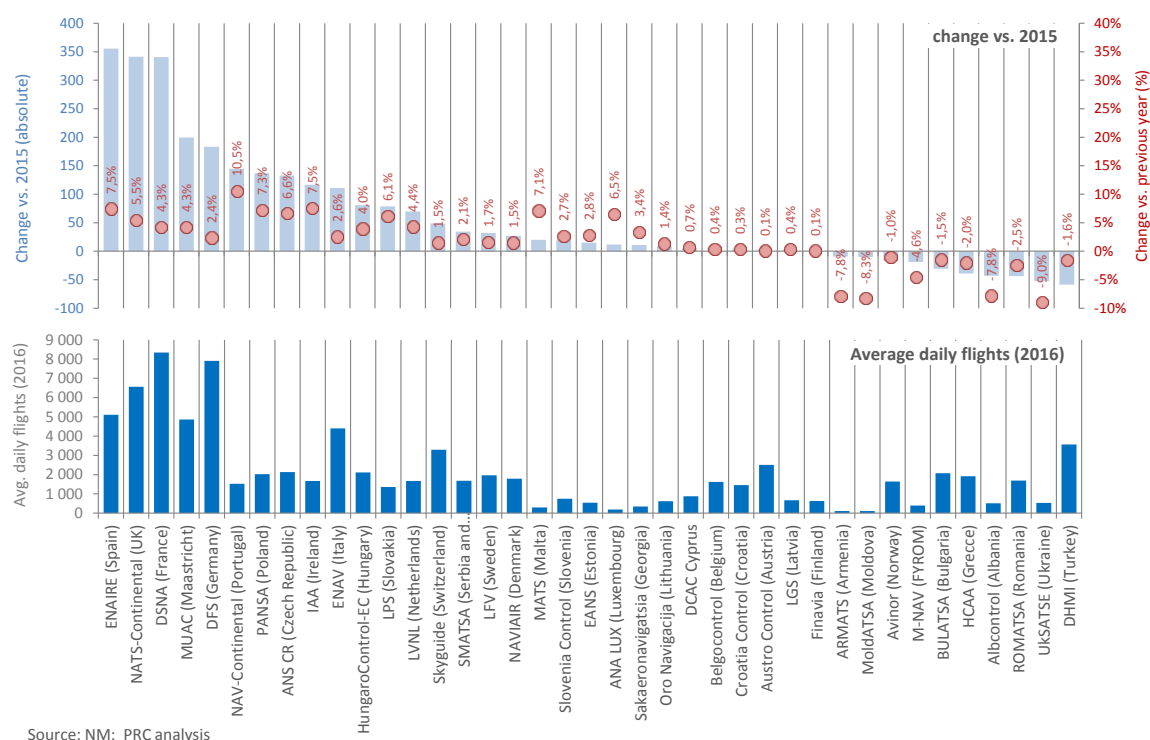
**Table 3-2: ASBU Performance Improvement Areas and Block upgrades (en-route)**

ASBU Improvement Area	Block 0 (2013)	Block 1 (2018)
Optimum capacity and flexible flights	<ul style="list-style-type: none"> <li>improved operations through enhanced en-route trajectories</li> <li>improved flow performance through planning based on a network wide view</li> <li>improved access to optimum flight levels</li> </ul>	<ul style="list-style-type: none"> <li>improved operations through optimised ATS routing</li> <li>increased capacity and efficiency through interval management</li> <li>improved flow performance through network operation planning</li> </ul>
Efficient Flight Path	<ul style="list-style-type: none"> <li>improved flexibility and efficiency in descent profiles using CDO and CCO</li> </ul>	<ul style="list-style-type: none"> <li>improved traffic synchronisation and initial trajectory based operation</li> </ul>

The ATFM delay cost estimates in this report are based on a study from the University of Westminster [Ref. 9] which addresses estimated costs to airspace users. The report is available for download on the [PRC website](#).

## 3.2 Traffic evolution

The 2.4% traffic increase in the EUROCONTROL area in 2016 was not homogenous throughout the network. Of the 39 ANSPs included in the analysis, 25 showed an increase in traffic compared to 14 ANSPs which showed a traffic decline.



**Figure 3-1: Traffic variation by ANSP (2016/2015)**

Figure 3-1 shows the number of average daily flights by ANSP in 2016 at the bottom and the change compared to 2015 in absolute (blue bars) and relative (red dots) terms at the top. The figure is sorted according to the absolute change compared to the previous year.

In absolute terms, ENAIRE (Spain), NATS (UK), and DSNA (France) experienced the highest year on year growth in 2016. DHMI (Turkey), UKSATSE (Ukraine) and ROMATSA (Romania) reported the highest absolute decrease in 2016.

The traffic growth by Area Control Centres (ACCs) in Figure 3-2 confirms the contrasted picture already observed at ANSP level in Figure 3-1.

ACCs with growth rates above 10% in 2016 were Palma, Lisbon, Canarias, and Dublin ACC.

It is remarkable that 35 of the 63 ACCs reported their highest traffic levels on record in 2016, surpassing the previously highest levels dating back before the start of the economic crisis in 2008.

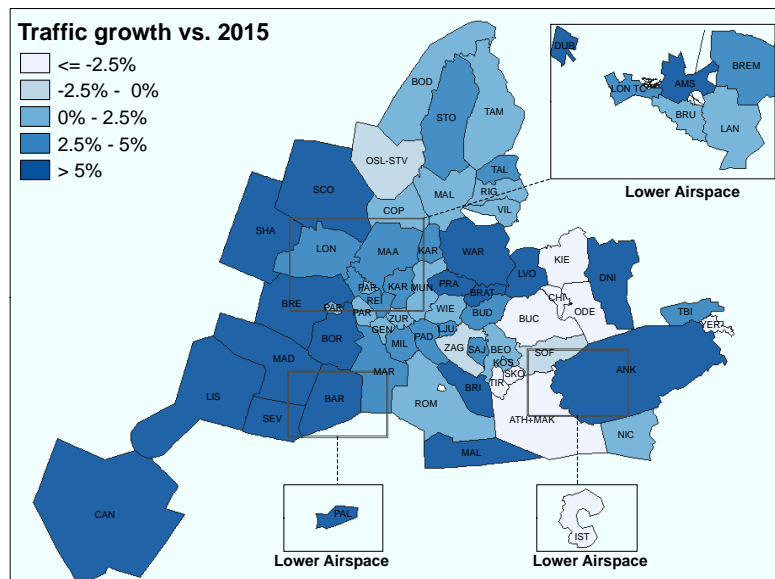


Figure 3-2: Traffic growth by ACC (2016)

### 3.3 ANS-related operational en-route efficiency

This section evaluates ANS-related flight efficiency constraints on airspace users' flight trajectories. It addresses several performance areas including efficiency (time, fuel), predictability, and environmental sustainability (emissions, noise).

#### 3.3.1 En-route ATFM delays

Please note that software release 20.0 of the Network Manager on 04 April 2016 introduced a change to improve the accuracy of the ATFM delay calculation for operational purposes which resulted in an estimated overall reduction of 11.8% of delay compared to the old methodology. More information on the change is available online at <http://www.eurocontrol.int/ansperformance/dataportal>.

Changes due to the Post Operations Performance Adjustment Process were not considered in this report. More information including the list of changes in 2016 is available from the [NM website](#).

Total en-route [ATFM delays](#), for the EUROCONTROL area, increased by +20.9% in 2016 which corresponds to 0.86 minutes (51 seconds) of en-route ATFM delay per flight (0.73 in 2015).

#### Evolution of en-route ATFM delay (EUROCONTROL area)

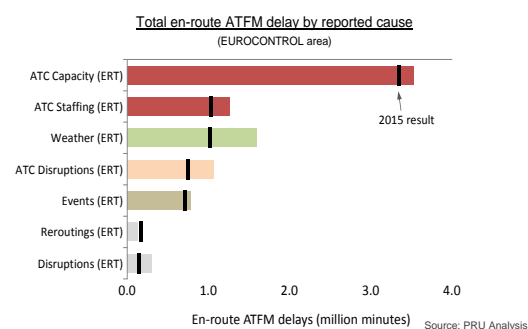
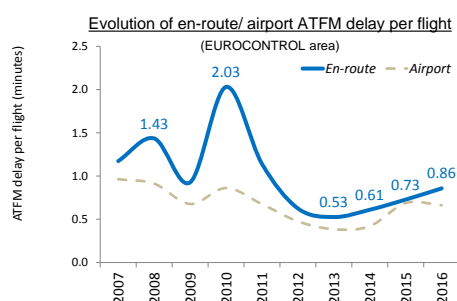
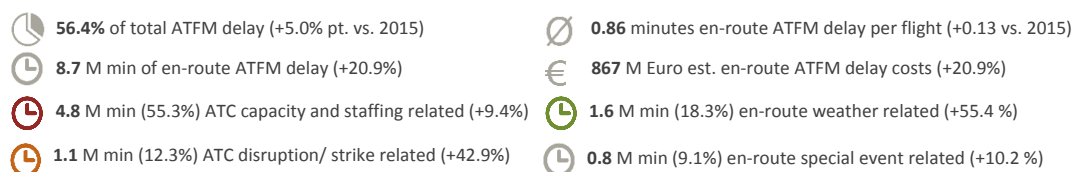
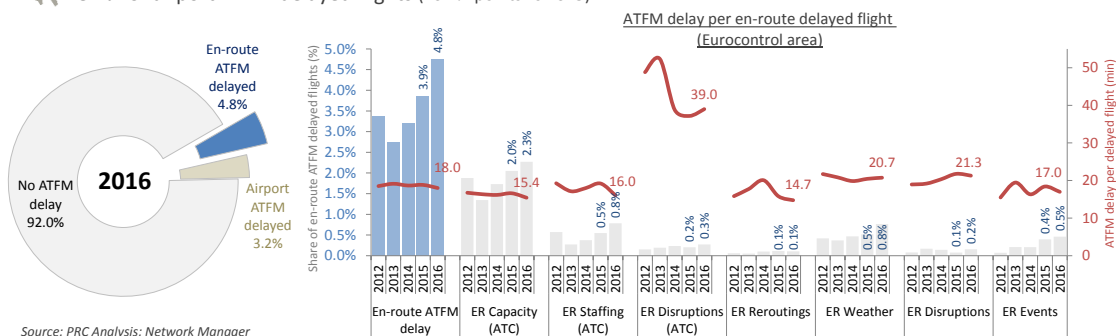


Figure 3-3: Average en-route ATFM delay (EUROCONTROL area)

According to the [delay classifications](#), as reported by the local flow management positions (FMPs), Capacity/Staffing related issues remain by far the main driver of en-route ATFM delays (55.3%), followed by weather related delays (18.3%), ATC disruptions/ industrial actions (12.3%), and Event related delays (9.1%) which also include delays due to ATC system upgrades.

### Evolution of en-route ATFM delayed flights and average delay per delayed flight (EUROCONTROL area)

- ✈️ **4.8% of en-route ATFM delayed flights (+0.9% points vs 2015)** ⌚ **18.0 minutes delay per en-route delayed flight**
- ✈️ **3.2% of airport ATFM delayed flights (+0.2% points vs 2015)**



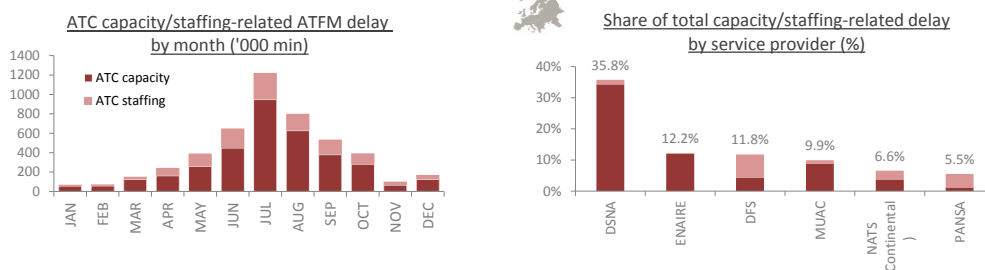
**Figure 3-4: En-route ATFM delayed flights and delay per delayed flight (EUROCONTROL area)**

Following the increase observed already for the past two years, the number of flights affected by ATFM en-route delays in the EUROCONTROL area increased further in 2016 from 3.9% to 4.8%. At the same time, the delay per delayed flight decreased from 18.8 minutes to 18.0 minutes in 2016.

**ATC capacity/staffing related en-route ATFM delays** accounted for more than half of all en-route ATFM delays. In 2016, 3.3% of the flights were delayed due to ATC capacity or staffing related ATFM regulations, an increase of 0.5% on 2015.

#### Impact of ATC capacity/staffing related ATFM delays on airline operations (2016)

- ⌚ **55.3% of total en-route ATFM delay**
- ✈️ **3.3% of flights delayed (+0.5% vs. 2015)**
- ⌚ **4.79 M min of en-route ATFM delay (+410k vs. 2015)**
- 📅 **361 days with capacity-related ATFM delay (+5 vs. 2015)**
- ⌚ **16.3 minutes delay per delayed flight**
- 💶 **479 million est. delay costs (+41 vs. 2015)**

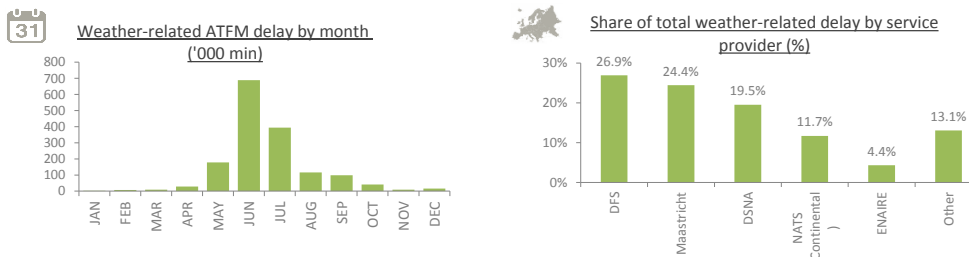


**Figure 3-5: Estimated ATC capacity/staffing related impact on airline operations (2016)**

Figure 3-6 shows the impact of **weather related en-route ATFM delays** on airline operations. In 2016, weather related en-route ATFM delays accounted for 18.3% of all en-route ATFM delays delaying 1.9% of the flights. More than half of the weather related delay in 2016 was concentrated in DFS and Maastricht UAC.

#### Impact of weather-related en-route ATFM delays on airline operations (2016)

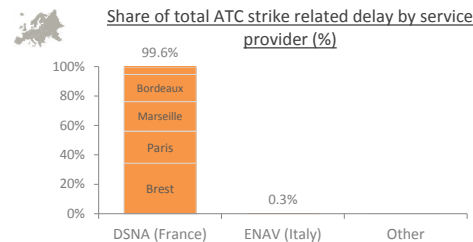
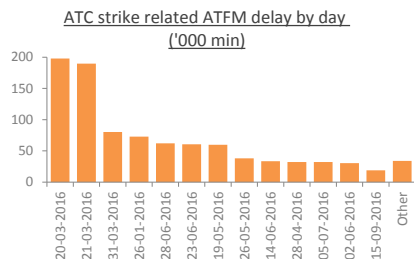
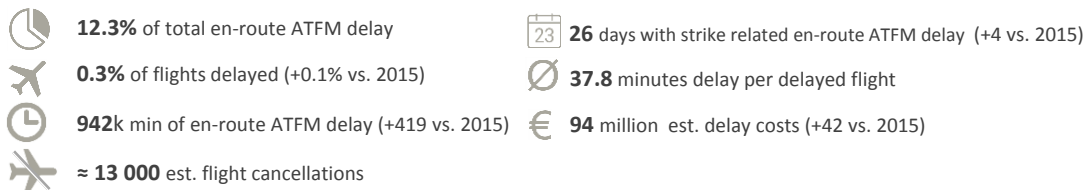
- ⌚ **18.3% of total en-route ATFM delay**
- ✈️ **1.9% of flights delayed (+0.3% vs. 2015)**
- ⌚ **1 104 days of en-route ATFM delay (+394 vs. 2015)**
- 📅 **175 days with weather related ATFM delay (+18 vs. 2015)**
- ⌚ **23.3 minutes delay per delayed flight**
- 💶 **159 million est. delay costs (+57 vs. 2015)**



**Figure 3-6: Impact of weather related en-route ATFM delays on airline operations (2016)**

ATC disruptions accounted for 12.3% of all en-route delays, almost entirely attributable to DSNA.

#### Estimated ATC strike related impact on airline operations (2016)

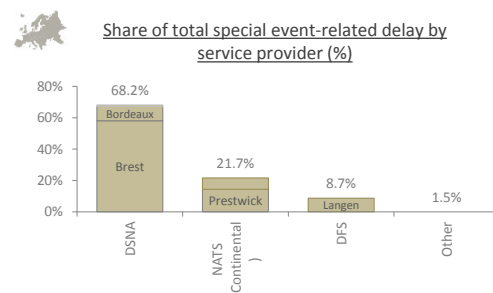
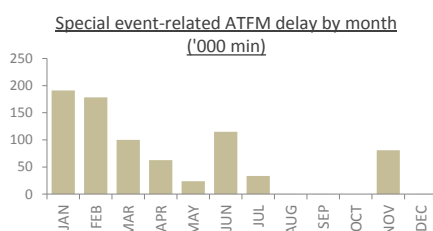
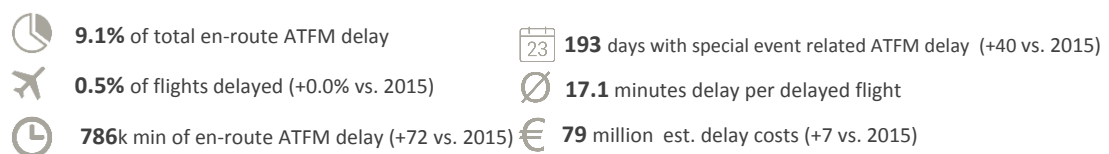


**Figure 3-7: Estimated ATC strike related impact on airline operations (2016)**

Although only 0.3% of the flights were affected by **ATFM delays due to ATC industrial action**, the average delay per delayed flight (due to ATC industrial action) of 37.8 minutes caused substantial disruption in the network. Moreover the estimated number of cancellations due to ATC industrial action was 13 000 flights in 2016.

The share of **special event related delay** was 9.1% in 2016 and 0.5% of the flights were impacted with an average delay per delayed flight of 17.1 minutes. Almost 70% of the delay was due to the ERATO implementation in French ACCs.

#### Impact of special event-related en-route ATFM delays on airline operations (2016)



**Figure 3-8: Estimated special event related impact on airline operations (2016)**

New or upgrades of ATM systems are planned in a large number of States over the coming years.

The ERATO implementation in France over the past two years showed the substantial impact that airspace and/or equipment changes can have on the network.

As voiced already in PRR2015, it is vital that ANSPs effectively coordinate the planning and implementation of all changes to the ATM system that could adversely affect operations with the Network Manager.

Whilst such changes are inevitable, and indeed desirable, airspace users need to be assured that all appropriate measures have been taken to reduce disruption, and that there will be an operational benefit to the users following the implementation.

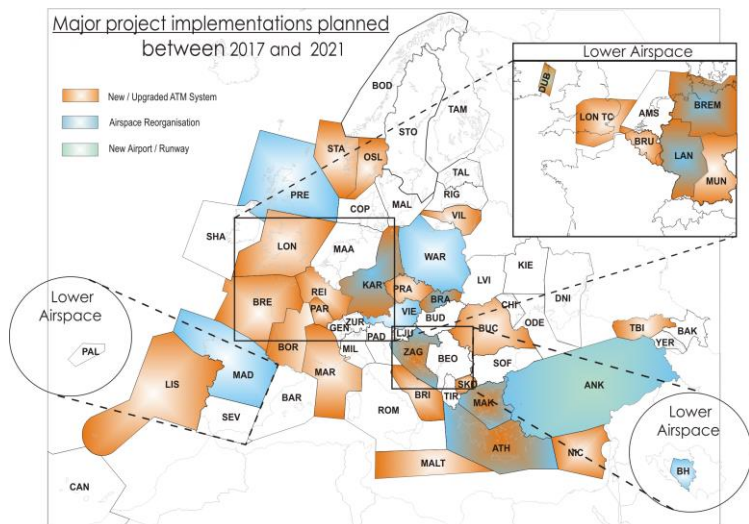


Figure 3-9: Planned major project implementations (2017-2021)

### Most constraining ACCs in 2016

While capacity constraints can occur from time to time, air navigation services should not generate high delays on a regular basis. Figure 3-10 shows the most constraining<sup>10</sup> ACCs in 2016 by ANSP.

In 2016, the most constraining ACCs in 2016 accounted for 69.8% of all en-route ATFM delays and 26.3% of total flight hours controlled in Europe. Compared to 2015, Lisbon, Athens, and Zagreb ACCs notably improved their performance and are therefore no longer among the most constraining ACCs.

Brussels, Bordeaux, Prestwick, Maastricht, Karlsruhe, Warsaw and Marseille ACCs are new among the most constraining ACCs in 2016.

In 2016, DSNA (France) generated 41.6% of all en-route ATFM delays in the EUROCONTROL area with three ACCs among the most constraining ACCs (Brest ACC, Bordeaux ACC and Marseille AC). Overall, 5.8% of all flights crossing airspace controlled by DSNA experienced en-route ATFM delay with an average delay per delayed flight of 20.4 minutes.

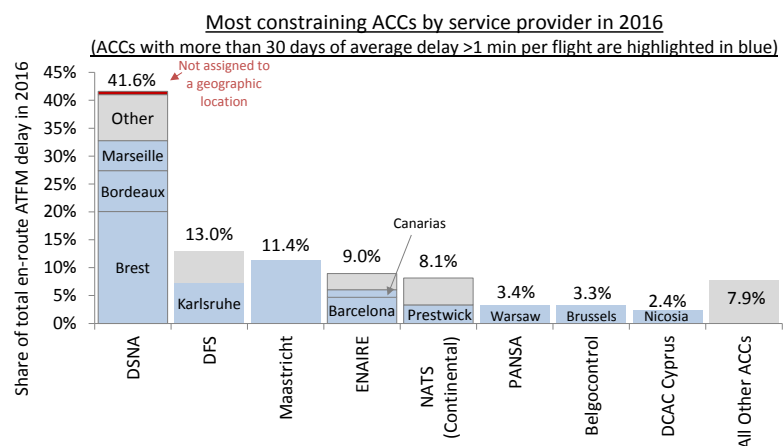


Figure 3-10: Overview of most constraining ACCs (2016)

The PRC also note that a considerable amount of en-route delays (48k minutes, circa 5%) have been recorded in France but without assignment to one of the existing ACC / UACs (see Figure 3-10). Instead these delays have been grouped under the label LFDSNA referring to all French ACCs.

The PRC understands that this is the result of a trial to improve cooperation and coordination between individual ACCs but de-linking the ATFM delay from specific locations risks losing the ability to identify, and therefore resolve, the root causes of capacity constraints. Even though the 48k minutes allocated to LFDSNA may be due to constraints at a small number of specific capacity bottlenecks, if these bottlenecks are not identifiable, they cannot be resolved, and will continue to constrain airspace users.

<sup>10</sup> The selection threshold was set at more than 30 days with significant en-route ATFM delay (>1 min per flight).



Whilst efforts to improve cooperation and coordination among ANSPs, with the objective of improving the service provided to airspace users, should be encouraged; it is essential to be able to accurately identify specific capacity constraints and the impact such constraints have on air traffic.

**Brest ACC** continued to generate significant delays due to the implementation of the ERATO system, until April 2016. (Original planning for implementation of the ERATO system published in NOP 2014 and NOP 2015 envisaged capacity reductions for a limited period of 1-2 months only).

Capacity levels increased from April 2016 and July 2016 saw Brest ACC handling the highest monthly traffic levels on record, albeit with high delays (285k minutes).

#### Brest ACC en-route performance overview (2016)

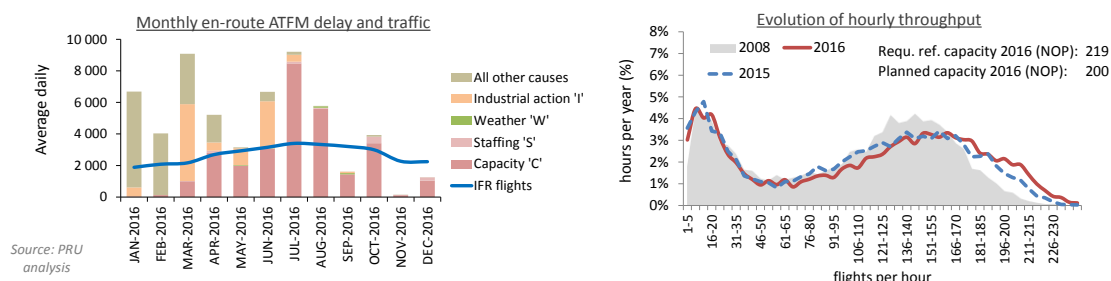
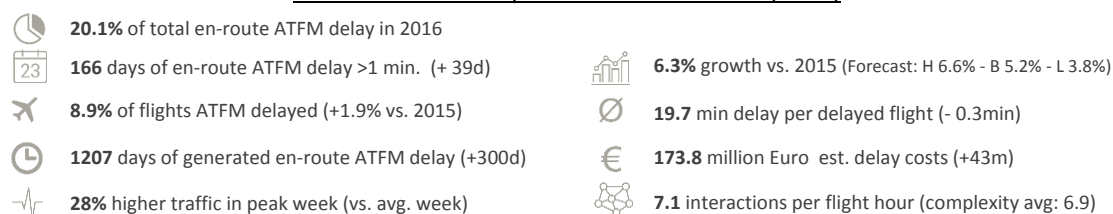


Figure 3-11: Brest ACC en-route performance overview (2016)

There were 23 days in July 2016 when delays in Brest ACC exceeded 2 minutes per flight. The table below shows, for the three main sector groups: North, South and East, the 5 days with the highest delays in July, the maximum number of sectors opened and the period for which this capacity was provided.

Table 3-3: ATFM regulations applied by Brest ACC (July 2016)

Date (ACC delay per flight)	Sector Group	Planned sectors at maximum capacity (NOP)	Highest number sectors actually opened	Time of operation at highest config. (hh:mm)	Period of regulations due to ATC capacity. (hh:mm)	Delay due ATC capacity (minutes)	Overlap btw. ATC capacity regulation and deployment of highest cap. on that day (hh:mm)	
01/07	North	6	6	3:00	2:20	1106	0	0%
(5.3)	South	6	5	5:30	11:20	8843	5:30	49%
	East	6	6	8:30	12:17	6596	6:20	52%
02/07	North	6	5	5:30	12:40	7087	5:30	43%
(5.4)	South	6	6	2:00	6:00	4426	0:00	0%
	East	6	6	6:30	12:50	8261	6:30	43%
05/07	North	6	4	Industrial Action				
(4.0)	South	6	3					
	East	6	4					
15/07	North	6	5	5:30	7:40	5333	4:20	57%
(4.5)	South	6	5	4:00	8:40	5164	2:00	23%
	East	6	6	4:00	9:55	7003	4:00	40%
16/07	North	6	6	1:00	8:00	4593	0:00	0%
(4.3)	South	6	5	6:30	11:55	5829	6:10	52%
	East	6	6	2:00	15:10	6319	1:40	11%

The delays on Tuesday 5<sup>th</sup> July were due to industrial action and an associated reduction in the numbers of sectors available.

The above table raises two concerns. Firstly, even though the demand levels were high and massive delays were accruing, there was an inability or refusal to open the maximum number of sectors. Secondly, there are significant mismatches between the deployment of maximum capacity and the traffic demand, evidenced by the necessity to apply regulations for lengthy periods when only a limited number of sectors are opened.

The Provisional Council, in recommendations from PRR 2014 and PRR 2015, highlighted the need for capacity to be made available during peak traffic periods rather than regulating demand to meet reduced capacity.

**Bordeaux ACC** saw an increase in traffic over 2015 levels (+5.4%) and recorded the highest traffic level on record. Industrial disputes were responsible for delays in every month, from January until July, except February.

#### Bordeaux ACC en-route performance overview (2016)

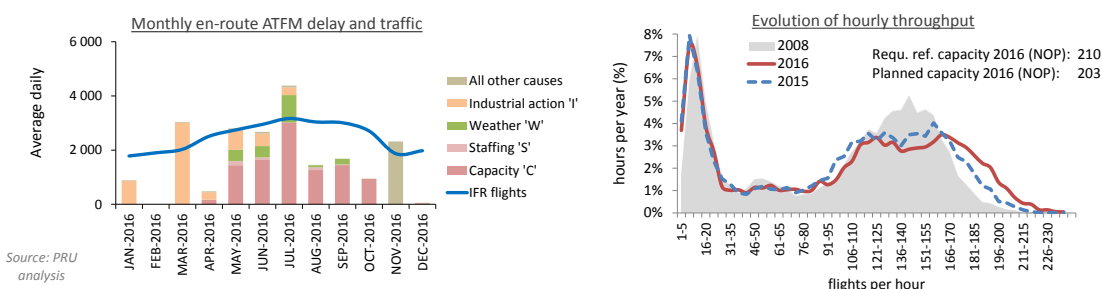
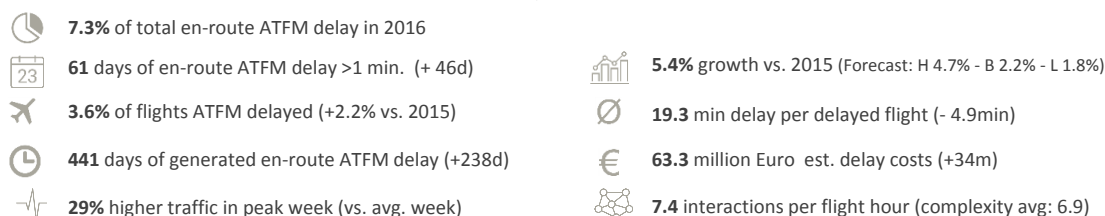


Figure 3-12: Bordeaux ACC en-route performance overview (2016)

Delays attributed to ATC Capacity prevailed from May until September peaking in July at almost 94k minutes of delay for 98k flights, approximately 1 minute per flight.

Delays were also attributed to adverse en-route weather phenomena from May to September peaking again in July at 31k minutes of delay.

November saw the beginning of implementation of the ERATO system (as previously implemented in Brest ACC) with a reduction in capacity. Following the experiences in Brest ACC, the DSN, the Network Manager, and adjacent ACCs worked together to reduce the impact of the ERATO implementation. Action such as mandatory rerouting and off-loading into adjacent ACCs / ANSPs reduced the traffic demand below normal operational levels.

**Marseille ACC** handled 4.7% more traffic in 2016 than in 2015. Delays attributed to industrial action made up 40.5% of the total delays in Marseille ACC during 2016, 85% of which occurred in March.

#### Marseille ACC en-route performance overview (2016)

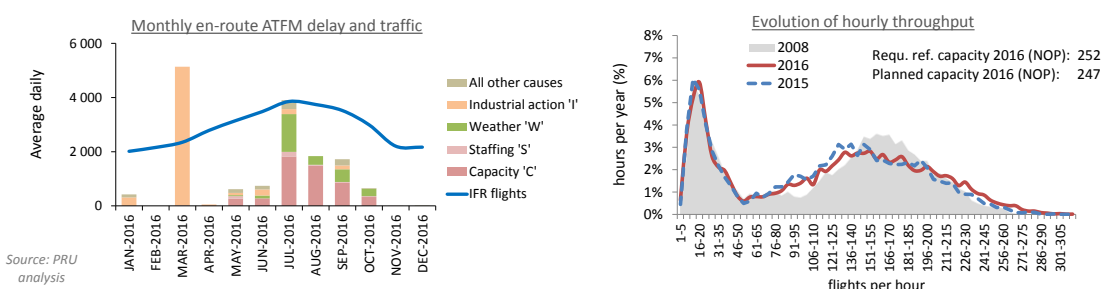
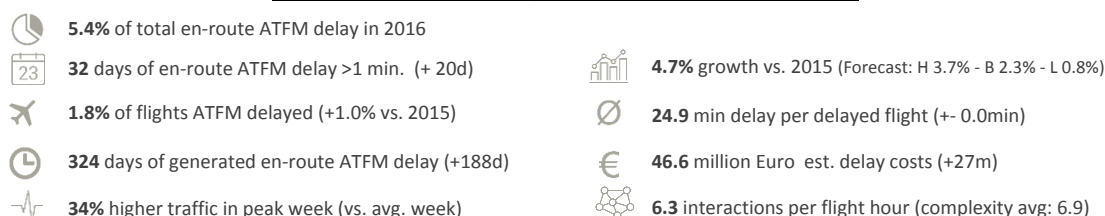


Figure 3-13: Marseille ACC en-route performance overview (2016)

**Karlsruhe UAC:** Similarly to Maastricht UAC, the majority of en-route ATFM delays were attributed to adverse weather phenomena, particularly during June and July 2016.

#### Karlsruhe UAC en-route performance overview (2016)

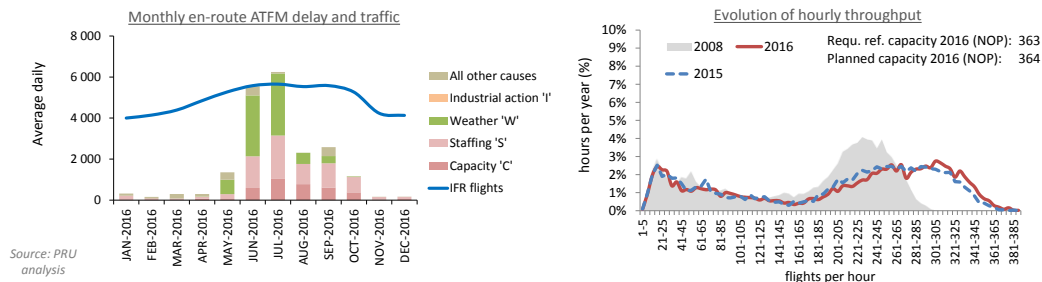


Figure 3-14: Karlsruhe UAC en-route performance overview (2016)

Closer examination of the delays allocated to adverse weather correlates with the publication of SIGMETs for the Rhein UIR, wherein Karlsruhe UAC provides air traffic services.

The traffic growth was slightly above the high forecast and as a consequence Karlsruhe UAC serviced more flights than ever before.

Figure 3-15 shows how Karlsruhe UAC is handling higher levels of monthly traffic year on year. This underlines the importance of planning sufficient capacity to meet ever growing traffic levels.

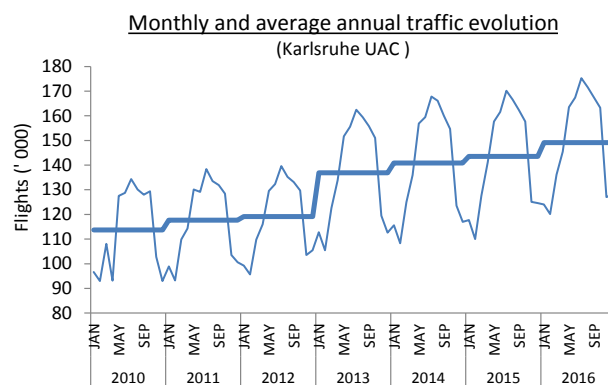


Figure 3-15: Karlsruhe UAC traffic evolution (2010-2016)

**Maastricht UAC** also achieved the highest traffic level on record in 2016. En-route weather was responsible for significant portions of delay in May (57%), June (67%), July (39%) and August (25%).

Maastricht UAC allocated a high level of delays to adverse en-route weather phenomena during the May to August period, much greater than in previous years. Adverse en-route weather phenomena such as severe icing, severe turbulence, thunderstorms etc. usually necessitate the publication of SIGMET (**S**ignificant **M**eteorological information) advising aircraft of the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations.

As with Karlsruhe UAC, closer investigation of the delays attributed to adverse weather correlates with the publication of SIGMETs for one or more of the FIRs in which MUAC provide air traffic services: Brussels FIR (EBBU), Amsterdam FIR (EHAA) and Hannover UIR (EDYY).

### Maastricht UAC en-route performance overview (2016)

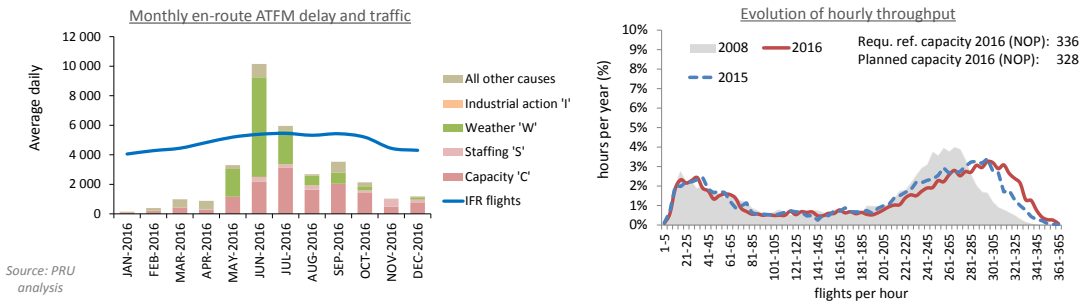
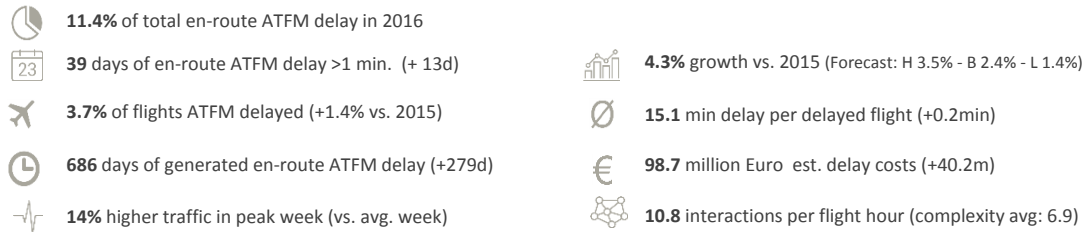


Figure 3-16: Maastricht UAC en-route performance overview (2016)

The traffic growth in Maastricht UAC was above the high traffic forecast which led to higher traffic levels than previously handled.

Figure 3-17 shows that Maastricht UAC is handling higher levels of monthly traffic year on year.

This underlines the importance of ensuring that capacity plans are implemented in sufficient time to handle the ever growing traffic levels.

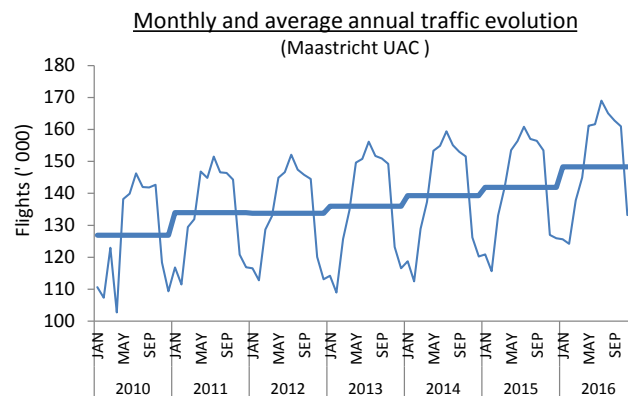


Figure 3-17: Maastricht UAC traffic evolution (2010-2016)

**Barcelona ACC** traffic increased dramatically from 2015 levels during 2016 (+8.4%). July and August saw over 98 thousand flights per month, the highest monthly totals in Barcelona on record.

### Barcelona ACC en-route performance overview (2016)

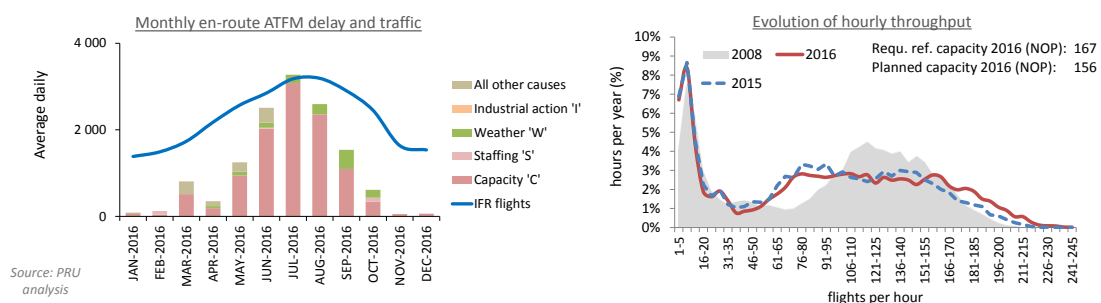


Figure 3-18: Barcelona ACC en-route performance overview (2016)

The number of days when delay was more than one minute per flight rose from 37 in 2015 to 49 in 2016. Even though August had a slightly higher number of flights, the amount of delay was significantly less than in July (80k compared to 101k minutes). In July delays attributed to capacity were 95% of the total value compared with 90% for the month of August.

An analysis of the days in July and August when total ATFM delay was greater than 2 minutes per flight, as in PRR2015, shows the following:

**Table 3-4: ATFM regulations applied by Barcelona ACC (July/August 2016)**

Date	Sector Group	Planned sectors at maximum capacity (NOP)	Highest number sectors actually opened	Time operation of highest configuration (hh:mm)	Period of regulations due to ATC capacity. (hh:mm)	Delay due ATC capacity (minutes)	Overlap between ATC capacity regulations and deployment of highest capacity on that day (hh:mm)	
02/07	West	6	6	14:30	14:50	2671	12:50	87%
	East	6	6	14:30	12:00	4449	9:20	78%
22/07	West	6	6	15:00	5:00	803	5:00	100%
	East	6	6	11:00	10:00	3431	5:00	50%
23/07	West	6	6	15:00	11:00	2932	9:10	83%
	East	6	6	15:00	9:40	3068	8:20	87%
31/07	West	6	6	15:00	3:40	1314	3:40	100%
	East	6	6	15:00	9:00	3179	6:40	74%
13/08	West	6	6	15:00	5:00	1534	5:00	100%
	East	6	6	15:00	8:40	3732	8:40	100%

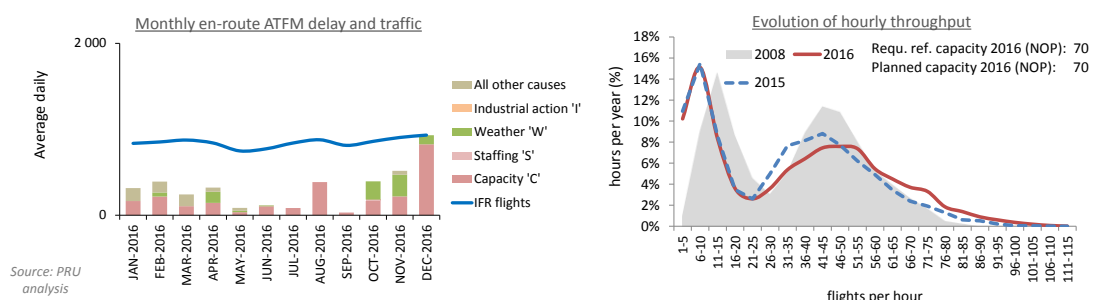
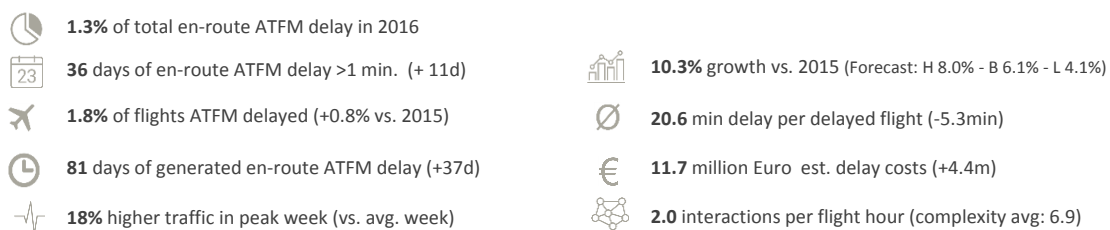
In comparison to 2015, the ANSP provides the maximum number of sectors for much longer periods-up to 15 hours. This is a significant improvement, especially in Sector Group East (which was usually restricted to deployment of maximum sectors for less than 8 hours in 2015.)

The above table show that there is still room for further improvement in making sure that capacity is deployed according to the traffic demand instead of rigidly providing capacity independently of traffic demand. However, the predominant issue for Barcelona ACC appears to be the necessity of providing additional capacity.

Failure to plan and implement adequate capacity for Barcelona ACC has been flagged by the Network Manager in each Network Operations Plan since 2012.

**Canarias ACC** experienced 10.3% growth in traffic levels over 2015, which was above the predicted high forecast (8%) and the highest annual level on record so far.

#### Canarias ACC en-route performance overview (2016)



**Figure 3-19: Canarias ACC en-route performance overview (2016)**

Out of 36 days where delays were greater than one minute per flight: 24 were Saturdays; 3 were Tuesdays, 3 were Fridays; 2 Thursdays 2 Mondays, and 2 Sundays.

Comparison of the capacity performance on Saturdays in November and December 2016 alone shows that the highest amount of traffic occurred on 17<sup>th</sup> December although there were relatively fewer delays than on the other Saturdays in December.

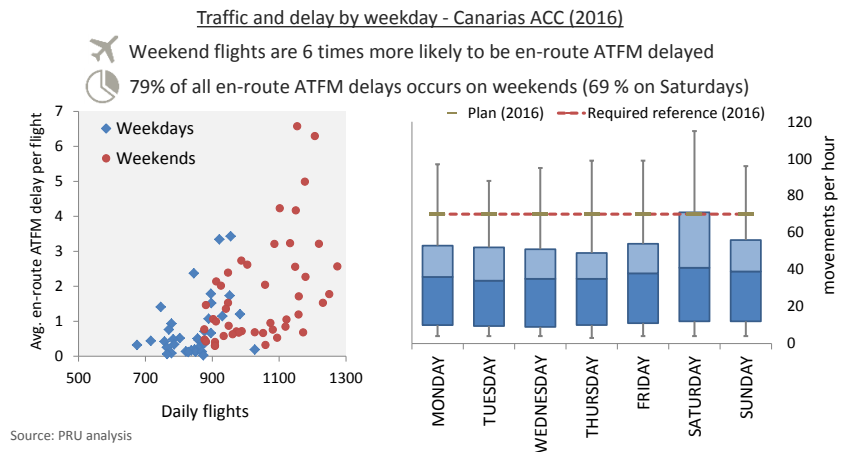


Figure 3-20: Traffic and ATFM delay by weekday – Canarias ACC (2016)

Closer analysis shows that the orientation of the runways-in-use in the Canarias has a significant impact on the en route capacity performance. When northerly runways are in use (17<sup>th</sup> December) the en route capacity performance is significantly better than when traffic is landing / departing in a southerly direction.

The aerodrome charts for airports in the Canarias shows a significant mismatch in location and type of runway exits for traffic landing in a northerly direction compared to traffic landing in a southerly direction. Factors such as location and type of runway exits influence the landing, and departure, rate which can create congestion in the TMA and further upstream into the en-route sectors.

Mis-identification of causal capacity constraints hinders mitigation and resolution of capacity problems. If capacity constraints are due to the lack of rapid-exit-taxiway in southerly landing configuration then allocating the delay as being due to en route ATC capacity will not lead the airport authorities to build a new taxiway.

Similarly, if a TMA does not have sufficient holding patterns to accommodate traffic holding for the airports it serves, allocating the delay as being due to ATC capacity in the en-route sectors will not lead to the creation and use of suitable holding patterns through a TMA redesign project.

**Prestwick ACC** experienced a traffic growth in 2016 (+6.6%) which was notably higher than forecast (+2.9%). ATFM en-route delays in Prestwick ACC peaked during June and July with the primary reason being the implementation of, and training associated with, a new iTec (interoperability Through European Collaboration) air traffic management system. Performance improved notably in the second half of 2016 and following the successful implementation of the new system no further constraints are expected in 2017.

**Warsaw ACC:** Following a 7.2% increase of traffic on 2015, Warsaw reached a traffic level never achieved before and notably higher than forecast. As a result, delays more than doubled (+127%) and the number of days when en-route ATFM delay was greater than 1 minute per flight increased from 4 in 2015 to 39 for 2016. A dramatic rise in delays occurred in July with peak traffic (72k flights), and continued, albeit at a smaller levels, until November. 72% of delays are attributed to staffing issues.

Further investigation of days with high delay in July 2016 reveals an inability to open the maximum number of sectors (10) for lengthy periods of high demand, or even at all.



### Warsaw ACC en-route performance overview (2016)

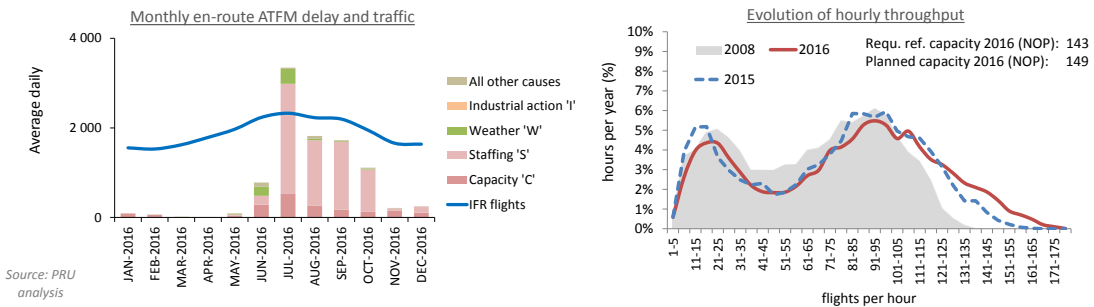
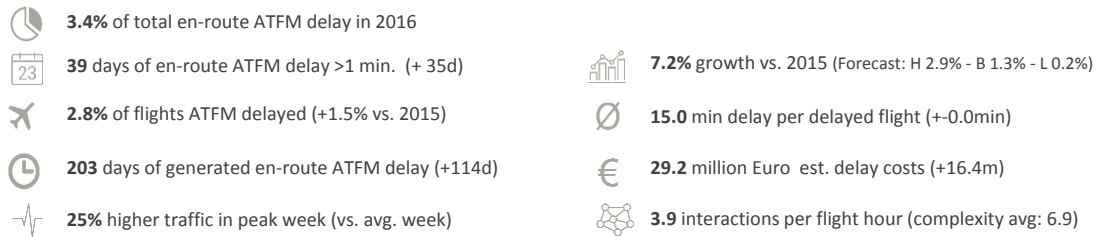


Figure 3-21: Warsaw ACC en-route performance overview (2016)

**Brussels ACC** 75% of the ATFM delays from Brussels ACC in 2016 was attributed to staffing reasons, predominantly in the period April to July. Traffic levels remained reasonably stable with a traffic growth of 0.2%.

### Brussels ACC en-route performance overview (2016)

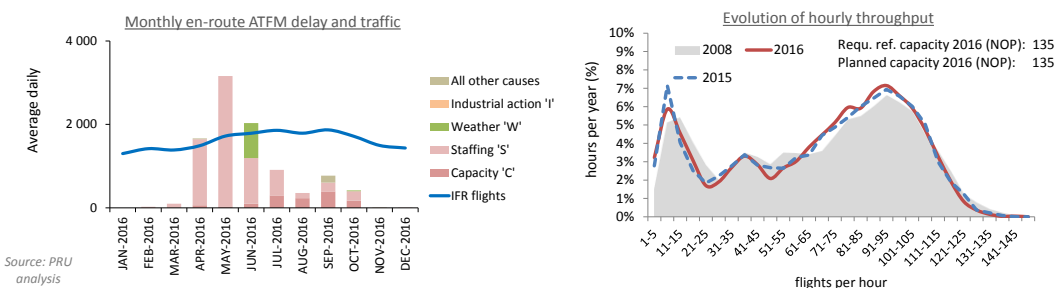
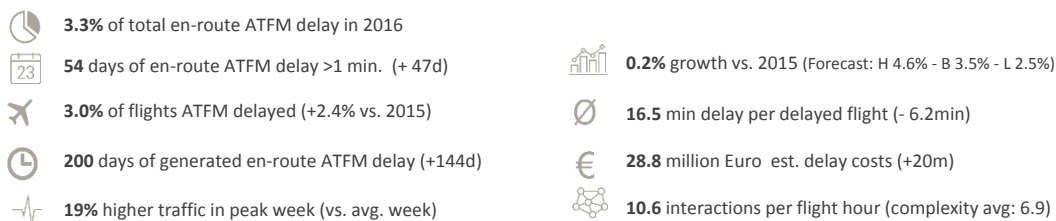


Figure 3-22: Brussels ACC en-route performance overview (2016)

**Nicosia ACC** showed a significant capacity improvement in 2016. July August and September saw higher traffic levels with significantly lower delays than in 2015. However, Nicosia continued to be a bottleneck in the European network and previously published capacity plans were not implemented as had been envisaged.

The NOP promised the availability of 6 ATC sectors during peak periods but this never materialised. The highest number of sectors opened was 5, although this is an improvement on the maximum of 4 sectors, provided during the same time in 2015.

Nicosia ACC operated five sectors for a total of 38 hours over 21 separate days in July; 75 hours over 28 days in August and 66 hours over 25 days in September. The inability to open the maximum number of sectors during peak traffic periods indicates that staffing needs to be addressed, both in terms of the recruitment of new area controllers and in deploying the existing controllers in a more efficient manner.



### Nicosia ACC en-route performance overview (2016)

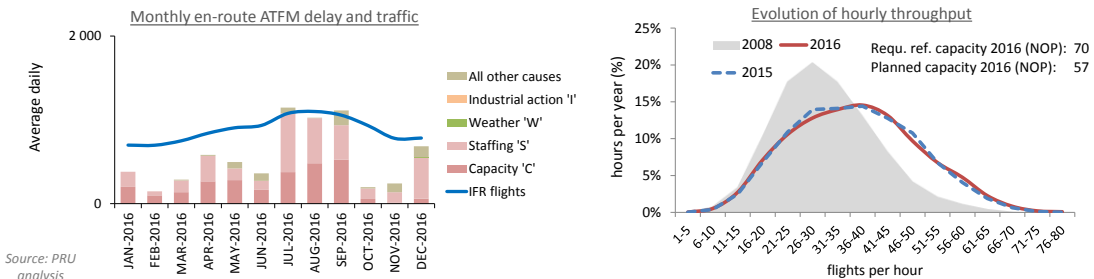
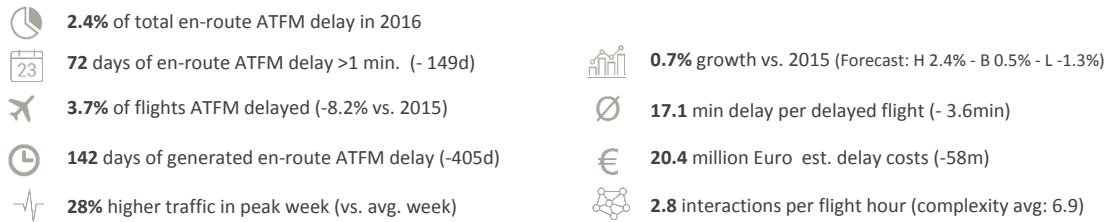


Figure 3-23: Nicosia ACC en-route performance overview (2016)

It is notable that, despite the significant increase in aircraft-carrier-based military flight operations in the eastern Mediterranean in 2016, no ATFM delays in the Nicosia FIR were attributed to military activity.

Finally, the PRC notes the growth in traffic to and from Israel and that a significant portion of this traffic will, most likely, seek to fly through the Nicosia FIR. This underlines the necessity of planning and implementing additional capacity, as soon as possible, to meet the traffic demand.

### ATFM performance (network level)

The ATFM function in Europe is jointly executed by local ATFM units and the Network Manager (central unit for ATFM). ATFM regulations are put in place by the Network Manager to protect en-route sectors or airports from receiving more traffic than ATC can safely handle upon request of the local Flow Management Positions (FMP).

Figure 3-24 shows the evolution of the three high-level indicators presently in use to monitor the performance of the ATFM function at system level.

In 2016, ATFM slot adherence continued to improve and the regulated hours with excess demand also decreased slightly. Following the notable improvement in 2015, ATFM delays due to avoidable regulations increased again to 2014 levels.

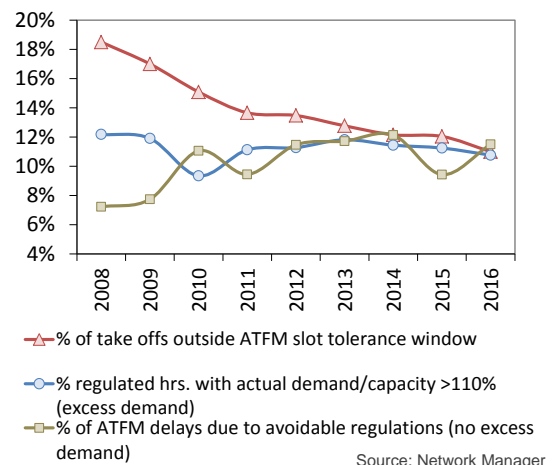


Figure 3-24: ATFM performance (network indicators)

### 3.3.2 En-route Flight Efficiency

This section evaluates en-route flight efficiency in Pan-European airspace. En-route flight efficiency has a horizontal (distance) and vertical (altitude) component and is the result of numerous interactions between stakeholders with different objectives and constraints. More information on methodologies (approach, limitations) and data for monitoring the ANS-related performance is available online at <http://www.eurocontrol.int/ansperformance/dataportal>.

There is a close link between operational efficiency and environmental sustainability. Improved flight efficiency has not only an economic impact in terms of fuel savings but also an impact in terms of reduced emissions (most notably carbon dioxide (CO<sub>2</sub>)) impacting on the environment.

With air traffic expected to double by 2035 [Ref.7] and the airspace being finite, there is a need to make the ATM system more efficient to keep up with demand and to reduce operational inefficiencies as much as possible. However, as pointed out in previous reports, 100% flight efficiency cannot be achieved for a number of reasons including, inter alia, safety, weather and capacity issues.

In view of the numerous factors and complexities involved, and with traffic levels growing again, flight efficiency improvements will become more and more challenging and will require the joint effort of all involved parties, coordinated by the Network Manager.

#### 3.3.2.1 Horizontal en-route flight efficiency

Please note that the scale of the horizontal flight efficiency metric has been changed so that it now shows the level of efficiency instead of the level inefficiency. The underlying methodology remained unchanged.

Figure 3-25 shows the horizontal en-route flight efficiency for the actual trajectory and the last filed flight plan for the EUROCONTROL area<sup>11</sup>.

While remaining at very high levels (the 100% level is a theoretical value), after a continuous improvement over the past years, the value of horizontal flight efficiency slightly decreased in 2016 compared to 2015. At Pan-European level, horizontal flight efficiency in filed flight plans decreased from 95.5% in 2015 to 95.4% in 2016. At the same time, the efficiency of actual trajectories decreased stronger from 97.3% to 97.1% in 2016.

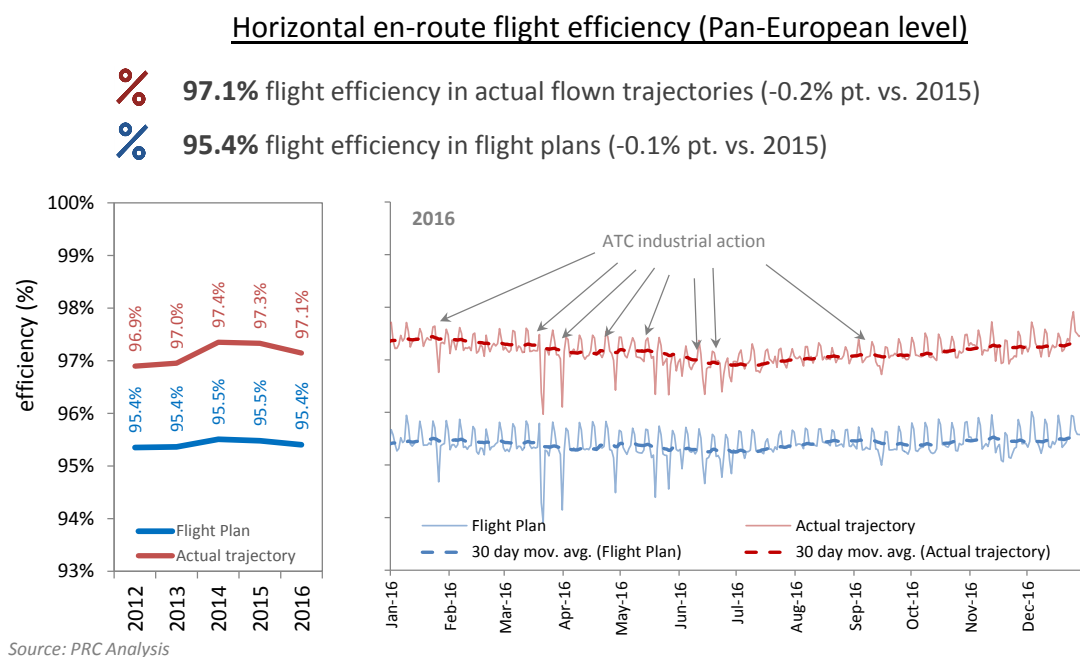


Figure 3-25: Horizontal en-route flight efficiency (Pan-European level)

<sup>11</sup> The Pan-European airspace analysed in this section refers to the NMOC area.

The analysis of daily values shows a weekly pattern with higher efficiency during the weekend and lower efficiency during the week (which has been the subject of detailed analysis in PRR2015).

Although the effects of ATC industrial action on specific days in 2016 are clearly visible on the right graph of Figure 3-25, at Pan-European level, the annual value for horizontal flight efficiency improves by merely 0.03% points if days with industrial action are removed from the analysis.

A possible indirect reason for the deterioration is linked to the rising congestion, leading to more and more cases in which the trade-off between length of the trajectory and delay is solved in favour of longer trajectories to avoid congested airspace.

With the current route network to a large extent designed on a structure based on ground-based navigation aids, technological developments on board of new aircraft have outpaced the way the current ANS system is operated resulting in a sub optimal utilisation of the aircraft capabilities. The implementation of [Free Route Airspace \(FRA\)](#), which would now be possible throughout the entire EUROCONTROL area, gives the aircraft operators more freedom in the choice of the flight plan and the possibility to avoid some of the restrictions imposed by a rigid route network. This leads to a more flexible environment which responds more dynamically to changes in traffic flows.

Although flight efficiency will never be 100%, the benefits that the implementation of FRA can bring in terms of flight efficiency gains and resulting reductions in costs, fuel burn and emissions are substantial.

Figure 3-26 shows the level of flight efficiency in actual trajectories (X-Axis) and filed flight plans (Y-Axis) by State in 2016. States in which FRA is available 24 hours are shown in red.

The benefits are clearly visible. On average, States where FRA has been fully implemented all day show a 1.6 percent point higher flight efficiency compared to the other States where FRA has not been fully implemented. It should however be noted that improvements due to FRA implementation vary by airspace and depend, inter alia, on traffic volume, complexity and other factors.

Furthermore, it can also be seen that the gap between the flight plan efficiency and the efficiency in the actual flown trajectory (the vertical distance between a point and the diagonal) is narrower than for the other States (1.0 percent point smaller gap). Actual operations closer to plan improves the level of predictability for all players involved with a positive impact on capacity and resource utilisation.

The notable gap between flight plans and actual flown trajectories, which has been highlighted in previous years, is clearly more prominent in States where FRA has not been fully implemented all day.

This provides evidence that, while the inefficiencies are the result of complex interactions between airspace users, ANSPs and the Network Manager, FRA enables a better match between the planning and operational phase.

#### Free route airspace (FRA) benefits on flight efficiency (2016)

- 1.6 %pt. higher average flight efficiency in FRA States (2016)
- 1.0 %pt. smaller gap between flight plan and actual in FRA States (operations closer to plan)

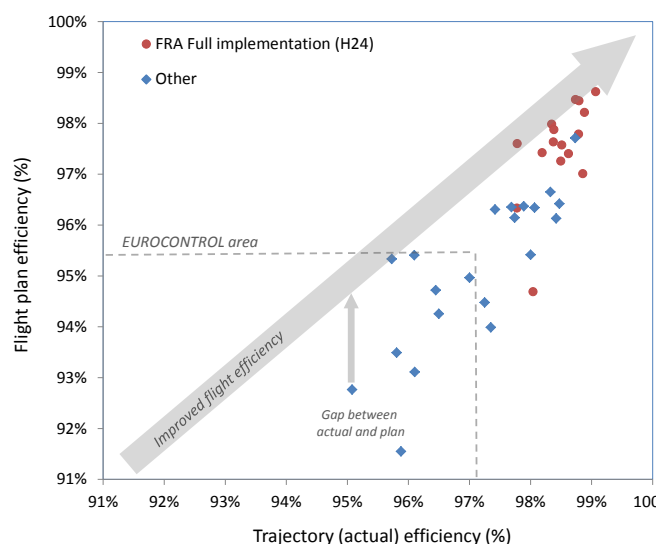
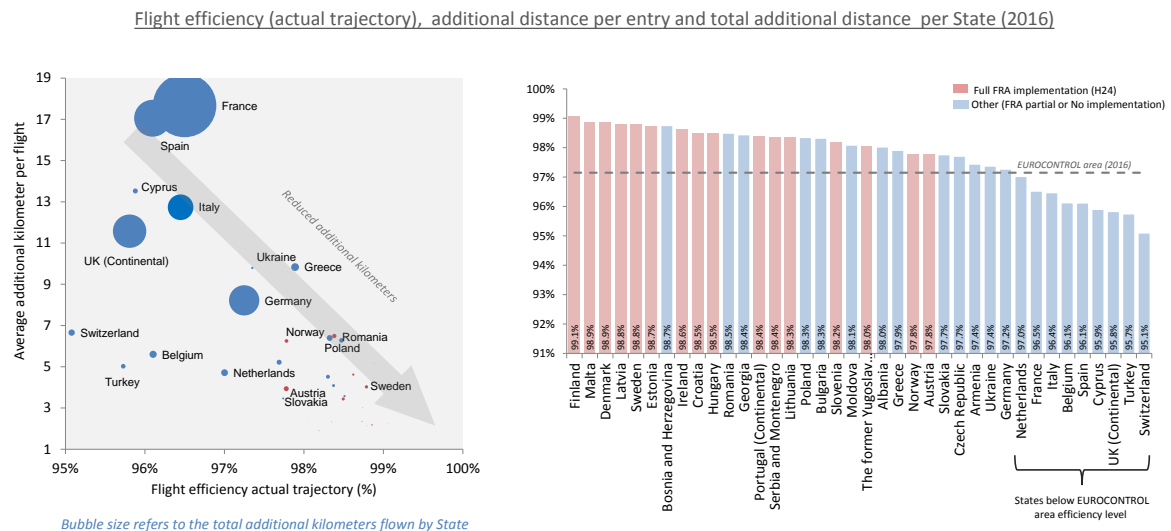


Figure 3-26: Flight efficiency by State (2016)

Figure 3-27 shows the horizontal en-route flight efficiency on the actual trajectories by State for 2016. Those States where FRA is fully implemented all day are highlighted in red<sup>12</sup>.



**Figure 3-27: Horizontal en-route flight efficiency (actual trajectory) by State (2016)**

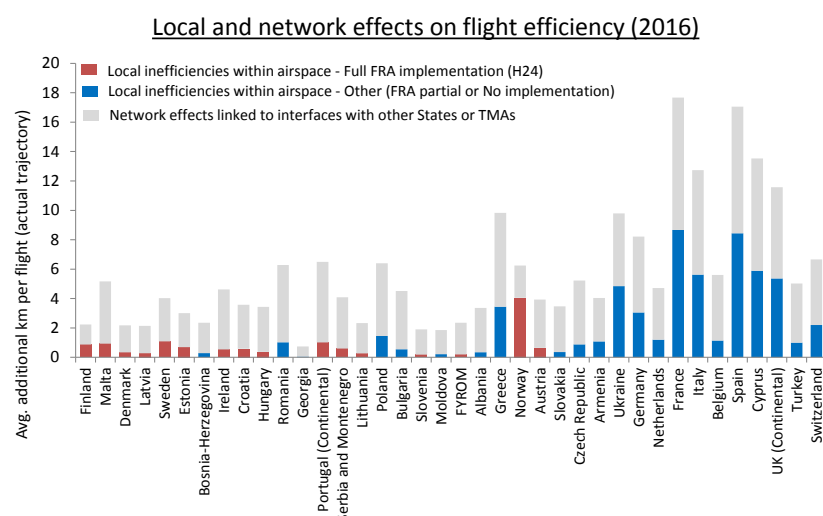
Flight efficiency is expressed as a ratio of total distances and is therefore not influenced by traffic volume or individual flight length. The absolute values of the additional distance per flight and per State provide a more complete picture and explain which States influence more the overall value for the EUROCONTROL area.

The scatter plot on the left side of Figure 3-27 provides a link between the three quantities. It shows the flight efficiency of the actual trajectory (X-axis), the average additional distance per flight (Y-axis), and the total additional distance of the Member State (the size of the bubble). France combines a below average flight efficiency with long average flight segments (and a high traffic volume) which consequently results in a substantial amount of total additional kilometres in 2016 (the bubble for the EUROCONTROL area would be the sum of all the bubbles).

All else being equal, if the nine States below the EUROCONTROL average could have improved the flight efficiency of the actual trajectories by 0.2 percent points in 2016, the saved distance would have been equivalent to 8.2 million kilometres in 2016 and flight efficiency in the EUROCONTROL area would have improved by 0.1 percent points. On the other hand, the same improvement of 0.2 percent points by the nine best States would improve system wide flight efficiency performance by merely 0.02 percent points.

The Horizontal Flight Efficiency methodology considers the entire flight extension and not local Great Circle Distances. It allows therefore a breakdown of local and network effects.

Figure 3-28 shows the results on a per flight basis.



**Figure 3-28: Local and network effects on flight efficiency by State (2016)**

<sup>12</sup> Please note that Italy is not shown in red as FRA was only fully implemented in early December 2016. The resulting benefits are therefore expected to be visible in the analysis of 2017.

In general, States implementing FRA show a very low local component (the coloured part of the bars), while other States present potential for reduction of those local inefficiencies.

There is potential for additional reduction in the length of the trajectories by reducing the network component (grey part of the bars). This requires the joint effort of all involved parties, best coordinated by the Network Manager.

According to the ATM Master Plan, Free Route Airspace on a H24 basis should be implemented throughout the entire EUROCONTROL area<sup>13</sup> by 2021. As highlighted in PRR2015, ANSPs should work actively with the Network Manager and the Deployment Manager to deliver FRA across the entire EUROCONTROL area including necessary cross-border implementation as soon as possible.

Research is ongoing to better understand and quantify the individual contributing factors (flight planning, awareness of route availability, civil-military coordination, etc.) in order to identify and formulate strategies for future improvements. A crucial prerequisite for the development of a better understanding is the collection of better data on the activation of special use airspace and on route availability when the flight plan was submitted by airspace users (shortest available route).

### 3.3.2.2 Vertical en-route flight efficiency

In order to address a growing stakeholder interest to better evaluate the vertical component of flight efficiency, this section presents a first evaluation of vertical en-route flight efficiency. Because of the distinct nature of the different phases of flight, specific methodologies were developed for the analysis of vertical flight efficiency during climb and descent on the one hand and for the analysis of en-route vertical flight efficiency on the other hand. More information on methodologies is available online at <http://www.eurocontrol.int/ansperformance/dataportal>.

The focus of the following section is on the en-route phase rather than on the climb and descent phases which is addressed in more detail in Chapter 4 of this report. It is also important to point out that the analysis in this section does not aim at quantifying the total amount of vertical en-route inefficiencies in the EUROCONTROL area nor does it identify all underlying reasons for the observed inefficiencies. Instead, it enables an understanding to be gained of the potential level of vertical flight inefficiencies on specific airport pairs, in order to evaluate some specific cases in more detail.

The main assumption for the analysis of en-route vertical flight efficiency is that level capping due to ATC constraints is inefficient during the flight planning. Based on the assumption that flights on airport pairs with similar Great Circle Distance (GCD) should be able to reach similar cruising altitudes, the methodology compares the maximum filed flight levels of flights on a specific airport pair and flights on reference airport pairs with a similar GCD and without RAD (Route Availability Document) constraints.

Figure 3-29 illustrates the distribution of observed maximum filed flight levels on a given airport pair (blue line) and the reference distribution based on airport pairs with a similar GCD (red line).

This representation allows determining the share of flights that are filing lower than the reference flights (impacted flights) and also the altitude difference between them.

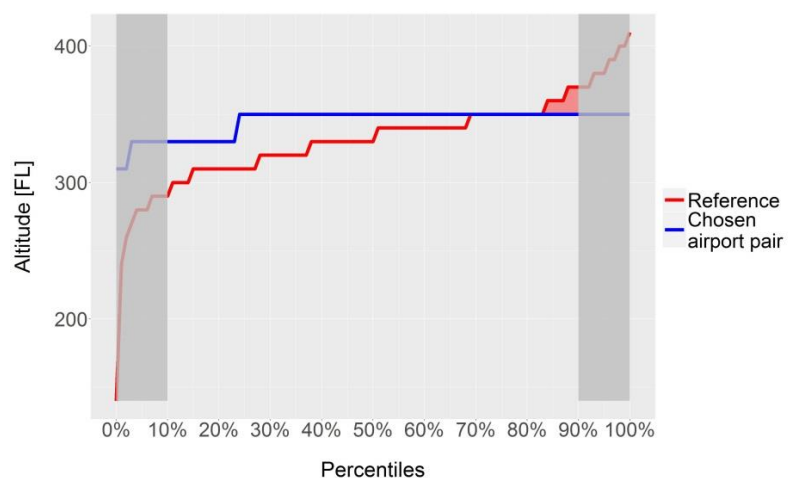


Figure 3-29: Example distribution of maximum filed flight levels

<sup>13</sup> Updates on the status of FRA implementation can be found on the corresponding [EUROCONTROL web page](http://www.eurocontrol.int).

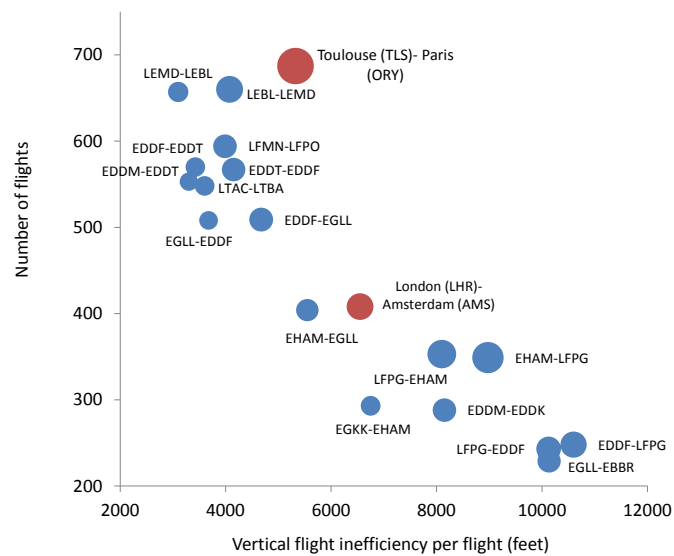
Although in a number of cases the flights on the given airport pair show a higher maximum flight level than the reference distribution, the focus is on vertical inefficiencies represented by the red shaded area in Figure 3-29.

The total vertical flight inefficiency (VFI) is then based on the number of impacted flights and the altitude differences. To account for statistical uncertainties, the lowest and highest 10% of the flights (grey areas in Figure 3-29) are not considered in the analysis. A more detailed explanation of the methodology can be found on the [ANS data portal](#).

The methodology was applied to all airport pairs within the ECAC area that have at least 1,000 flights per year.

The analysis was carried out for the May 2015 AIRAC cycle (30/04/2015 to 27/05/2015).

**Top 20 airport pairs in terms of total vertical flight inefficiency**  
(30/04/2015 to 27/05/2015)



Bubble size refers to the total vertical flight inefficiency on the respective city pair

**Figure 3-30: Results for the top 20 airport pairs in terms of total VFI**

Figure 3-30 shows the results for the top 20 airport pairs by total vertical flight inefficiency.

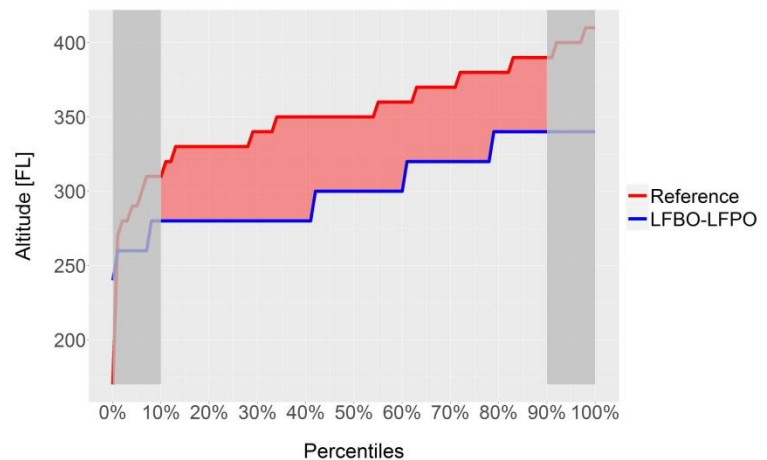
The number of flights is shown on the Y-axis and the vertical inefficiency per flight is shown on the X-axis. The size of the bubble refers to the total vertical flight inefficiency on the respective airport pair during the analysed period.

The flights from Toulouse (TLS) to Paris Orly (ORY) showed the largest total vertical flight inefficiency with each flight filing 5,325 feet below the reference flights on average.

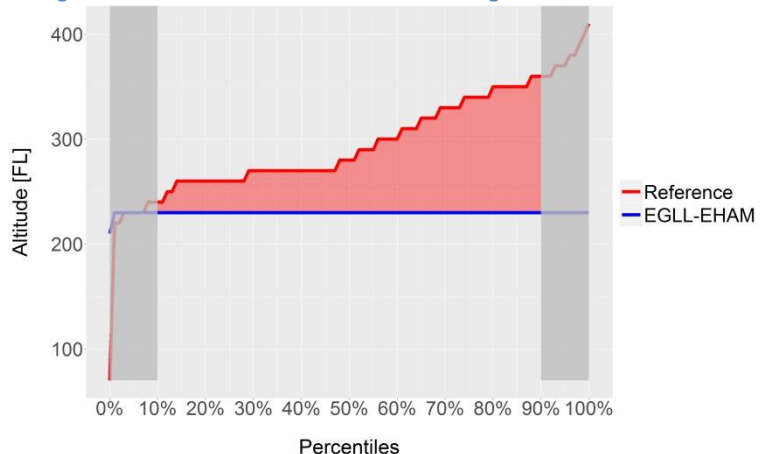
The distributions of the maximum filed flight levels on the two airport pairs Toulouse (TLS)-Paris (ORY) and London Heathrow (LHR) to Amsterdam (AMS) (highlighted in red in Figure 3-30) are shown below in more detail.

Flights from Toulouse to Paris Orly cannot file higher than FL345 according to the Route Availability Document (RAD) which explains that the maximum filed altitude is FL340 (Figure 3-31).

Further investigation revealed that one airline filed FL280 as their maximum flight level, probably because of an old restriction in their flight planning system. Around 30% of the flights are filing at FL300 or FL320 but the reason for this is not immediately clear.



**Figure 3-31: Distribution of maximum filed flight levels for LFBO-LFPO**



**Figure 3-32: Distribution of maximum filed flight levels for EGLL-EHAM**



Flights from London Heathrow (LHR) to Amsterdam (AMS) are level-capped below FL235, according to the RAD. In practice, this results in almost all flights filing at FL230 as can be seen in Figure 3-32. According to NATS, this constraint is applied due to Swanwick sectorisation, the inbound standing agreement level and the need to simplify traffic flows into and out of the London and Amsterdam areas. On average, flights are filing 6,550 feet lower than the reference flights.

The methodology will be further developed in order to increase the stability of the reference distributions. Future outputs will include time series of the inefficiencies over several AIRAC cycles and a first quantification of the measured inefficiencies in terms of fuel burn and CO<sub>2</sub> emissions.

### 3.3.3 Short term ATFCM measures (STAM)

**Definition:** An approach to smooth sector workloads by reducing traffic peaks through short-term application of minor ground delays, appropriate flight level capping and exiguous rerouting to a limited number of flights.

Short-term ATFCM measures (STAMs) can reduce the complexity of anticipated traffic peaks and hence help reducing the number of ATFM regulations. [FMPs](#) analyse the associated lists of flights to anticipate ATC workload and identify actions to be taken in order to reduce the traffic complexity generated by those flights.

Aircraft operators have expressed concerns that, although they generally support the concept of applying specific localised measures to avoid systematically applying more cumbersome regulations, the adverse effects of STAM measures need to be monitored so that they can be considered in the overall service quality of ANS operations.

The PRC agrees with this approach and has investigated how and where the adverse effects of STAM are, or could be, recorded.

**Minor ground delays:** The application of minor ground delays on departing traffic at the behest of local/national ATC can lead to an increase in the taxi-out time of the aircraft concerned as they have to queue until the departure conditions are met: therefore the local performance indicator for Taxi-Out-additional time would increase. If the departing aircraft is delayed at the gate instead of during the taxi-out, then the adverse impact would be captured in the ATC pre-departure delay 'IATA code 89', which is also monitored as a local airport performance indicator.

**Flight level capping:** Currently there is no metric for quantifying the ad-hoc flight level capping arrangements between ATC units as part of STAM. This is somewhat similar to non-availability of requested flight level due to safety (conflicting traffic) or weather (turbulence etc), or indeed tactical change in cruising level per pilot request. Any flight level capping arrangements promulgated through the Network Manager, for example the application of a RAD restriction or the application of a scenario, can identify the impact of the restrictions on filed flight plans (see en-route vertical flight efficiency later in this report).

**Re-routing:** If the re-routing constraints are propagated through the Network Manager resulting in changes to flight plans, then this will become visible and measurable for the horizontal flight efficiency metric that is based on the last filed flight plan. If the re-routing is of a tactical nature, such as STAM re-routing, it will become visible through the horizontal flight efficiency metric based on actual trajectory. Basing both horizontal flight efficiency metrics on achieved distance enables the identification and reporting of performance at local level.

In summary, most of the adverse effects of STAM can be monitored through different performance indicators and the PRC will work towards developing new metrics and improving existing ones so that eventually, all ANS constraints can be identified and monitored.

## 3.4 Civil Military cooperation & coordination

### 3.4.1 PRC Review on behalf of Provisional Council.

To meet the increasing needs of both sets of stakeholders in terms of volume and time and to maximise the use of finite resource airspace, close civil/military co-operation and co-ordination across all ATM-related activities is crucial.



Following the PC recommendation, stemming from PRR 2015 [Ref. 5], to evaluate how the current arrangements could be further improved to benefit both civil and military stakeholders; the PRC carried out a review of existing civil/military co-operation and co-ordination procedures [Ref. 10] within EUROCONTROL Member States.

The questionnaire focused in particular on the information available to the Level 2 actors in airspace management: to the airspace managers involved in the pre-tactical activities and in the allocation of airspace to satisfy the requirements of both civil and military airspace users.

It was structured around 9 specific criteria relevant to individual aspects of civil military coordination and cooperation. All criteria are linked; the information obtained in each allows the different entities (civil, military) to share information and take effective decisions for the benefit of all airspace users.

The summary of the identified main issues from the feedback received through the questionnaire is shown in Figure 3-33. They suggest that there is scope for improvement in the overall processes related to the management of airspace. In particular, the main issues relate to:

- the lack of impact assessments regarding restricted or segregated airspaces and the effect they have on general air traffic, in terms of available ATC capacity and route options;
- the absence of clear national / regional strategic objectives for both OAT and GAT at ASM level 1; and,
- the haphazard flow of information throughout the ASM process (availability of the right information to the relevant parties at the right time).

There is a need to ensure a functioning feedback loop to ensure that results and issues observed at ASM level 3 are fed back to the previous two levels (strategic, pre-tactical) in order to improve processes where necessary for the benefit of all airspace users.

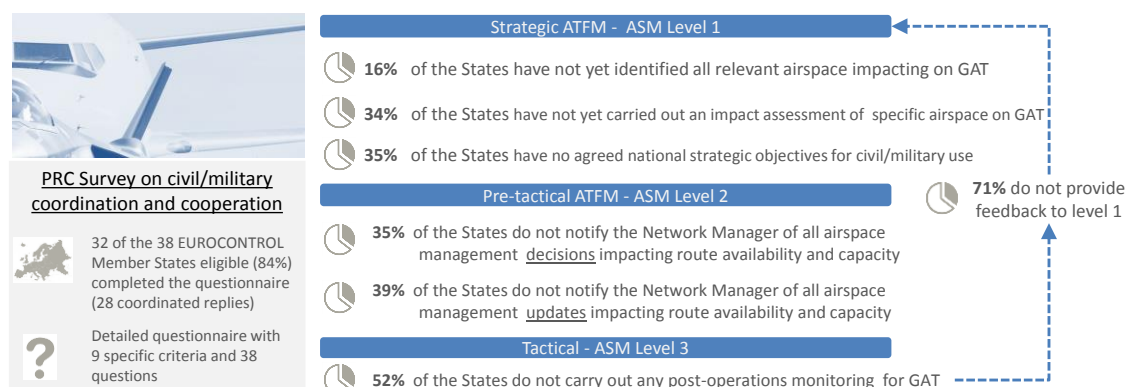


Figure 3-33: Identified improvement areas for civil/military cooperation and coordination

### 3.4.2 Additional questions on civil military coordination and cooperation.

In preparation for PRR 2016, the PRC invited Member States to provide additional information on cases where military booking requests were adjusted, or cancelled, because of conflicts with GAT traffic demand - by providing answers to the following two questions:

- Number of times that specific airspace booking requests for military operations and training, were conflicting with GAT traffic demands, and which directly led to the mission being cancelled;
- Number of times that specific airspace booking requests for military operations and training, were conflicting with GAT traffic demands but where adaptations in either the timing or the location of the mission enabled the mission to be completed as required.

Only ten Member States replied to the follow up question but all of them stated that no adjustments were made due to conflicts with GAT traffic demand. The replies support the observations from the questionnaire that there is scope for improvement in terms of impact assessment and in the formulation of strategic objectives for civil/military coordination and cooperation.

### 3.5 Conclusions

Traffic in the EUROCONTROL area increased for the third consecutive year in 2016. Of the 39 ANSPs included in the analysis, 25 showed an increase in traffic compared to 14 ANSPs which showed a traffic decline. In absolute terms, ENAIRE (Spain), NATS (UK), and DSNA (France) experienced the highest year on year growth in 2016. DHMI (Turkey), UKSATSE (Ukraine) and ROMATSA (Romania) reported the highest absolute decrease in 2016.

It is remarkable that 35 of the 63 Area Control Centres (ACCs) reported their highest traffic levels on record in 2016, surpassing the previously highest levels dating back before the start of the economic crisis in 2008. ACCs with growth rates above 10% in 2016 were Palma, Lisbon, Canarias, and Dublin ACC.

En-route ATFM delays in the EUROCONTROL area increased for the third year in a row in 2016 (+20.9% vs 2015). The percentage of flights affected by ATFM en-route delays increased from 3.9% to 4.8% but the delay per delayed flight decreased slightly from 18.8 minutes to 18.0 minutes in 2016.

ATC Capacity/Staffing related constraints remained by far the main driver of en-route ATFM delays (55.3%), followed by weather related constraints (18.3%), ATC disruptions/ industrial actions (12.3%), and Event related constraints (9.1%) which also include delays due to ATC system upgrades.

Three quarters of the en-route delays were generated by four air navigation service providers: DSNA (41.6%), DFS (13.0%), Maastricht (11.4%), and ENAIRE (9%).

The most constraining ACCs in 2016 were Brest, Nicosia, Bordeaux, Brussels, Barcelona, Prestwick, Maastricht UAC, Warszawa, Canarias, Karlsruhe UAC, and, Marseille. Together, they accounted for 70.1% of all en-route ATFM delays but only 30.1% of total flight hours controlled in the EUROCONTROL area.

After a continuous improvement over the past years, horizontal flight efficiency slightly decreased in 2016 compared to 2015. At Pan-European level, horizontal flight efficiency in filed flight plans decreased from 95.5% in 2015 to 95.4% in 2016. At the same time, the efficiency of actual trajectories decreased stronger from 97.3% to 97.1% in 2016.

At Pan-European level, the effects of ATC industrial action on specific days in 2016 are clearly visible but the overall impact on horizontal flight efficiency remains within 0.03% points.

The benefits that the implementation of FRA can bring in terms of flight efficiency and related reductions in fuel burn, emissions and costs are substantial. The average of horizontal en-route flight efficiency is 1.6% better for member States in which Free route airspace (FRA) is fully implemented all day. Furthermore, most of the gains are already realised in the flight planning phase - the gap between flight planned and actual flown trajectory efficiency is 1.0% point narrower than for the other States.

All else being equal, if the nine States below the EUROCONTROL average could have improved the flight efficiency of the actual trajectories by 0.2 percent points in 2016, the saved distance would have been equivalent to 8.2 million kilometres in 2016 and flight efficiency in the EUROCONTROL area would have improved by 0.1 percent points.

In order to address a growing stakeholder interest to better evaluate the vertical component a first evaluation of vertical en-route flight efficiency has been carried out. The analysis did not aim at quantifying exactly the total level of vertical en-route inefficiencies in the EUROCONTROL area but to gain an understanding of the potential level of vertical flight inefficiencies on specific airport pairs in order to evaluate some specific cases in more detail. The results, expressed in terms of feet (total VFI) and feet per flight (VFI per flight), showed clear differences in airport pairs. The methodology will be further developed in order to gain a better understanding of the measured inefficiencies, also in terms of fuel burn and CO<sub>2</sub> emissions.

Close civil military cooperation and coordination is a crucial enabler to improve capacity and flight efficiency performance. The PRC has identified that areas for further improvement relate to the lack of impact assessment in terms of capacity and route options for restricted/segregated airspace, the absence of clear strategic objectives and the lack of feedback throughout the ASM process.



## 4 Operational ANS Performance at Airports

SYSTEM TREND (TOP 30 AIRPORTS IN TERMS OF TRAFFIC)	2016	Trend	change vs. 2015
<i>Average daily movements (arrivals + departures)</i>	22 365	↑	+2.7%
<b>Arrival flow management (per arrival)</b>			
<i>Average Airport Arrival ATFM Delay</i>	1.36	↓	-0.1 min
<i>Average Additional ASMA Time (without Turkish airports)</i>	2.15	↓	-0.1 min
<i>Average time flown level during descent (without Turkish airports)</i>	3.1	↑	+0.2 min
<b>Departure flow management (per departure)</b>			
<i>Avg. ATC Pre-departure Delay (based on airline delay data)</i>	1.0	→	+/-0.0 min
<i>Average additional Taxi-out Time (without the Turkish airports)</i>	3.7	↑	+0.2 min
<i>Average time flown level during climb (without Turkish airports)</i>	0.5	→	+/-0.0 min

### 4.1 Introduction

The economic downturn starting in 2008 led to a notable downward adjustment of airport capacity expansion plans over the next 20 years. At the same time, air traffic demand in Europe in 2035 is forecast to be some 50% higher than in 2012 which makes the provision of sufficient airport capacity one of the key challenges for future air transport growth [Ref.7].

There are difficulties in achieving infrastructure growth at the locations where capacity is needed and even in regions where expansions are possible the difficulty will increase as the population grows. Hence, in view of the expected shortfall of airport capacity, the optimised use of available capacity is crucial to keep delays to a minimum. Operational ANS performance plays a key role in balancing traffic with available capacity at airports within the given infrastructural and environmental constraints and in the integration of airports in the European air transport network.

This chapter provides a review of operational ANS performance at major European airports. The evaluation of future airport capacity requirements (e.g. new runway, taxiways, etc.) is beyond the scope of this report.

As part of the regular operational ANS performance review at European airports, this chapter presents an evaluation of the top 30 airports in terms of IFR movements in 2016, which have the strongest impact on network-wide performance. Together those airports accounted for 45.5% of total European movements in 2016. Any unusual performance observed at an airport not included in the top 30 is commented on in the respective sections of the chapter.

Further information on the underlying methodologies and data for monitoring the ANS-related performance at all reviewed airports is available online on the [ANS performance data portal](#).

For the interpretation of the analysis in this chapter, it is important to point out that the observed outcome is the result of complex interactions between stakeholders (airlines, ground handlers, airport operator, ATC, slot coordinator, etc.), which make a clear identification of underlying causes and attribution to specific actors difficult. While at airports, ANS is often not the root cause for an imbalance in capacity/demand (e.g. adverse weather, policy decisions in the airport scheduling phase, traffic demand variation, airport layout) the way air traffic is managed has an effect on airspace users (time, fuel burn, costs), the utilisation of available capacity, and the environment (emissions).

Hence, the analyses in the respective sections of this chapter should not be interpreted in isolation, but as an integral part of the overall operational performance observed at the airport concerned.

At congested airports, one of the primary tools for balancing operational capacity and demand is the airport slot coordination process. But even after unaccommodated demand is removed by allocating airport arrival and departure slots in the strategic phase, there is an important trade-off between the maximised use of scarce capacity and the acceptable level of operational inefficiencies to be considered.

Depending on the commercial value of the airport slots, the number of contingency slots can be close to zero during certain peak periods or in some cases throughout most of the day.

The closer airports operate at maximum capacity, the more severe is the impact in terms of operational inefficiencies if reduced capacity is available (due to weather, etc.) or if demand is higher than planned due to variability of traffic demand.

The following sections evaluate ANS-related inefficiencies on the departure and arrival traffic flow at the top 30 airports. The performance indicators used for the analysis in this chapter are below.

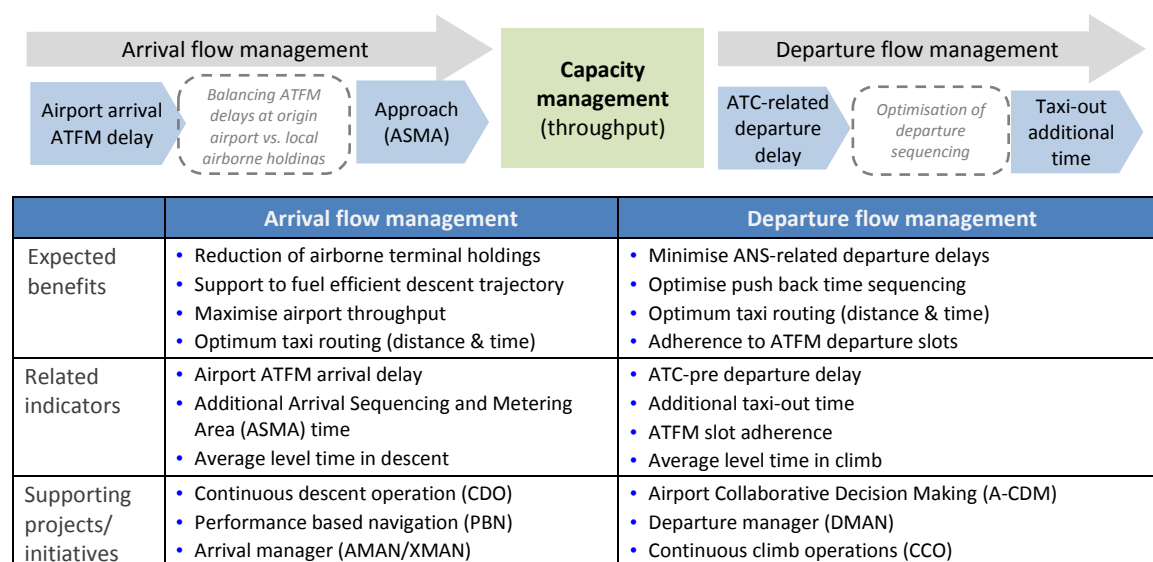


Figure 4-1: ANS-related operational performance at airports (overview)

The indicators relate to the optimisation of the inbound and outbound traffic flow and are also part of the SES performance scheme. Complementary to the four standard indicators, an analysis of continuous climbs and descents is provided. A separate study looking at the en-route aspect of vertical flight efficiency can be found in Chapter 3.

Through the Global Air Navigation Plan (GANP) [Ref.8], ICAO has established a framework for harmonising airborne and ground-based capabilities. The Aviation System Block Upgrades (ASBUs) comprise packages of capabilities with clearly defined measurable operational improvements, necessary equipment on the ground and in the air, and associated standards and operational procedures.

The focus of the current implementation roadmaps are the ASBU Block 0 and 1 Upgrades. With a view to operational ANS performance at airports these upgrades include the following modules.

Table 4-1: ASBU Performance Improvement Areas and Block upgrades (airport)

ASBU Performance Improvement Area	Block 0 (2013)	Block 1 (2018)
Airport Operations	<ul style="list-style-type: none"> <li>optimised approach procedures, incl. vertical guidance</li> <li>increased runway throughput through optimised wake turbulence separation</li> <li>improve traffic flow through sequencing (AMAN/DMAN)</li> <li>Improved airport operations through Airport-CDM</li> </ul>	<ul style="list-style-type: none"> <li>optimised airport accessibility</li> <li>further enhanced enablers</li> <li>increased runway throughput through optimised wake turbulence separation</li> <li>improved airport operations through departure, surface, and arrival management</li> </ul>
Efficient Flight Path	<ul style="list-style-type: none"> <li>improved flexibility and efficiency in descent profiles using CDO and CCO</li> </ul>	<ul style="list-style-type: none"> <li>improved flexibility and efficiency</li> <li>improved traffic synchronisation</li> </ul>

## 4.2 Traffic evolution at the top 30 European airports

Figure 4-2 shows the evolution of average daily IFR movements at the top 30 airports in absolute and relative terms<sup>14</sup>. On average, movements (arrival + departure) at the top 30 airports in 2016 increased by 2.7% compared to 2015.

Amsterdam airport, with a global increase in traffic of 5.9%, reported the highest traffic level on record and became the busiest airport in Europe in terms of IFR movements in 2016. The observed growth was mainly due to a substantial increase in low-cost traffic.

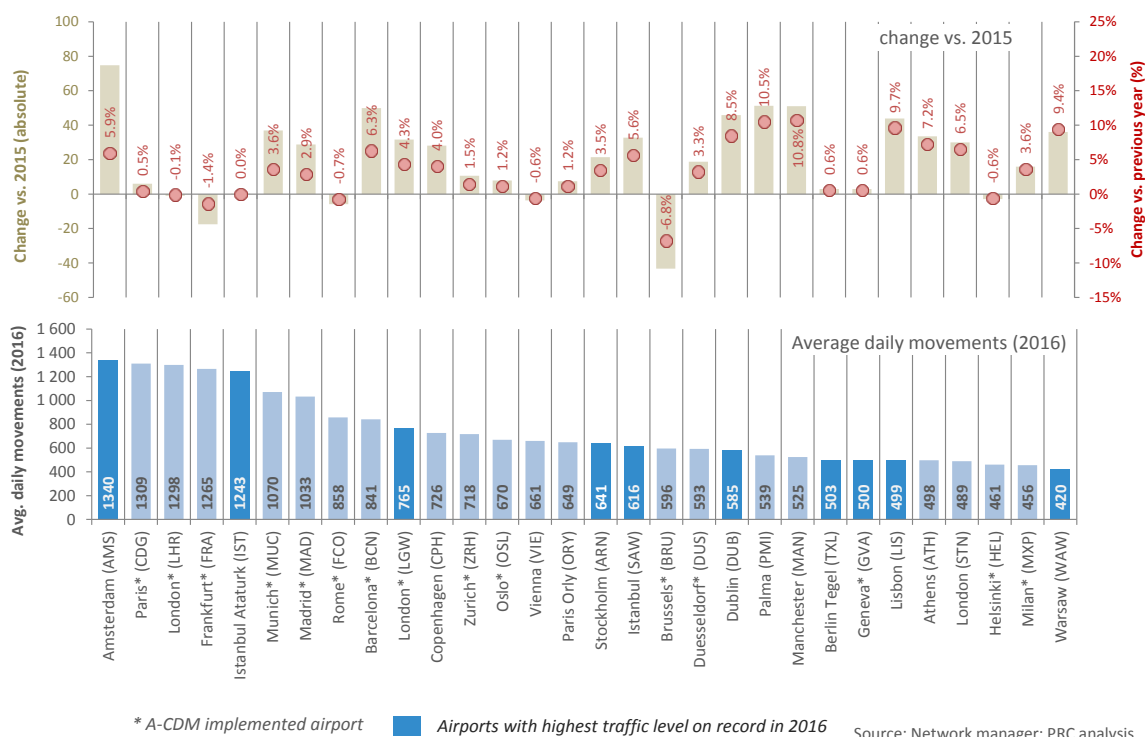


Figure 4-2: Traffic variation at the top 30 European airports (2016/2015)

Antalya, previously in the top 30 airports, has suffered a major drop in traffic of almost 30% of movements in total and up to 40% in the summer season showing the tourism downfall mainly due to the migration crisis, escalating security concerns and political problems. This resulted in Warsaw entering the top 30 airports, reinforced by a significant increase in Warsaw traffic of almost 10%.

The two Istanbul airports, which reported a remarkable traffic growth over the past years, were affected by the situation in Turkey and by the capacity constraints, showing a slowdown in this yearly traffic increase.

Traffic at Brussels (BRU) airport decreased by -6.8% over 2015 as a result of the reduced capacity following the terrorist attacks in March 2016, causing a decrease of 30% and 40% in March and April respectively.

As in previous years, the number of passengers at the top 30 airports in 2016 (+4.6% vs. 2015) increased at a higher rate than flights (+2.7%) which is consistent with the observed increase in average aircraft size and passenger load factors.

As a result of this ongoing trend, passenger numbers at the top 30 airports were in 2016 27.5% higher than in 2008 which is remarkable considering the fact that movements are merely 1.0% above 2008 levels.

<sup>14</sup> Please note that the airport ranking is based on total IFR movements, which is different from ACI Europe statistics, based on commercial movements only.

## 4.3 Capacity management (airports)

### 4.3.1 Coordination levels

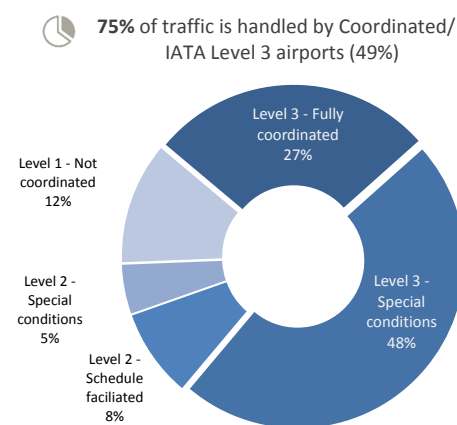
In general, the expansion of airport capacity faces various challenges ranging from administrative (e.g. regulatory requirements, planning rules) to environmental sustainability requirements (e.g. noise abatement). While increasing airport capacity in Europe is a must in the long term, there is already the need to make the best use of existing capacity at congested airports.

The objective of airport coordination is to ensure the limited airport resources are efficiently used to benefit the greatest number of airport users.

Airports are categorised as Level 1 (Non-Coordinated Airport), Level 2 (Schedules Facilitated Airport) and Level 3 (Coordinated Airport). Figure 4-3 shows the distribution of these coordination levels across airports in Europe with more than 20,000 annual movements.

Currently almost half of these airports are fully coordinated or coordinated in certain cases (only summer season, only certain hours in the day, etc.) and this number is expected to grow given the lack of capacity to cope with increasing demand.

This represents more than 60% of total movements in Europe, and nearly 75% of movements at these airports above 20,000 movements. Amongst the top 30 airports, only Athens is not coordinated. The coordination process therefore plays an important role for the capping and distributing of demand in the strategic phase which may have an impact on performance on the day of operations.



Source: PRU analysis based on IATA data

Figure 4-3: European airports coordination level (>20.000 movements/year)

### 4.3.2 Throughput and declared capacity

While the airport capacity declaration process targets the balance between the demand and the declared capacity in the strategic phase, the actual achieved throughput provides an understanding of the real utilisation of the capacity.

Figure 4-4 provides an indication of the capacity utilisation at European airports. The [Base Load Index \(BLI\)](#) refers to the share of time an airport operates above a defined base level (15% of the reference capacity) and the [Peak Load Index \(PLI\)](#) provides an indication of the share of time the airport operates above peak level (80% of reference capacity).

More information on the methodology is available on the [ANS performance data portal](#).

Considering the achieved levels of throughput across the European top 30 airports, a diverse picture emerges.

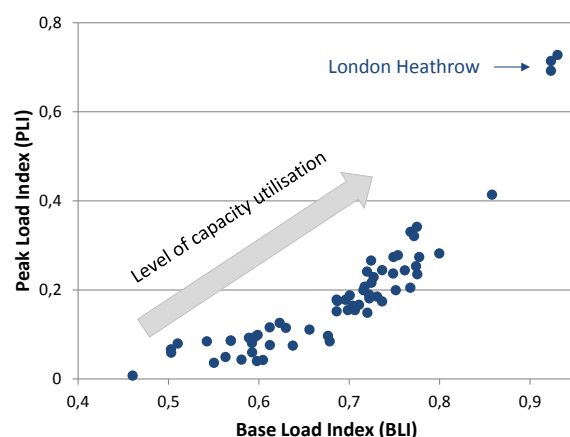


Figure 4-4: Capacity utilisation at top 30 European airports

While a number of airports show the classical throughput peaking behaviour with a consistent base level throughout ( $0.65 < \text{BLI} < 0.8$ ), London Heathrow (LHR) in the top right corner shows a clear exceptional capacity utilisation, which needs to be considered when interpreting the results given in this chapter.



The next section focuses on arrival throughput at airports which is usually more challenging than departure throughput. It compares the declared peak arrival capacity to actual throughput at the top 30 European airports. It provides an understanding of the distribution of the arrival throughput including the “peak service rate” which can be achieved in ideal conditions and with a sufficient supply of demand.

Figure 4-5 shows the declared peak arrival capacity (brown bars) in 2016 together with the observed arrival throughputs (06h00 – 22h00 local time) shown as box plots which give also an indication of the degree of dispersion of the arrival throughput.

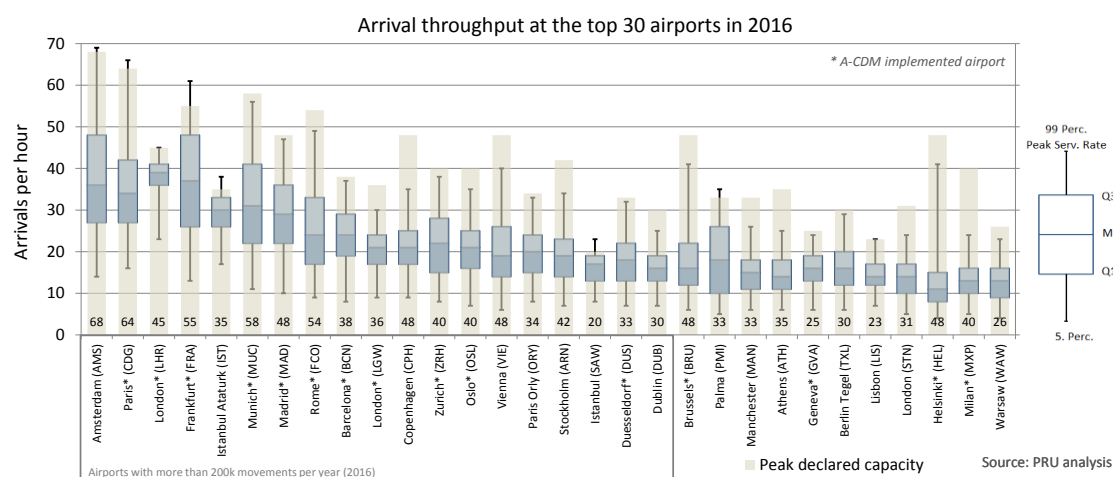


Figure 4-5: Arrival throughput at the top 30 airports

Confirming the observation from Figure 4-4 on page 40, the analysis in Figure 4-5 shows London Heathrow (LHR) with the highest median arrival throughput of all airports and with a small spread close to the peak declared arrival capacity which suggests a high intensity operation all day long. Moreover it is quite remarkable that this performance was achieved with two runways operated in segregated mode.

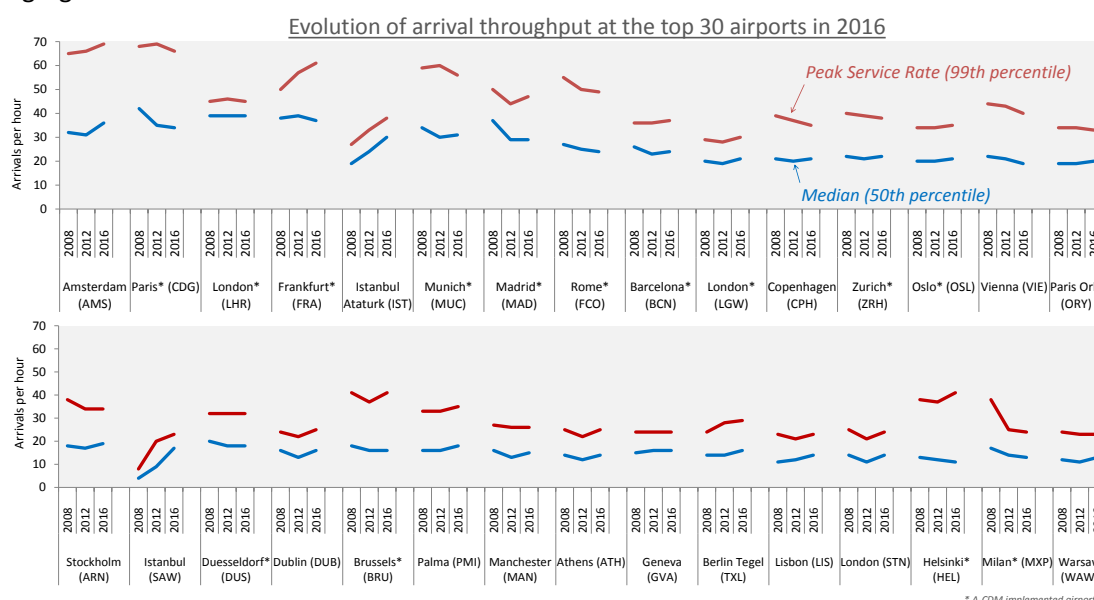


Figure 4-6: Evolution of arrival throughput at the top 30 airports (2016)

Both Istanbul airports show also a narrow distribution of the hourly throughput with a peak service rate above their declared capacities. As shown in the historic evolution of arrival throughputs (median and peak service rate) in Figure 4-6, these two airports also show a great increase of their throughput in the last 8 years during which Sabiha Gökçen quadrupled its hourly throughput. This and other indicators shown in the report highlight the urgent need for capacity deployment at Istanbul, together with improved planning and monitoring of operations.



Although the analyses in Figure 4-5 and Figure 4-6 provide a first indication of the operations at the airports, it is acknowledged that other factors such as runway layout, mode of operation, and available configurations (many runways may not be operated independently), as well as the societal factors such as noise and environmental policies, would need to be considered in a more detailed analysis.

A number of initiatives to further increase airport throughput including, inter alia, time based separation, improved wake vortex separation standards are being implemented at various capacity constrained airports across Europe, and it will be interesting to monitor the benefits of those initiatives in terms of performance in future reports.

For instance, the European Wake Vortex Re-categorisation (RECAT-EU) implemented at Paris Charles de Gaulle airport in March 2016 aims at safely increasing airport capacity by redefining wake turbulence categories and their associated separation minima, creating more categories than the traditional ICAO ones. This would allow more accurate and efficient spacing delivery with potential benefits in both runway throughput and safety.

## 4.4 ANS-related operational efficiency at and around airports

### 4.4.1 Arrival flow management

This section analyses ANS-related inefficiencies on the arrival flow at the top 30 European airports in terms of [arrival ATFM delay](#) and [additional ASMA time](#).

Please note that software release 20.0 of the Network Manager on 04 April 2016 introduced a change to improve the accuracy of the ATFM delay calculation for operational purposes which resulted in a reduction of delay compared to the old methodology as of April 2016. More information on the change is available online at <http://www.eurocontrol.int/ansperformance/dataportal>.

Changes due to the Post Operations Performance Adjustment Process were not considered in this report. More information including the list of changes in 2016 is available from the [NM website](#).

Figure 4-7 shows the arrival ATFM delay (top of figure) and the additional ASMA time (bottom of figure) per arrival at the top 30 European airports in 2016.

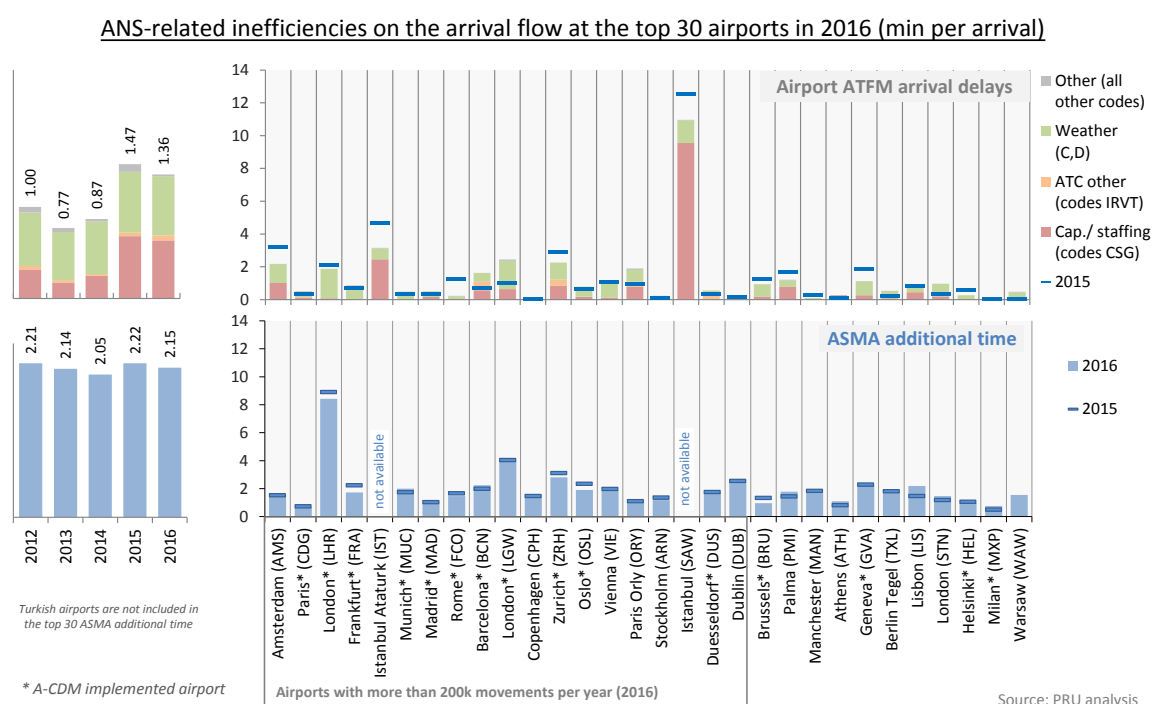


Figure 4-7: ANS-related inefficiencies on the arrival flow at the top 30 airports in 2016

On average, 6.8% of the flights arriving at the top 30 airports were delayed due to ATFM arrival regulations in 2016 (+0.3%pt. vs 2015). At the same time delays were on average shorter than in 2015 resulting in a decrease of the average delay per delayed arrival decreased by 2.4 minutes to reach 20.1 minutes in 2016.

As could be assumed from the results in Figure 4-7, Istanbul Sabiha Gökçen (42.5%) and Istanbul Atatürk airport (20.3%) had by far the highest share of arrivals delayed due to arrival ATFM regulations in 2016.

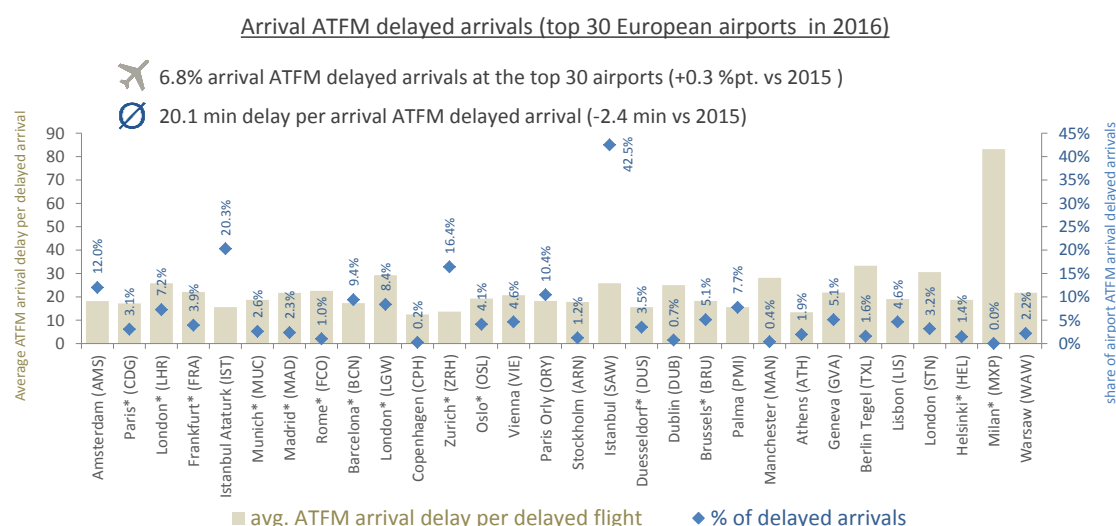


Figure 4-8: Arrival ATFM delayed arrivals at the top 30 airports (2016)

While the European average of the additional ASMA time ranges around 2 minutes per arrival throughout the last years, significant variations can be seen at local level.

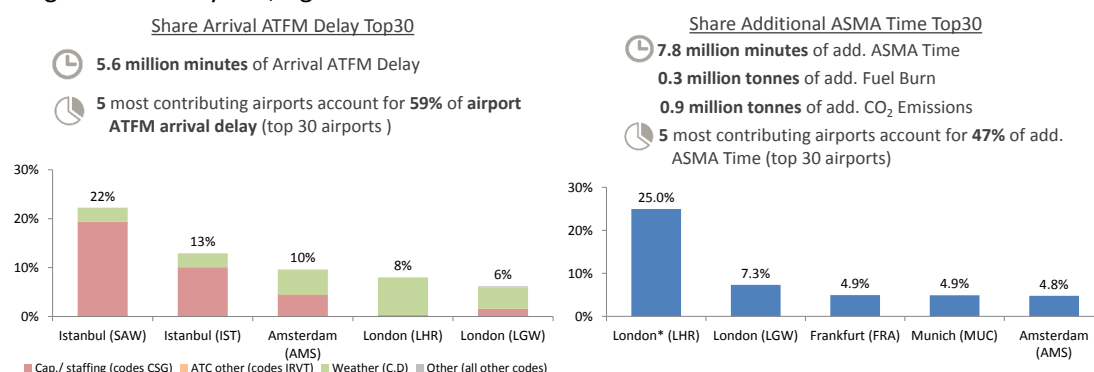


Figure 4-9: Five most contributing airports in 2016 (Arrival ATFM delay/ ASMA add. time)

At a global scale, the inefficiencies in the arrival flow at the top 30 airports resulted in 5.6 million minutes of arrival ATFM delay (84% of the total arrival ATFM delay in Europe) and 7.8 million minutes of additional ASMA (excluding Istanbul airports for which there is no ASMA data) in 2016. While the arrival ATFM delay minutes affect aircraft on the ground, the extra minutes spent in the ASMA area have an important environmental effect and associated fuel cost for the airspace users.

The 5 highest contributors to each of these indicators accounted for approximately half of total delay at the top 30 airports which is to some extent linked to the high traffic volume at those airports.

Overall, 30% of the total minutes of arrival ATFM in Europe were generated by regulations at the two Istanbul airports mainly for capacity reasons, while they only accounted for 9% of the traffic. The arrival regulations at Heathrow and Gatwick were mainly due to weather.

The main contributor for the additional ASMA time in Europe was London Heathrow which accounted for 25 % of the total minutes of the top 30 airports, while its traffic share was less than 3%. This is a consequence of the mode of operations at Heathrow, ensuring a constant demand to maximise runway throughput.

## Regional Greek airports

Although not included in the top 30, it is noteworthy to highlight the performance observed at a number of small Greek airports. As already pointed out in 2015, those regional airports continue to generate very high delays during summer with a notable impact on the network. Overall, nine smaller Greek airports (Mikonos, Zakynthos, Skiathos, Khania, Kefallinia, Santorini, Iraklion, Makedonia, Diagoras) accounted again for 5.3% of total European airport arrival ATFM delays in 2016, while handling only 1% of the traffic.

The observed airport ATFM arrival delays are linked to capacity issues but since the airports are fully coordinated during the summer months the continuous application of ATFM regulations to manage demand should not occur. Even though there is a high level of seasonality at those airports, there is a need to proactively address the issues in order to avoid a repetition of high delays in summer 2017.

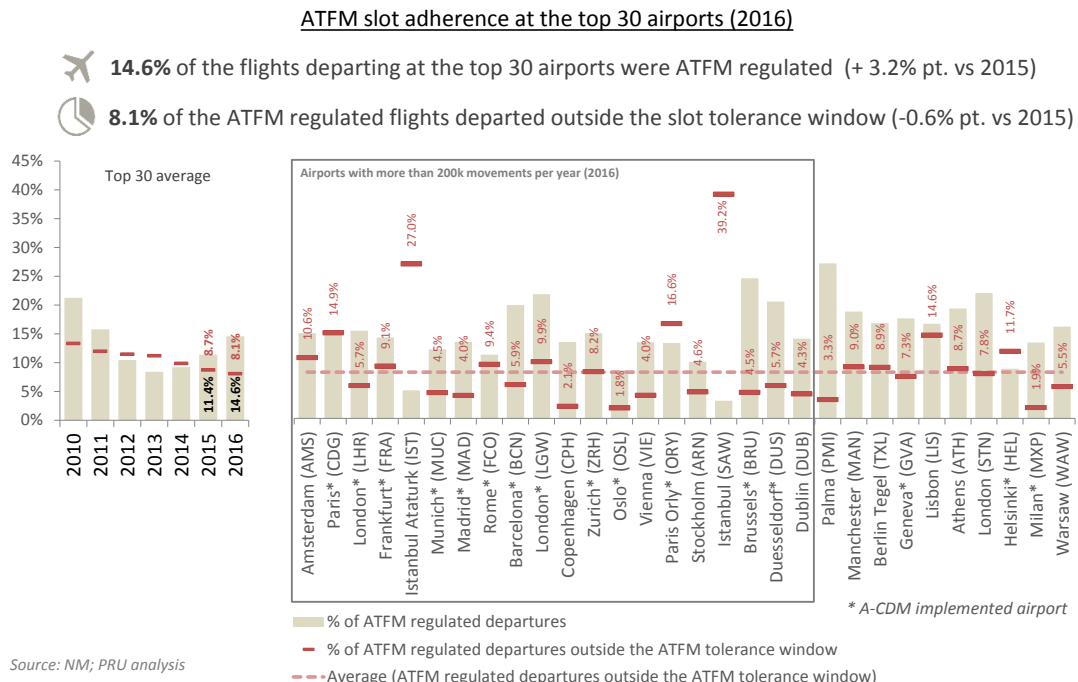
### 4.4.2 Departure flow management

This section analyses ANS-related inefficiencies on the departure flow at the top 30 European airports in terms of [ATFM departure slot adherence](#), [additional taxi-out time](#), and, [ATC pre-departure delays](#) at the gate.

#### 4.4.2.1 ATFM departure slot adherence

ATFM departure slot adherence ensures that traffic does not exceed regulated capacity and increases overall traffic flow predictability. ATFM regulated flights are required to take off at a calculated time (ATC has a 15 minute slot tolerance window [-5 min, +10 min] to sequence departures).

Figure 4-10 shows that although the share of ATFM regulated departures at the top 30 airports (brown bar) increased in 2016 from 11.4% to 14.6% the share of regulated flights departing outside the ATFM slot tolerance window (red line) further decreased from 8.7% to 8.1% which is positive in terms of network predictability.



**Figure 4-10: ATFM slot adherence at airport (2016)**

Although with a comparatively small share of ATFM regulated departures in 2016, Istanbul Sabiha Gökçen (39.2%) and Istanbul Atatürk airport (27.0%) showed again the highest share of departures outside the ATFM slot tolerance window, followed by Paris Orly (ORY), which suggests scope for improvement.

As was the case already in 2015, in contrast to almost all other fully A-CDM implemented airports, Paris Charles de Gaulle (CDG) and Paris Orly (ORY) showed again a surprisingly high share of departures outside the ATFM slot tolerance window.

#### 4.4.2.2 ANS-related inefficiencies on the departure flow

Figure 4-11 shows the local ATC departure delays (top of figure) and the taxi-out additional time at the top 30 airports. Although the level of inefficiencies cannot be reduced to zero, on average, the less fuel efficient taxi-out additional time is almost four times higher than the local ATC departure delays at the gate which suggests scope for further improvement.

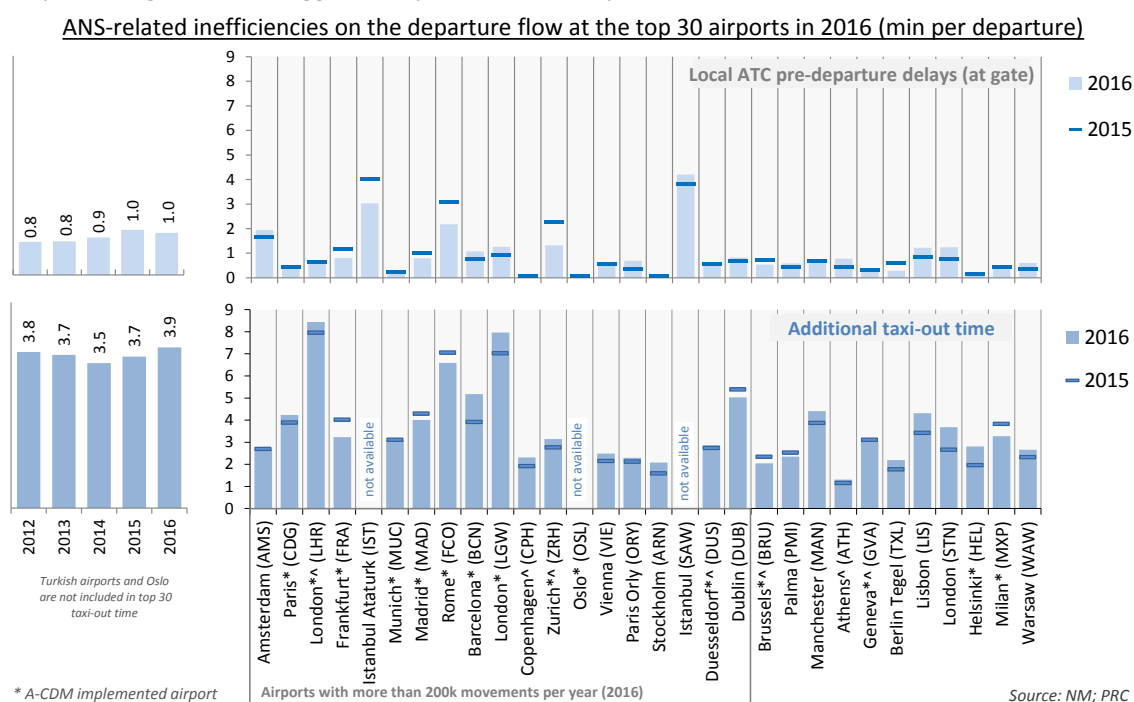


Figure 4-11: ANS-related inefficiencies on the departure flow at the top 30 airports in 2016

A-CDM should help transfer some of these minutes of extra Taxi-Out time to delay at the gate, reducing the emissions and costs. However, this effect is not visible in Figure 4-11, where A-CDM implemented airports show similar taxi-out performance as non CDM airports.

In 2016, the total additional Taxi-Out time at the top 30 airports was 12.8 million minutes with an associated fuel burn of 0.2 million tonnes. Figure 4-10 shows the 5 main contributors in 2016, all of them A-CDM airports, which accounted for 43% of the total additional Taxi-Out time. The traffic share within the top 30 airports was 23%. London Heathrow showed a similar behaviour in the departure queue as in the arrival flow, with long additional times. However, being an A-CDM airport, the holding should mostly take place at the gate.

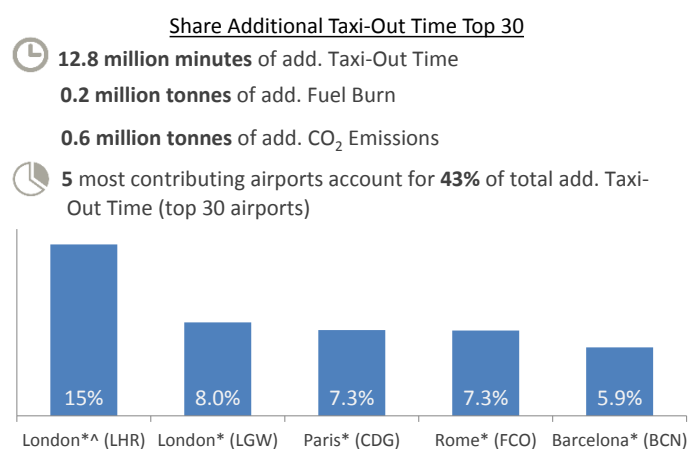


Figure 4-12: Five most contributing airports in 2016 (taxi-out add. time)

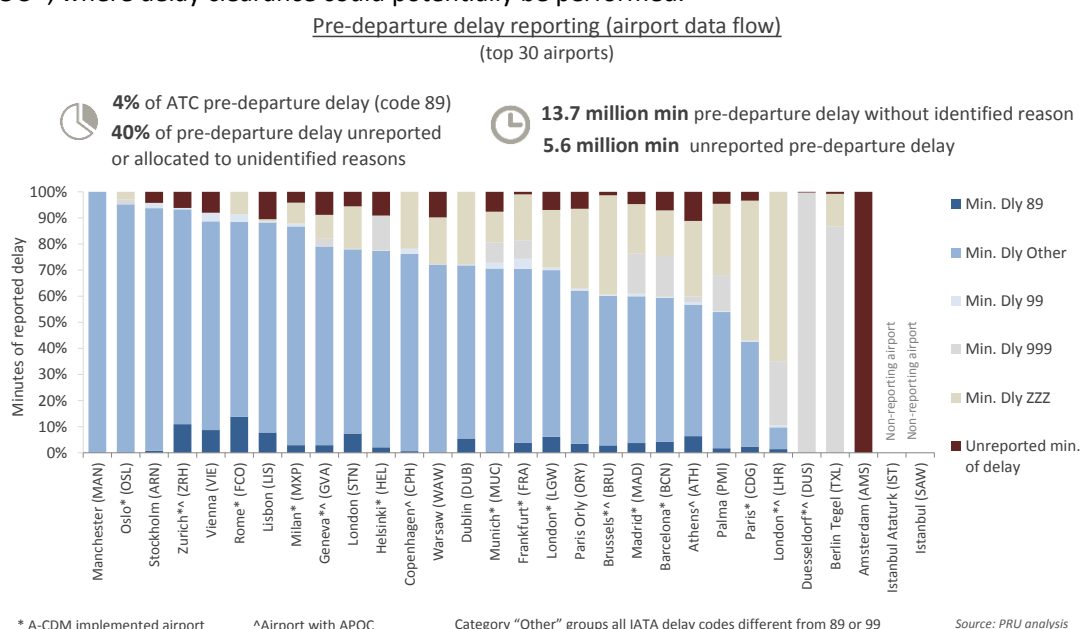
Local ATC pre-departure delay addresses the effect of capacity/demand imbalances surrounding the departure process. The local ATC departure delay is derived from off-block delays attributed to IATA delay codes reported by airlines, more specifically code 89.

The pre-departure delay in Figure 4-11 is calculated according to CODA data as reported by the participating airlines. Nevertheless the pre-departure delay is also reported by the airports under the Performance Scheme through the Airport Data Flow (currently Istanbul airports do not provide the data). This data flow allows for allocation of delay according to the IATA delay codes plus special codes 999 and ZZZ<sup>15</sup>, and it is required information for all departures.

A high share of delays attributed to unknown or unspecified reasons<sup>16</sup> might hide a higher share of pre-departure delay attributable to code 89 (local ATC) or other codes.

Figure 4-13 shows the breakdown of total minutes of pre-departure delay in 2016 as reported by the airports. It shows a varying picture of the delay allocation at different airports across Europe. While airports like Düsseldorf and Berlin Tegel attribute all their delay to “999” and “ZZZ” codes, in other airports like Zurich, Stockholm, Oslo or Manchester more than 90% of the minutes of delay are allocated to identified reasons. In Heathrow that share is 10%, leaving unexplained 90% of the minutes of delay.

This inconsistency in the reporting is not linked to A-CDM implemented airports or those with an APOC<sup>17</sup>, where delay clearance could potentially be performed.



**Figure 4-13: ATC Pre-departure delay reporting at the top 30 airports**

Additionally, the chart shows the minutes of delay that should have been reported according to the specifications but nevertheless are not. This could be due either to flights where reported delay is less than the actual or delayed flights for which no delay is reported at all. The latter is only possible in the old reporting mechanism that is still used by some airports. It is the case for Amsterdam, for which there is no information regarding pre-departure delay at the moment. The transition of all reporting airports to the new Airport Data Flow is ongoing.

Based on the above, the Local ATC Pre-departure delay only accounts for 4% of the total pre-departure delay of the Top30 airports in Europe.

<sup>15</sup> Code 999: Delay code clearing is not possible.

Code ZZZ: No delay code information is available/attainable.

<sup>16</sup> IATA delay code 99 or specified ambiguity codes in the airport data flow specification, i.e. codes 999 or ZZZ.

<sup>17</sup> APOC: Airport Operations Centre

#### 4.4.3 Vertical flight efficiency during climb and descent

This section reports on possible complementary indicators for the measurement of the vertical dimension of flight efficiency during the climb and descent phase. Eliminating intermediate level-offs and diversions for arrivals can save substantial amounts of fuel and reduce CO<sub>2</sub> emissions. More information on the methodology and data are available on the [ANS performance data portal](#).

Figure 4-14 shows the average time flown level per flight within a 200NM radius around the airport. Generally, climb outs (top bar chart) are less subject to level offs than descents (bottom bar chart). For descents, a significant amount of level flight can be observed.

It is worth noting that at Stockholm (ARN), Athens (ATH) and Helsinki (HEL) the amount of level flight in the descent phase is comparatively low. They all have an average time flown level of less than 1 minute.

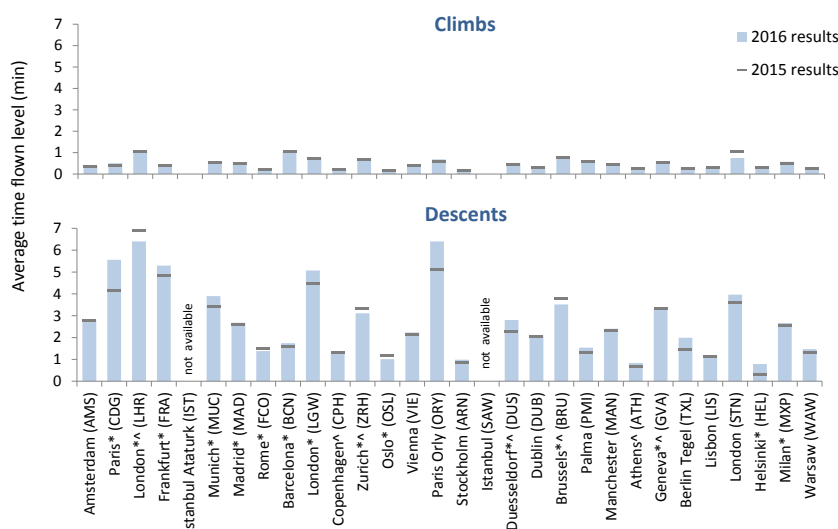


Figure 4-14: Average time flown level per flight at the top 30 airports

While Figure 4-14 illustrates the time dimension of vertical flight efficiency, Figure 4-15 provides an understanding about the median altitudes at which continuous descent operations (CDO) started and at which continuous climb operations (CCO) ended.

For this metric, the altitude of the lowest level segment during the climb/descent of each flight has been used.

The choice for the lowest level segment is due to the fact that this level segment has the highest environmental impact, mainly in terms of fuel consumption. Indeed, if we would have a level segment with a fixed duration, the lower the altitude of the level segment, the higher is the fuel burn.

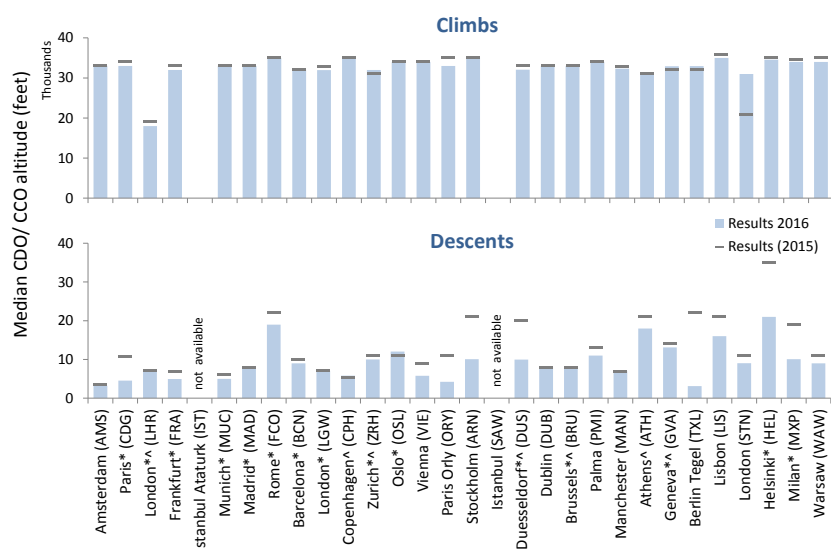


Figure 4-15: Median CDO/CCO altitude at the top 30 airports

It can be seen that climbs (top figure) are performed more efficiently than descents (bottom bar chart).

Most airports have their median CCO altitudes above FL300 which is close to the nominal cruising altitude of jet aircraft. For arriving traffic, the median CDO altitude is notably lower for all considered airports, which is probably due to the application of arrival procedures and the use of holding stacks.

It is worth noting that the average time flown level per flight during descent for the Paris airports (CDG, ORY) is in 2016 much higher than in 2015. After consulting DSNA, it became clear that the update rate of the surveillance data changed significantly on 02/09/2015. Since that day, France is providing data with an overall update interval of 1 minute instead of 3 minutes. Further examination of the impact of the update rate on the results revealed that the higher the update rate (smaller update interval), the more correct level flight is being detected since the available trajectory data give a more accurate representation of the true trajectory. Because a lower update rate can “hide” certain level segments, overall more level flight is being detected.

Despite the legal requirement to provide surveillance data based on 30 seconds reporting interval, France is only making them available with a 1 minute update interval, being the only EUROCONTROL State not complying.

#### Case study - Amsterdam Schiphol

The number of flights to and from Amsterdam (AMS) has increased significantly. Nevertheless, the average time flown level is for the second year in a row comparatively low.

Figure 4-16 shows that the monthly values for average time flown level per flight remain stable during 2015 and 2016, although a slightly decreasing trend for the descent value can be observed towards the end of 2016.

Figure 4-17 presents the monthly median CDO/CCO altitudes. Also these values are quite constant in 2015 and 2016. However, it is remarkable that the median CDO altitude is pretty low.

To get a better view on the altitudes of the level flight segments, the vertical trajectories of flights arriving at Amsterdam airport in July 2016 are plotted in Figure 4-18. The detected level segments are highlighted in red. Most level flight happens at 2000 and 3000 feet which explains the low median CDO altitude values. The level segments at these altitudes are part of the approach procedures during the day in peak hours. According to LVNL, the level segments are used during radar vectoring to increase capacity. Also, because the Schiphol TMA is relatively small, LVNL is unable to implement the level segments at higher altitudes.

Figure 4-19 presents the top down view of the arrival trajectories into Amsterdam airport. This figure illustrates that the level segments are happening primarily in the final stages of the approach. The green lines indicate the FIR boundaries.

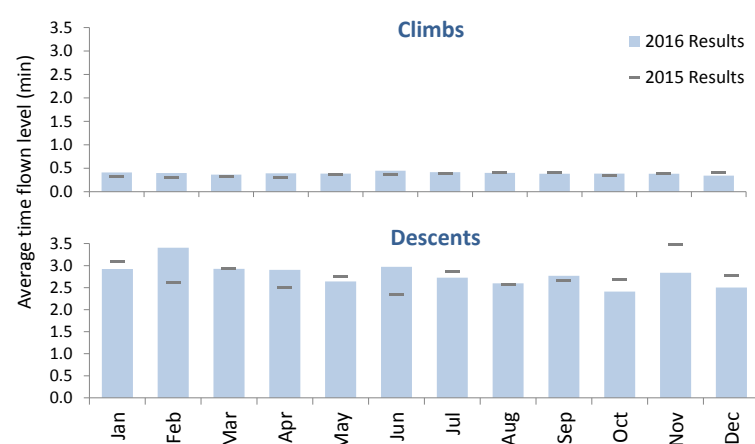


Figure 4-16: Monthly average time flown level per flight to/from EHAM

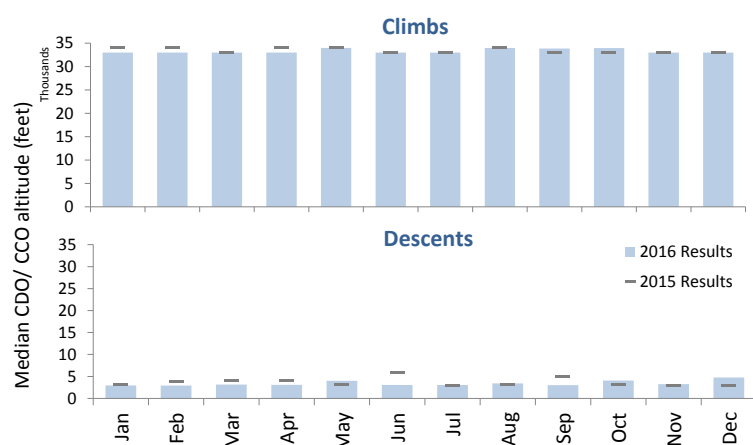


Figure 4-17: Monthly median CDO/CCO altitude to/from EHAM



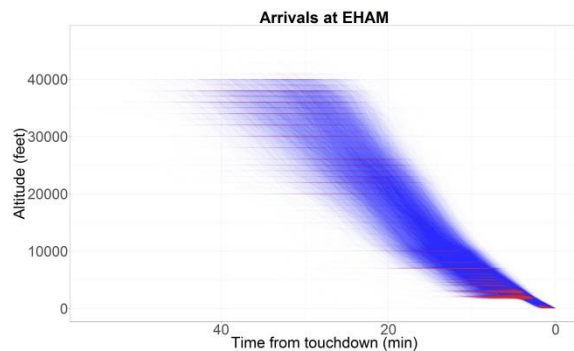


Figure 4-18: Vertical trajectories of Amsterdam (EHAM/AMS) arrivals

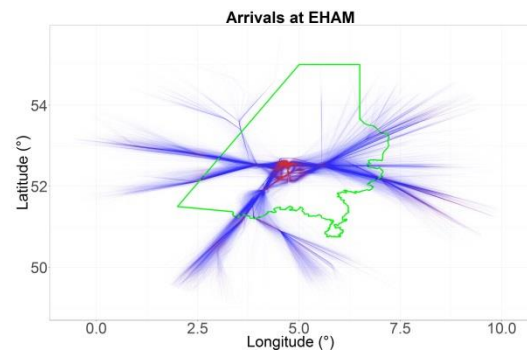


Figure 4-19: Horizontal trajectories of Amsterdam (EHAM/AMS) arrivals

## 4.5 Conclusions

Controlled movements at the top 30 airports in the EUROCONTROL area (in terms of traffic) increased for the third consecutive year in 2016. Average daily movements increased by +2.7% compared to 2015 which corresponds to 594 additional movements each day.

At the same time, the number of passengers continued to outpace traffic growth in 2016 (+4.6% vs. 2015). As a result of this ongoing trend, passenger numbers at the top 30 airports were in 2016 27.5% higher than in 2008 which is remarkable considering the fact that movements are merely 1.0% above 2008 levels (the year with the highest level of traffic on record so far).

Ten of top 30 airports (Amsterdam, Istanbul Ataturk, London Gatwick, Stockholm Arlanda, Istanbul Sabiha Gökçen, Dublin, Berlin Tegel, Geneva, Lisbon, and Warsaw) reported their highest traffic level on record surpassing the traffic levels observed before the economic crisis starting in 2008.

Antalya experienced a 30% reduction in traffic in 2016 which resulted in Warsaw entering the top 30 airports in terms of traffic instead. Amsterdam reported a 5.9% increase in traffic in 2016 which made it the airport with the most commercial movements in Europe in 2016. A number of airports (Manchester (MAN), Palma (PMI), Lisbon (LIS), Warsaw (WAW), and Dublin (DUB) experienced high growth rates above 8% in 2016.

The two Istanbul airports, which reported a remarkable traffic growth over the past years, were affected by the situation in Turkey, resulting in a notable slowdown in traffic growth. Of the top 30 airports, six showed a traffic decrease in 2016. The highest decrease in traffic among the top 30 airports in 2016 was observed for Brussels (BRU) airport with -6.5% compared to 2015 as a result of the reduced capacity following the terrorist attacks in March 2016.

The global implementation roadmaps driven by the ICAO Global Air Navigation Plan (GANP) and the supporting Aviation System Block Upgrades (ASBU) modules cast their light on Europe. This strengthens the level of enabler deployments such as Airport Collaborative Decision Making (A-CDM) or procedural changes in form of continuous climb or descent operations, time based separations and the use of improved wake vortex categorisations.

Despite the positive effect the aforementioned enablers are expected to have on performance, the substantial traffic increase at some airports contributed to higher levels of operational inefficiency and resulted in somewhat higher additional times during descent and in the taxi-out phase compared to 2015.

Average airport arrival ATFM delay decreased slightly in 2016 at the top 30 airports but is still heavily concentrated among a few airports. Five airports (Istanbul Sabiha Gökçen, Istanbul Ataturk, Amsterdam, London Heathrow, and London Gatwick) accounted for 59% of the airport arrival ATFM delay reported for the top 30 airports. At Istanbul Sabiha Gökçen, 42.5% of all arrivals in 2016 were airport ATFM delayed compared to Istanbul Ataturk with 20.3% of the arrivals being delayed.

The problem at the two Turkish airports is clearly capacity related and linked to the substantial growth observed over the past years. The peak arrival throughput at Sabiha Gökçen airport quadrupled over the past eight years making it the second busiest single runway airport in the EUROCONTROL area after London Gatwick. The situation in Istanbul is expected to improve with the opening of the first phase of the new Istanbul Airport which is scheduled for 2017/2018.

Airport arrival ATFM performance at Amsterdam and the two London airports (LHR, LGW) was to a large extent affected by weather which required reducing the available capacity.

London Heathrow, Istanbul Ataturk, and Istanbul Sabiha Gökçen show all up with a continuously high arrival throughput close to the peak declared arrival capacity. Constant operations close to maximum capacity generate high delays and possibly cancellations when there is a mismatch between scheduled demand and the capacity that can be made available.

At London Heathrow, wind is by far the most dominant factor affecting the airports arrival capacity. The introduction of time based separations in spring 2015 is expected to reduce ATFM delays due to high headwinds at the airport. In 2016, the average weather related ATFM delay per arrival decreased slightly and it will be interesting to see the impact on time based separation on performance once longer time series of data are available.

The high intensity operation with a clear focus on the maximisation of runway throughput at London Heathrow comes at a price and the analyses of the additional time in approach and in the taxi out phase show comparatively high levels of inefficiency. In fact, London Heathrow alone accounted for one quarter of the total additional ASMA time in 2016. The average holding per arrival at London Heathrow improved slightly in 2016 but is still above 8 minutes per arrival which is in line with a deliberate decision taken during the airport scheduling process after consultation with airlines. The cross border arrival management (XMAN) project was set up already in March 2014 to reduce airborne holdings on specific traffic flows but it would be worth to investigate further possibilities to reduce holding times at airports through a better support of the network while ensuring a continuous arrival flow into the airport.

Due to the lack of data the additional holding time is presently not available for the two Istanbul airports and it would be interesting to get this complementary information in addition to the airport arrival ATFM delay to be able to provide a more balanced picture.

The problem with the small Greek airports generating very high delays highlighted in last year's report still persisted in 2016. Overall, nine regional Greek airports accounted for 5.3% of all airport ATFM delays in the EUROCONTROL area. ATFM regulations should not be applied continuously to regulate demand at airports and the issue, most likely linked to scheduling and variability needs to be addressed proactively in order to avoid a repetition of high delays also in summer 2017. The PRC will be monitoring the situation which now persists for several years.

Despite yet a higher number of ATFM regulated flight in 2016, overall ATFM slot adherence at the top 30 airports improved again which is positive in terms of network predictability.

Whereas A-CDM implementation is considered to be an enabler to improve situation awareness and performance, it is important to ensure that the available information is used to improve local processes. A-CDM can also help improving the data quality which is presently an issue for the measurement of ATC pre-departure delays. An evaluation of the 2016 data showed that 40% of the delay reported by the top 30 airports was not attributed to a valid delay cause which clearly requires improvement in the future.

Building on the initial analysis included in last year's report, the vertical flight efficiency in climbs and descents at the top 30 airports was also addressed. It is worth pointing out that the measure is complementary to the ASMA additional time and cannot be added to get a combined measure.

On average, inefficiencies (expressed in average time flown level per flight) were more than 6 times higher in descent than in climb with notable differences by airport. On average, level flight time during descent increased slightly in 2016 to reach 3.1 minutes per arrival (+0.2 min vs 2015).

## 5 ANS Cost-efficiency (2015)

SYSTEM TREND	2015	Trend	change vs. 2014
En-route ANS cost-efficiency performance (39 States)			
<i>Total en-route ANS costs (M€<sub>2009</sub>)</i>	6 539	↑	+1.5%
<i>En-route service units (M)</i>	133	↑	+3.9%
<i>En-route ANS costs per service unit (€<sub>2009</sub>)</i>	49.2	↑	-2.4%
Terminal ANS cost-efficiency performance (30 States)			
<i>Total terminal ANS costs (M€<sub>2009</sub>)</i>	1 084		<i>Time series analysis not available<sup>18</sup></i>
<i>Terminal service units (M)</i>	6.3		
<i>Terminal ANS costs per terminal service unit (€<sub>2009</sub>)</i>	171.6		
Air Navigation Service Provider gate-to-gate economic performance (38 ANSPs)			
<i>Gate-to-gate ATM/CNS provision costs (M€<sub>2015</sub>)</i>	8 124	↑	+0.5%
<i><a href="#">Composite flight-hours</a> (M)</i>	19.0	↑	+1.7%
<i>Gate-to-gate ATM/CNS provision costs per <a href="#">composite flight-hour</a> (€<sub>2015</sub>)</i>	427	↓	-1.2%
<i>Gate-to-gate economic costs (M€<sub>2015</sub>)</i>	9 493	↑	+4.9%
<i>Gate-to-gate unit costs of ATFM delays(€<sub>2015</sub>)</i>	74	↑	+38.8%
<i>Gate-to-gate economic costs per <a href="#">composite flight-hour</a> (€<sub>2015</sub>)</i>	501	↑	+3.2%

### 5.1 Introduction

This chapter analyses ANS cost-efficiency performance in 2015 (i.e. the latest year for which actual financial data are available) and provides a performance outlook, where possible.

It provides a Pan-European view, covering 39 States<sup>19</sup> operating 38 en-route charging zones<sup>20</sup> that are part of the multilateral agreement for Route Charges. This includes the 30 States which are subject to the requirements of the Single European Sky (SES) Performance Scheme ("SES States") and also 9 EUROCONTROL Member States which are not bound by SES regulations (see section 5.2 below).

The cost-efficiency performance of SES States in 2015 has already been scrutinised in accordance with the SES Regulations and the results have been reflected in the Performance Review Body (PRB) 2015 monitoring report. The annual Performance Review Report published by the PRC does not seek to duplicate this analysis nor assess performance against SES targets. Instead, it takes into account the SES data and aggregates it with the information provided by the non-SES States to present a Pan-European view. The chapter also provides an outlook for the 2016-2019 period.

Section 5.2 presents a detailed analysis of en-route cost-efficiency performance at Pan-European system level. Section 5.3 gives an evaluation of terminal ANS costs within the SES area. In order to ensure consistency and comparability with indicators defined in the SES performance scheme and the information provided in RP2 Performance Plans, the cost-efficiency indicators presented in Sections 5.2 and 5.3 are expressed in terms of costs per service unit and in Euro 2009.

<sup>18</sup> 2015 coincides with the beginning of second Reference Period under the SES Performance Scheme which entails a number of changes for Terminal cost-efficiency. For this reason, it was not possible to analyse changes in terminal cost-efficiency performance between 2014 and 2015 (see page 55 for further details).

<sup>19</sup> This is different from the 41 EUROCONTROL Member States in 2015 since: (1) Ukraine is a EUROCONTROL Member State which is not yet integrated into the multilateral agreement for Route Charges, and (2) Monaco en-route costs are included in the French cost-base.

<sup>20</sup> Note that in the Route Charges system, two en-route charging zones include more than one State (Belgium-Luxembourg and Serbia-Montenegro). Similarly, there are two charging zones for Spain (Spain Continental and Spain Canarias).

Finally, Section 5.4 provides a factual benchmarking analysis of ANSPs' 2015 gate-to-gate economic performance focusing on ATM/CNS costs which are under ANSPs direct responsibility, and including the estimated costs of total ATFM delays (en-route and airport) attributable to the respective service providers.

## 5.2 En-route ANS cost-efficiency performance

The analysis of en-route ANS cost-efficiency in this section refers to the en-route charging zones which were part of EUROCONTROL's Route Charges System in 2015 (with the exception of Portugal Santa Maria) but includes Estonia which joined EUROCONTROL on 1<sup>st</sup> January 2015 and which is part of the SES Performance Scheme.

As shown in Figure 5-1, the "SES States" refer to the 28 Member States of the European Union (EU), plus Switzerland and Norway. These States operate under the "determined costs" method which includes specific risk-sharing arrangements, defined in the Charging Regulation [Ref. 11] aiming at incentivising economic performance.

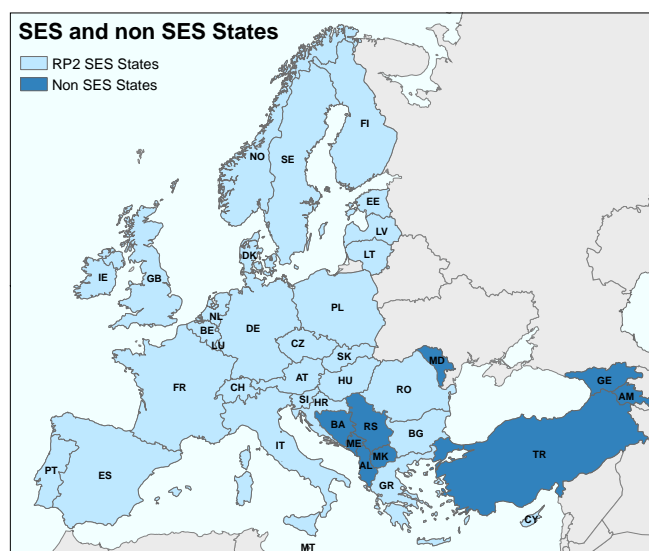


Figure 5-1: SES and non-SES States

The "non-SES States" refer to nine States which are not bound by SES regulations but which were part the EUROCONTROL Multilateral Route Charges System in 2015 (i.e. Albania, Armenia, Bosnia-Herzegovina, FYROM, Georgia, Moldova, Serbia, Montenegro and Turkey). For these nine States, the "full cost-recovery method" applied in 2015.

### 5.2.1 Changes in reporting of en-route costs and geographical coverage between 2014 and 2015

It is noteworthy that the geographical coverage of RP2 now includes Croatia which was not subject to cost-efficiency targets under the SES Performance Scheme during RP1. Apart from a different geographical scope, it should be noted that the cost-efficiency targets for RP2 are based on the Determined Unit Cost (DUC) instead of the Determined Unit Rate (DUR) concept as it was the case during RP1. The main difference between DUR and DUC is that the latter does not include costs associated to exempted VFR flights, while these costs were included in the DUR computation during RP1. Therefore, in order to ensure consistency in time-series analysis, historic en-route ANS costs (2009-2014) have been adjusted to: (a) include the costs associated with Croatia en-route Charging Zone, and (b) exclude the costs associated to VFR exempted flights. These adjustments are presented in the top Table of Figure 5-2 below.

Total en-route ANS costs (M€2009)	2009 Actuals	2010 Actuals	2011 Actuals	2012 Actuals	2013 Actuals	2014 Actuals	2015 Actuals	2015 vs 2014	2009-15 CAGR
SES States (EU-27+2) en-route costs based on RP1 definition	6 248	6 069	5 972	6 048	5 947	5 936	6 008	1.2%	-0.7%
+ Croatia en-route costs	65	66	76	72	77	82	80	-2.4%	3.6%
- Costs for VFR exempted flights	- 11	- 26	- 34	- 9	- 9	- 9	- 11	19.2%	-0.2%
SES States (EU-28+2) en-route costs based on RP2 definition	6 302	6 110	6 014	6 110	6 014	6 009	6 077	1.1%	-0.6%

Total en-route ANS costs (M€2009)	2009 Actuals	2010 Actuals	2011 Actuals	2012 Actuals	2013 Actuals	2014 Actuals	2015 Actuals	2015 vs 2014	2009-15 CAGR
SES States (EU-28+2) en-route costs based on RP2 definition	6 302	6 110	6 014	6 110	6 014	6 009	6 077	1.1%	-0.6%
- Adjustment relating to BiH costs included Croatia en-route cost-base	- 6.5	- 6.9	- 8.0	- 7.4	- 8.0	- 8.1	- 7.1	-12.8%	1.3%
- Adjustment relating to KFOR staff costs included in Hungary en-route cost-base	n/appl	n/appl	n/appl	n/appl	n/appl	- 1.7	- 2.3	36.9%	n/appl
SES States (EU-28+2) en-route costs used in PRR 2016	6 296	6 103	6 006	6 103	6 006	6 000	6 068	1.1%	-0.6%

Figure 5-2: Reconciliation between RP1 and RP2 en-route ANS costs for SES States (€2009)

It should be noted that Croatia en-route cost-base includes information relating to the provision of ATC services in Bosnia-Herzegovina, while these costs are also included in Bosnia-Herzegovina en-route cost-base.

Similarly, Hungary en-route costs comprise information relating to the provision of ATC services in Kosovo's upper airspace (KFOR sector) since April 2014, while these costs are also disclosed in Serbia and Montenegro en-route cost-base.

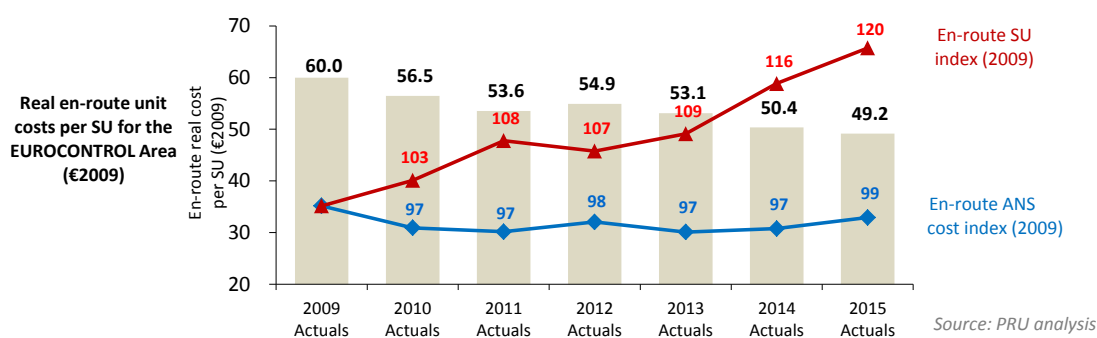
Therefore, in order to present a consistent analysis at Pan-European system level and to avoid any double counting of en-route costs, it was decided to remove these costs from Croatia and Hungary en-route cost-bases. For this reason, the en-route costs presented in this report for the SES States slightly differ from the information published in the PRB monitoring reports. These adjustments are detailed in the bottom Table of Figure 5-2 above.

The Tables above shows that the adjustments carried out on the historic data does not affect the trends in en-route costs whether these are computed on the 2009-2015 period (-0.6% p.a.) or between 2014 and 2015 (+1.1%).

### 5.2.2 Trends in actual en-route cost-efficiency performance at Pan-European system level

The analysis presented in this section focuses on the 38 Charging Zones that consistently provided en-route costs data over the 2009-2015 period. Georgia which started to provide actual en-route costs data for the year 2014 is not included in this trend analysis.

Figure 5-3 shows that in 2015, at Pan-European level, en-route total service units (TSUs) increased faster (+3.9%) than actual en-route ANS costs (+1.5%). As a result, actual en-route unit costs decreased by -2.4% compared to 2014.



	2009 Actuals	2010 Actuals	2011 Actuals	2012 Actuals	2013 Actuals	2014 Actuals	2015 Actuals	2015 vs 2014	2009-15 AAGR
<b>Total en-route ANS costs (M€2009)</b>	<b>6 637</b>	<b>6 451</b>	<b>6 419</b>	<b>6 501</b>	<b>6 416</b>	<b>6 445</b>	<b>6 539</b>	<b>1.5%</b>	<b>-0.2%</b>
SES States (EU-28+2)	6 296	6 103	6 006	6 103	6 006	6 000	6 068	1.1%	-0.6%
Other 8 States in the Route Charges System	342	348	413	398	409	445	471	5.8%	5.5%
<b>Total en-route service units (M SU)</b>	<b>111</b>	<b>114</b>	<b>120</b>	<b>118</b>	<b>121</b>	<b>128</b>	<b>133</b>	<b>3.9%</b>	<b>3.1%</b>
SES States (EU-28+2)	99	102	107	105	107	112	115	3.0%	2.5%
Other 8 States in the Route Charges System	11	12	13	13	14	16	18	10.1%	8.1%
<b>En-route real unit cost per SU (€2009)</b>	<b>60.0</b>	<b>56.5</b>	<b>53.6</b>	<b>54.9</b>	<b>53.1</b>	<b>50.4</b>	<b>49.2</b>	<b>-2.4%</b>	<b>-3.3%</b>
SES States (EU-28+2)	63.4	59.9	56.3	58.0	56.2	53.8	52.8	-1.8%	-3.0%
Other 8 States in the Route Charges System	30.4	28.3	31.4	30.2	29.3	27.3	26.2	-3.8%	-2.4%

Figure 5-3: Real en-route unit costs per SU for EUROCONTROL Area (€2009)

Over the 2009-2015 period, en-route unit costs reduced by -3.3% p.a. since traffic volumes rose by +3.1% p.a. while en-route costs remained fairly constant (-0.2% p.a.). Figure 5-3 shows that these average changes mask different trends for the SES and non-SES States.

Indeed, the en-route unit costs decrease for SES States (-3.0% p.a.) was achieved by slightly reducing costs (-0.6% p.a.) while traffic rose by +2.5% per year on average over the 2009-2015 period. Twelve en-route charging zones operated by SES States could achieve a reduction in en-route costs between 2009 and 2015. This is particularly the case for Spain Continental (-5.9% p.a.), Spain Canarias (-4.5% p.a.), Greece (-4.2% p.a.), Portugal (-3.1% p.a.), Switzerland (-2.8% p.a.), Belgium-Luxembourg (-2.7% p.a.) and Denmark (-2.1% p.a.).

The en-route unit costs reduction achieved between 2009 and 2015 by non-SES States (-2.4% p.a.) reflects the fact that traffic, measured in service units, increased faster (+8.1% p.a.) than en-route costs (+5.5% p.a.). This was particularly the case for Turkey which benefited from a +9.8% annual traffic increase over the 2009-2015 period.

These performance improvements should be seen in the light of (a) the cost-containment measures initiated in 2009-2010 in response of the traffic downturn arising from the economic recession, and (b) for SES States, the implementation of the Performance Scheme and the incentive mechanism embedded in the charging scheme which contributed to maintain a downward pressure on costs during RP1.

### 5.2.3 Breakdown of en-route costs by nature (2015 vs. 2014)

As shown in Figure 5-4, en-route costs can be broken down into the following main components:

- Staff costs is the largest category and represent some 58% of total en-route costs;
- The second largest category, other operating costs accounts for 24% of the total;
- Capital-related costs which represent 18% of total en-route costs can be further broken down into depreciation costs (12%) and cost of capital (6%);
- Finally, exceptional costs account for less than 1% of total costs.

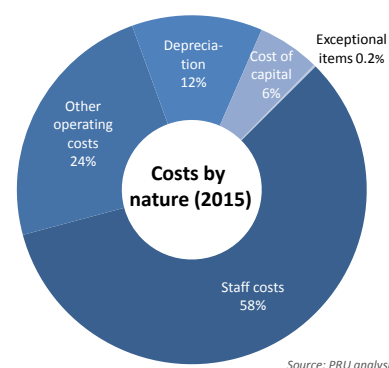


Figure 5-4: Breakdown on en-route ANS costs by nature

Figure 5-5 shows that in 2015 the increase in en-route ANS costs (+1.5% or +94 M€<sub>2009</sub>) is mainly due to higher staff costs (+3.1% or +115 M€<sub>2009</sub>), cost of capital (+2.4% or +9 M€<sub>2009</sub>) and exceptional costs (+12 M€<sub>2009</sub>), while other operating costs (-1.9% or -30 M€<sub>2009</sub>) and depreciation costs (-1.5% or -12 M€<sub>2009</sub>) were lower than in 2014.

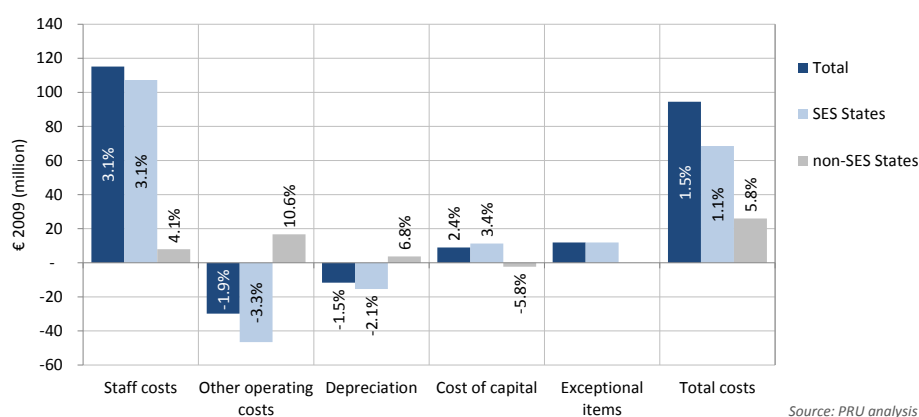


Figure 5-5: Breakdown of changes in en-route costs (2014-2015, (€<sub>2009</sub>))



Figure 5-5 also indicates that the changes in the various en-route cost categories at Pan-European system level masks diverging trends between SES and non-SES States. This is particularly the case for other operating costs (-3.3% and +10.6%, respectively), depreciation costs (-2.1% and +6.8%, respectively) and the cost of capital (+3.4% and -5.8%, respectively).

#### 5.2.4 Actual en-route unit costs at charging zone level

Figure 5-6 below shows the level of en-route unit costs for each individual charging zone in 2015. En-route unit costs ranged from 71.9 €<sub>2009</sub> for Italy to 18.4 €<sub>2009</sub> for Malta, a factor of more than three between these two charging zones. It should be noted that Figure 5-6 comprises en-route costs and traffic data relating to Georgia which has been integrated into the Multilateral Agreement for Route Charges on the 1<sup>st</sup> of January 2014.

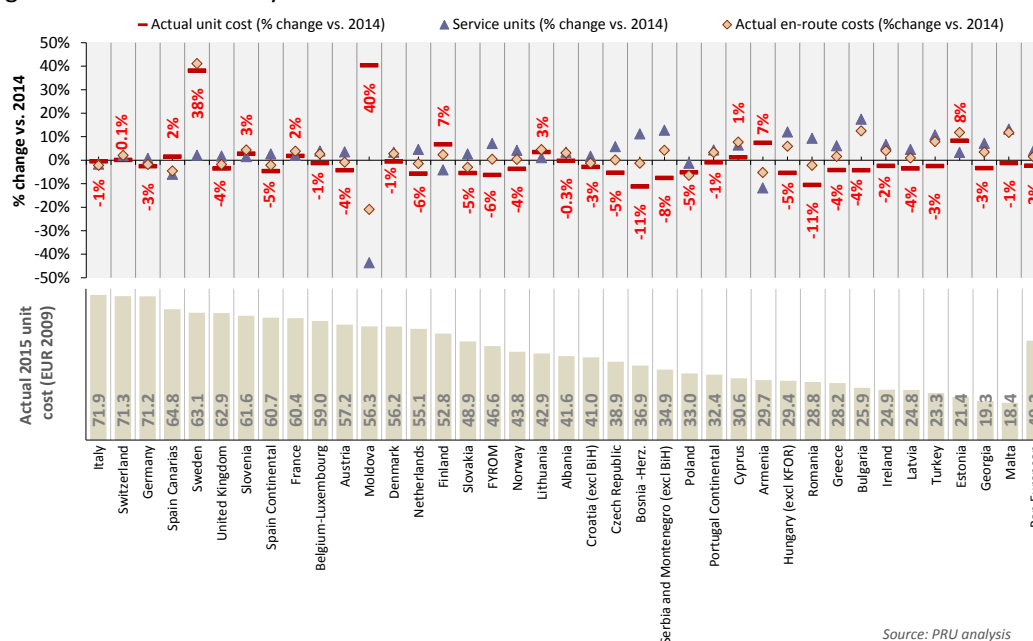


Figure 5-6: 2015 Real en-route ANS costs per TSU by charging zone (€<sub>2009</sub>)

Figure 5-6 also presents the changes in en-route unit costs, TSUs and costs compared to 2014. In 2015, unit costs increased for 11 en-route CZs out of the 38 included in the analysis. For five charging zones, en-route unit costs rose by more than +5% in 2015. This includes Moldova (+40.3%), Sweden (+38.1%), Estonia (+8.3%), Armenia (+7.4%) and Finland (+6.7%).

While Moldova and Armenia managed to significantly reduce costs between 2014 and 2015 (-21.0% and -5.3%, respectively), this was not sufficient to compensate the steep drop in TSUs (-43.7% and -11.8%, respectively) and to avoid increases in en-route unit costs. For these two CZs, the large decreases in traffic mainly reflect a change in traffic flows following the establishment of restricted/prohibited areas in Ukraine following the MH17 accident in 2014 and the military conflicts in the Eastern region of Ukraine. The changes in traffic flows also affected other CZs in the Eastern European region. This was particularly the case of Bulgaria for which traffic rose by +17% in 2015 following a +33% increase in 2014.

In 2015, Finland en-route cost-base rose (+2.3%) in a context of traffic decrease (-4.1%) resulting in an increase in en-route unit costs (+6.7%). The increase in Estonia unit costs (+8.3%) mainly reflects the fact that en-route costs rose faster (+11.8%) than TSUs (+3.3%).

En-route unit costs substantially rose for Sweden (+38.1%). This is due to an increase in en-route costs (+41.1%) which mainly reflects the reporting of significantly higher pension costs in 2015 following the use of a lower discount rate to compute the value of future pension obligations. Pension issues are complex and require the utmost attention given the long term consequences of pensions-related decisions. Clearly, a specific study would be required in order to better understand the magnitude of ANSPs pension costs and their impact on present and future cost-bases, as well as, on corresponding unit costs.

On the other hand, Figure 5-6 indicates that for nine CZs, en-route unit costs decreased by more than 5% in 2015: Bosnia-Herzegovina (-11.2%), Romania (-10.5%), Serbia and Montenegro (-7.6%), FYROM (-6.3%), the Netherlands (-5.7%), Slovakia (-5.5%), Czech Republic (-5.4%), Hungary (-5.4%) and Poland (-5.2%). For most of these CZs, the improvement in en-route cost-efficiency observed in 2015 is mainly due to a substantial traffic growth combined with lower or fairly constant en-route costs. The two notable exceptions were: (a) Serbia and Montenegro for which en-route costs rose by +4.2% in a context of substantial traffic increase (+12.7%), and (b) Poland which could significantly reduce its en-route cost-base (-6.4%) while TSUs fell by -1.3%.

### 5.2.5 Pan-European en-route cost-efficiency outlook for 2016-2019

The objective of this section is to provide information on planned en-route unit costs at Pan-European system level for the period 2016-2019. It is based on data reported by EUROCONTROL Member States in the en-route reporting tables submitted in November 2016 in the context of the Enlarged Committee for Route Charges<sup>21</sup>. It is important to note that for States bound by SES regulations, the planned data reported for the years 2016-2019 reflect the determined costs and traffic figures provided in the RP2 Performance Plans which are not updated on a yearly basis.

Overall, at Pan-European level between 2015 and 2019, en-route unit costs are expected to reduce by -1.8% per year on average. This reflects the fact that over this period traffic volumes are planned to increase faster (+2.3% p.a.) than en-route costs (+0.5% p.a.).

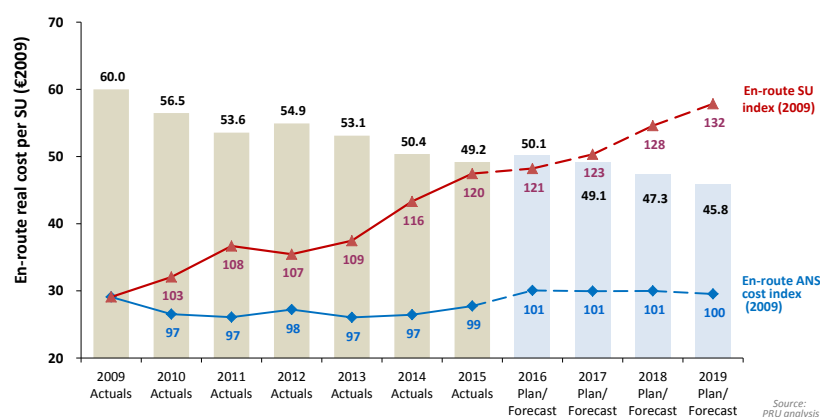


Figure 5-7: Pan-European en-route cost-efficiency outlook 2016-2019 (in €<sub>2009</sub>)

Figure 5-7 shows that in 2019, en-route unit costs are expected to amount to 45.8 €<sub>2009</sub>. This is -23.7% lower than in 2009 (60.0 €<sub>2009</sub>). This remarkable cost-efficiency performance improvement is expected to be achieved by maintaining the cost-base close to 2009 levels in a context of steady traffic increase (+2.8% p.a. over the 2009-2019 period).

Detailed analysis indicates that over the 2015-2019 period, en-route unit costs are expected to reduce for 26 en-route CZs out of the 38 included in the analysis. In particular, en-route unit costs are expected to decrease by more than -4% p.a. for six CZs: Sweden (-7.2% p.a.), Moldova (-7.0% p.a.), Serbia and Montenegro (-4.9% p.a.), Germany (-4.7% p.a.), Finland (-4.6% p.a.) and Italy (-4.0% p.a.). For most of these CZs, the planned improvement in en-route cost-efficiency performance observed over the 2015-2019 period is expected to arise from lower costs combined with a modest traffic growth. On the other hand, the expected reduction in Italy en-route unit costs (-4.0% p.a.) mainly reflects the substantial traffic growth planned between 2015 and 2019 (+4.9% p.a.).

<sup>21</sup> It should be noted that in 2016 three SES States (Bulgaria, Poland and Malta) have submitted requests to the European Commission to revise their adopted RP2 en-route cost-efficiency targets. For these three States, the information used in Figure 5-7 reflects the data provided in the November 2016 submission to the Enlarged Committee for Route Charges including the proposed revisions for the years 2017-2019. Similarly, Figure 5-7 reflects the information provided by FABEC in the revised RP2 Performance Plan submitted early 2017.

On the other hand, en-route unit costs are expected to significantly rise for Turkey (+4.8% p.a.) since en-route costs are expected to increase faster (+11.9% p.a.) than traffic volumes (+6.8% p.a.).

### 5.3 Terminal ANS cost-efficiency performance

The analysis of terminal ANS cost-efficiency in this section refers to the SES States (see Figure 5-8) which are required to provide terminal ANS costs and unit rates information in accordance with EU legislation [Ref. 11]. As for en-route, the SES States refers to the 28 Member States of the European Union (EU), plus Switzerland and Norway. These States report on 36 [Terminal Charging Zones \(TCZs\)](#).

2015 coincided with the beginning of second Reference Period under the SES Performance Scheme which entails a number of changes for Terminal cost-efficiency.

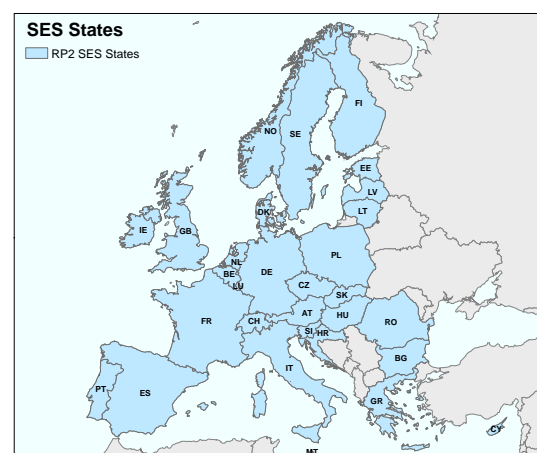


Figure 5-8: Geographical scope of terminal ANS cost-efficiency analysis

Indeed, for the first year, the “determined costs” method is applied for terminal ANS. This method includes specific risk-sharing arrangements which are aiming at incentivising economic performance.

In addition, in 2015 several States re-defined the number and composition of TCZs where they are responsible to provide terminal ANS. These changes are summarised in Figure 5-9 below which indicates that in 2015 the number of States reporting terminal ANS data increased to 30, reflecting the inclusion of Croatia terminal ANS data from RP2 onwards. In the meantime, the number of TCZs rose from 33 in 2014 to 36 in 2015, and the number of airports covered decreased from 230 to 172.

			RP1				RP2				
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Number of	SES States reporting	26	28	29	29	29	30	30	30	30	30
	Charging zones	28	30	31	31	33	36	36	38	38	38
	Airports covered	224	226	229	229	230	172	174	174	174	174

Figure 5-9: Changes in the reporting of terminal ANS data for SES States between 2010 and 2015

Examples of changes in the number or in the composition of TCZs include Italy, which went from three TCZs encompassing 47 airports in RP1 (2012-2014) to two TCZs comprising 5 airports. Another example is Belgium, which now reports five TCZs, while only one TCZ with the main airport (Brussels Zaventem) was reported during RP1.

#### 5.3.1 Terminal ANS 2015 cost-efficiency performance at terminal charging zone level

The terminal cost-efficiency KPI is computed as the ratio of terminal ANS costs with [terminal navigation service units \(TNSUs\)](#).

TNSUs are computed as a function of the maximum take-off weight ( $(MTOW/50)^{\alpha}$ ). Since 2015, in accordance with the Charging Scheme Regulation [Ref. 12], all States use a common formula  $(MTOW/50)^{0.7}$  to compute TNSUs.

This allows for a better comparison of the level of unit terminal costs per TNSU which is achieved by the different charging zones.



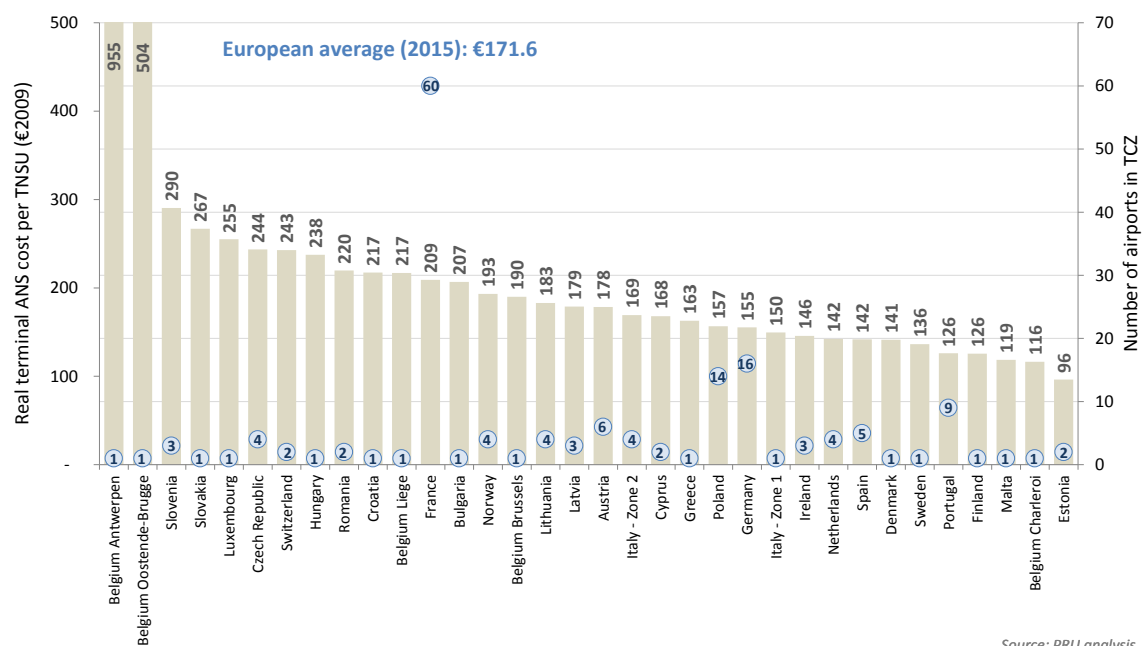
#### **Terminal Navigation Charges (TNC) vs. Airport Charges**

Given the risk for potential misunderstanding, it is useful to differentiate between Terminal ANS charges (also called “TNC” for terminal navigation charges) and “Airport charges”, which typically include landing, passenger, cargo, parking and hangar, and noise charges, and are covered by Directive 2009/12/EC.

Figure 5-10 shows the level of terminal ANS unit costs in 2015 for each of the 34 TCZs included in the analysis. It should be noted that the two TCZs reported by UK have been excluded from this analysis since:

- information relating to UK TCZ B, which refers to nine airports where terminal ANS are provided on a contractual basis, is not publicly available; and,
- UK TCZ C (London Approach) is not directly comparable with other TCZs since the service provided is of a different nature. Indeed, London Approach is making the transition between the en-route and terminal phases for the five London Airports which are also part of TCZ B.

In addition, for three charging zones (i.e. Cyprus, Belgium and Spain) the unit costs presented in the figure below do not consider other revenues which are used to subsidise all or part of terminal ANS costs.



Source: PRU analysis

Figure 5-10: Comparison of 2015 terminal ANS unit costs by TCZ

Figure 5-10 indicates that in 2015, the average terminal ANS costs per TNSU amounted to 171.6 €<sub>2009</sub> at system level. Figure 5-10 also shows that the unit terminal costs ranged from 955 €<sub>2009</sub> for Belgium Antwerpen TCZ to 96 €<sub>2009</sub> for Estonia TCZ, nearly a factor of 10.

Caution is needed when interpreting these results since several factors on top of performance-related issues can affect the level of terminal unit costs in a specific TCZ. These factors include the number and size of aerodromes included in the charging zone, the use of different cost-allocation between en-route and terminal ANS, differences in traffic levels across TCZs and the scope of ANS provided.

For instance, Figure 5-10 shows that the two Belgian TCZs with the highest unit terminal costs in 2015 only include one airport each. Similarly, while the French TCZ reflects the information relating to 60 airports (including regional airports), only the five main airports are included in the Italian TCZs.

Figure 5-11 below provides the distribution of the 34 TCZs included in this analysis based on the terminal ANS costs and also shows the share of the total TNSUs served at system level (see blue dashes). The three largest TCZs (France, Germany and Spain) account for nearly 50% of the European system total terminal ANS costs and traffic, while at the same time, the 16 smallest TCZs represent only around 8% of total terminal ANS costs (7% in terms of TNSUs).

Figure 5-11 also indicates that the two TCZs with the highest unit terminal costs in 2015 (Antwerpen (955 €<sub>2009</sub>) and Belgium Oostende-Brugge (504 €<sub>2009</sub>)) together represent 0.6% of terminal ANS costs and account for 0.1% of the TNSUs handled at system level.

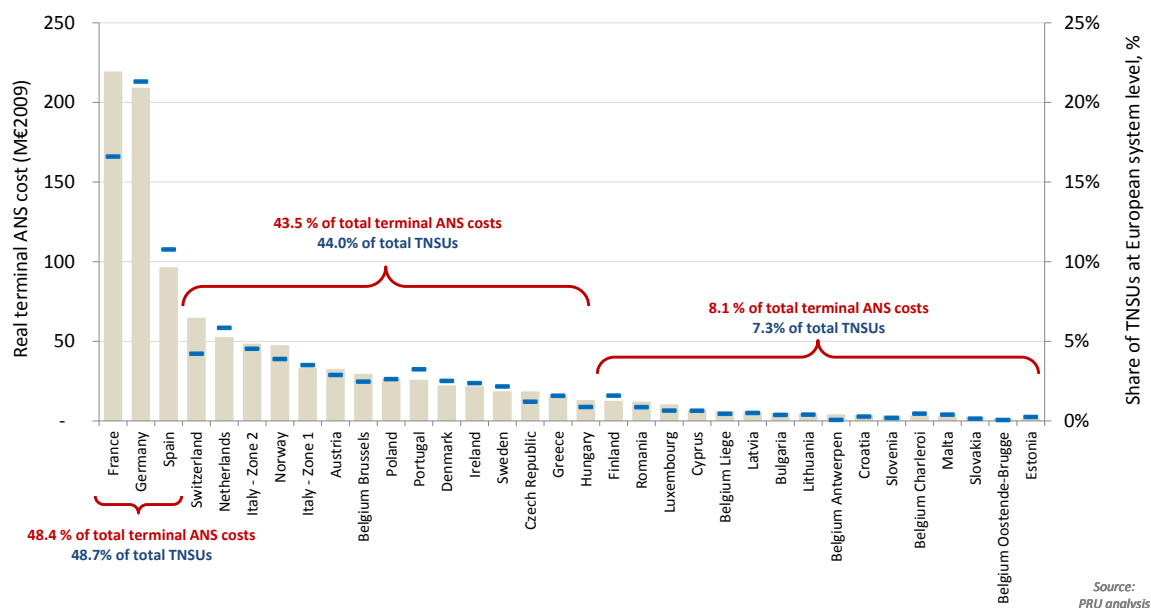


Figure 5-11: Distribution of terminal ANS costs and TNSUs by TCZ in 2015

### 5.3.2 Terminal ANS cost-efficiency performance: outlook for 2016-2019

The objective of this section is to provide information on planned terminal unit costs at system level for the period 2016-2019. It is based on data reported in the terminal reporting tables submitted to the EC in November 2016<sup>22</sup>.

Figure 5-12 shows that total terminal ANS costs are expected to slightly decrease (-0.7% p.a.) between 2015 and 2019 while TNSUs are foreseen to increase at an average rate of +1.4% per annum.

As a result, terminal ANS unit costs are expected to decrease from 171.6 €<sub>2009</sub> in 2015 to 157.3 €<sub>2009</sub> in 2019 (or -2.1% p.a.).

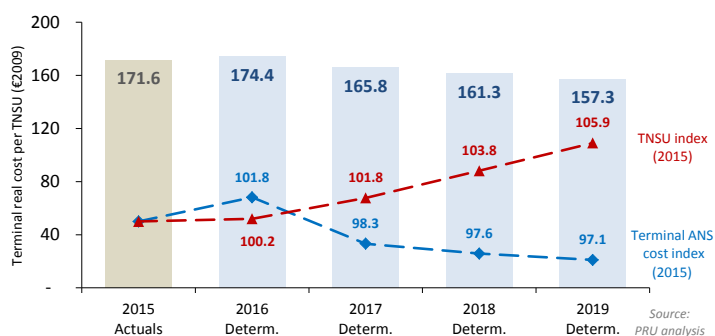


Figure 5-12: Real terminal ANS costs per TNSU, total costs (€<sub>2009</sub>) and TNSUs

<sup>22</sup> It should be noted that, to date, Malta has requested the European Commission to revise the adopted RP2 terminal cost-efficiency targets. For Malta, the information used in Figure 5-12 reflects the data provided in the November 2016 submission of Terminal Reporting Tables including the proposed RP2 cost-efficiency target revisions for the years 2017-2019. Similarly, Figure 5-12 reflects the information provided by FABEC in the revised RP2 Performance Plan submitted early 2017.

## 5.4 ANSPs gate-to-gate economic performance

The ATM Cost-Effectiveness (ACE) benchmarking analysis is a Pan-European review and comparison of ATM cost-effectiveness for 38 Air Navigation Service Providers (ANSPs). This includes 30 ANSPs which were at 1<sup>st</sup> January 2015 part of the SES, and hence subject to relevant SES regulations and obligations. Detailed analysis is given in the ACE 2015 Benchmarking Report [Ref. 13].

The ACE 2015 data analysis presents information on performance indicators relating to the benchmarking of cost-effectiveness and productivity performance for the year 2015, and shows how these indicators changed over time (2010-2015). It examines both individual ANSPs and the Pan-European ATM/CNS system as a whole. It is important to note that the year under review (2015) is the latest year for which actual financial data are currently available.

Some elements of ANS provision are outside the control of individual ANSPs. These elements include the costs of aeronautical MET services, the costs of the EUROCONTROL Agency and costs associated to regulatory and governmental authorities. Therefore, from a methodological point of view, the ACE Benchmarking analysis focuses on the specific costs of providing gate-to-gate ATM/CNS services which are under the direct responsibility of the ANSP.

The analysis developed in the ACE Reports allows identifying best practices in terms of ANSPs economic performance and to infer a potential scope for future performance improvements. This is a useful complement to the analysis of the en-route and terminal KPIs which are provided in the previous sections of this chapter.

Figure 5-13 shows a detailed breakdown of gate-to-gate ATM/CNS provision costs. Since there are differences in cost-allocation between en-route and terminal ANS among ANSPs, it is important to keep a “gate-to-gate” perspective when benchmarking ANSPs cost-effectiveness performance.

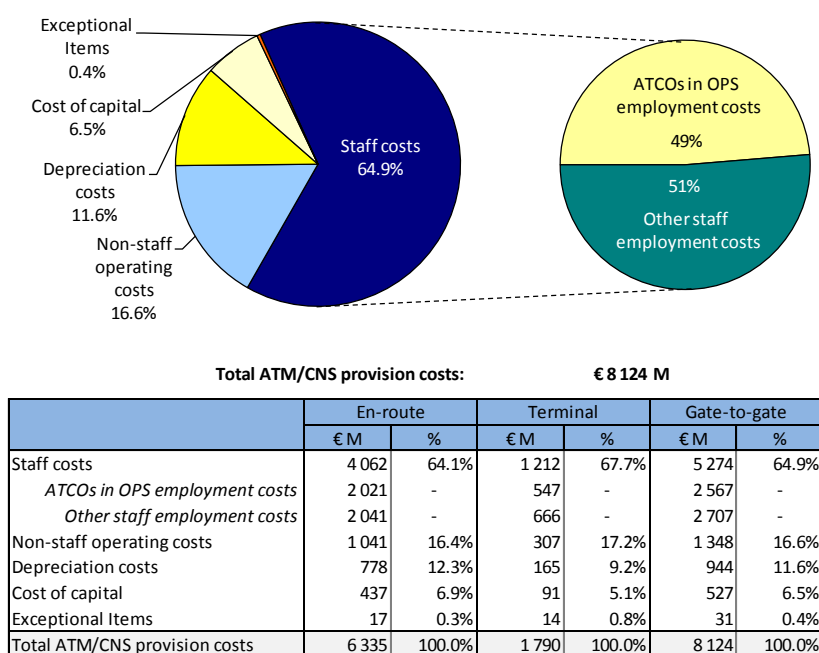


Figure 5-13: Breakdown of gate-to-gate ATM/CNS provision costs 2015 (€2015)

Figure 5-13 indicates that in 2015, at Pan-European system level, gate-to-gate ATM/CNS provision costs amount to some €8.1 Billion. Operating costs (including staff costs, non-staff operating costs and exceptional cost items) account for some 82% of total ATM/CNS provision costs, and capital-related costs (cost of capital and depreciation) amount to some 18%.

The analysis presented in this section is factual. It is important to note that local performance is affected by several factors which are different across European States, and some of these are typically outside (exogenous) an ANSP's direct control while others are endogenous. Indeed, ANSPs provide ANS in contexts that differ significantly from country to country in terms of environmental



characteristics (e.g. the size and complexity of the airspace), institutional characteristics (e.g. relevant State laws), and of course in terms of operations and processes.

A genuine measurement of cost inefficiencies would require full account to be taken of the exogenous factors which affect ANSPs economic performance. This is not straightforward since these factors are not all fully identified and measurable. Exogenous factors related to operational conditions are, for the time being, those which have received greatest attention and focus. Several of these factors, such as traffic complexity and seasonal variability, are now measured robustly by metrics developed by the PRU.

The quality of service provided by ANSPs has an impact on the efficiency of aircraft operations, which carry with them additional costs that need to be taken into consideration for a full economic assessment of ANSP performance. The quality of service associated with ATM/CNS provision by ANSPs is, for the time being, assessed only in terms of ATFM delays, which can be measured consistently across ANSPs, can be attributed to ANSPs, and can be expressed in monetary terms. The indicator of “economic” cost-effectiveness is therefore the ATM/CNS provision costs plus the costs of ATFM delay, all expressed per [composite flight-hour](#). In 2015, the total economic costs (sum of ATM/CNS provision costs with the costs of ATFM delays) amount to some 9 493 M€ which is +4.9% higher than in 2014. Further details on the methodology used to compute economic costs are available in the ACE 2015 Benchmarking Report.

#### 5.4.1 Trends in economic cost-effectiveness (2010-2015)

Figure 5-14 below displays the trend at Pan-European level of the gate-to-gate economic costs per composite flight-hour (“unit economic costs” thereafter) between 2010 and 2015 for a consistent sample of 37 ANSPs for which data for a time-series analysis was available<sup>23</sup>.

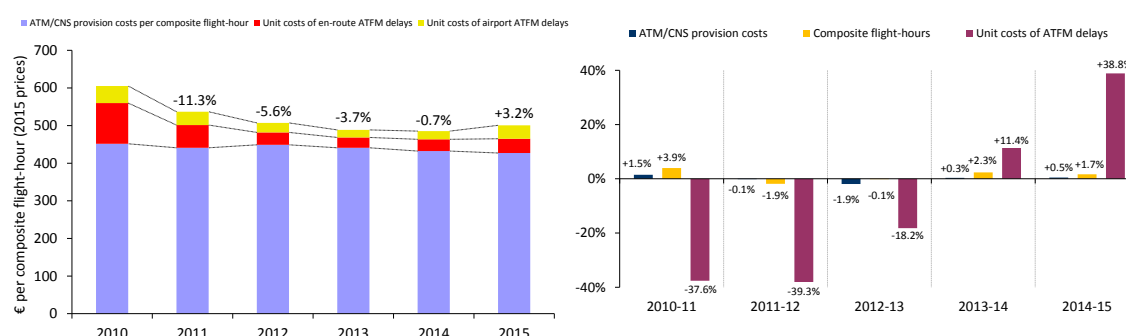


Figure 5-14: Changes in economic cost-effectiveness, 2010-2015 (€2015)

It is noteworthy that the year 2010, which is the starting point of this trend analysis, shows a relatively high level of unit economic costs for the ATM system. This mainly reflects the fact that the costs of ATFM delays were exceptionally high that year following a sharp increase in delays for a limited number of ANSPs.

Over the 2010-2014 period, economic costs per composite flight-hour decreased by -5.4% p.a. in real terms, mainly due to the substantial decreases in unit ATFM delay costs (-23.4% p.a.). Over this period, ATM/CNS provision costs remained close to their 2010 level (-0.1% p.a.) while the number of composite flight-hours slightly increased (+1.0% p.a.).

In 2015, composite flight-hours rose faster (+1.7%) than ATM/CNS provision costs (+0.5%) and as a result unit ATM/CNS provision costs reduced by -1.2%. However, since the unit costs of ATFM delays increased by +38.8%, unit economic costs rose by +3.2% compared to 2014. This is the first increase in unit economic costs since 2010.

<sup>23</sup> Sakaeronavigatsia which provided data for the first time as part of the ACE 2015 cycle is not included in this analysis.

The right-hand side chart in Figure 5-14 shows that the trend of decreasing unit costs of ATFM delays stopped in 2013, and that a new cycle characterised by higher delays started (+11.4% in 2014 and +38.8% in 2015 in terms of unit ATFM delays costs). This trend continued in 2016 since en-route ATFM delays were +20.9% higher than in 2015. This implies that in 2016, the unit costs of delays will be significantly higher than in 2015 and will negatively affect ANSPs economic cost-effectiveness.

Figure 5-15 below shows the comparison of ANSPs gate-to-gate unit economic costs in 2015. The economic cost-effectiveness indicator at Pan-European level in 2015 amounts to €501 per composite flight-hour, and, on average, ATFM delays represent 15% of the total economic costs. Figure 5-15 indicates that in 2015 unit economic costs ranged from €870 for Skyguide to €191 for MATS; a factor of more than four. Figure 5-15 also indicates that DFS had the highest unit economic costs amongst the five largest ANSPs.

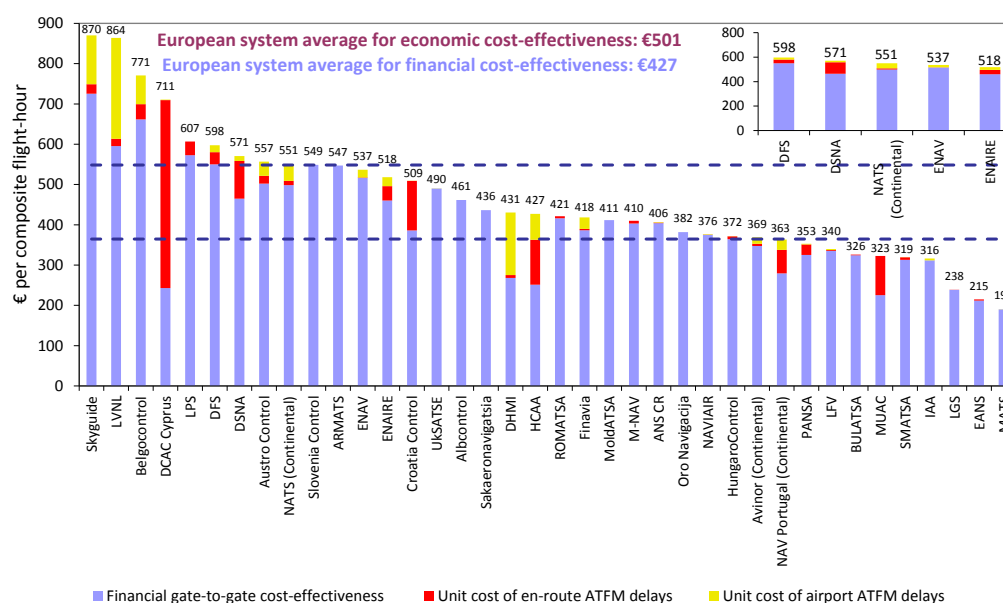


Figure 5-15: Economic gate-to-gate cost-effectiveness indicator, 2015

It is important to note that, for ANSPs operating outside of the Euro zone (such as Skyguide), substantial changes of the national currency against the Euro may significantly affect the level of 2015 unit economic costs when expressed in Euro. Assuming that the Swiss Franc had remained at its 2014 level, Skyguide 2015 unit economic costs would amount to some €783, and Skyguide would rank at the second position just below LVNL. More information on exchange rates variations and their impact on unit costs can be found in the ACE 2015 Benchmarking Report.

Figure 5-16 below shows the contribution of each of the 37 ANSPs to the change in ATFM delays observed in 2015 at Pan-European system level (i.e. increase from 9 881 to 13 946 thousands of minutes).

Figure 5-16 indicates that the increase in ATFM delays observed at system level in 2015 mainly reflects very large increases for a few ANSPs. Indeed, more than 90% of the total increase is generated by only five ANSPs (DSNA, DHMI, HCAA, MUAC and LVNL). The main factors explaining the increase in ATFM delays for the top five contributors are:

- airport capacity issues at the two Istanbul airports for DHMI;
- the training and implementation of the ERATO stripless environment in December 2015 at Brest ACC, as well as industrial action in April 2015 for DSNA;
- ACC staffing and capacity issues during the summer period for HCAA;
- capacity issues mainly due to shifting traffic flows for MUAC; and,
- weather issues at Amsterdam/Schiphol airport, as well as trials and the implementation of a new Voice Communication System for LVNL.

The right-hand side of Figure 5-16 shows that, as a result, for most of these ANSPs the share of ATFM delays in economic costs in 2015 is significantly higher than the European average (15%).

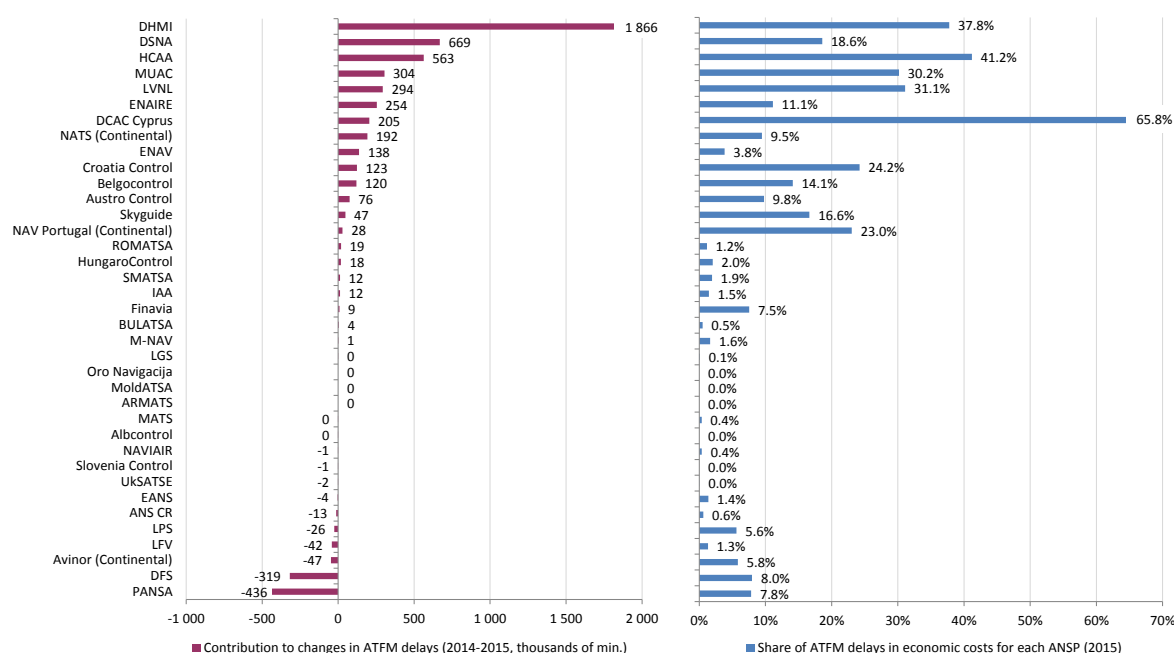


Figure 5-16: ANSPs contribution to ATFM delays increase at Pan-European system level in 2015

More details on the changes in ATFM delays in 2015 can be found in Chapter 4 (Operational en-route ANS performance) of PRR 2015 [Ref.5].

Figure 5-17 below shows how the unit ATM/CNS provision costs (see blue part of the bar in Figure 5-17 above) can be broken down into three main key economic drivers: (1) ATCO-hour productivity, (2) employment costs per ATCO-hour and (3) support costs per composite flight-hour. Figure 5-17 also shows how these various components contributed to the overall change in cost-effectiveness between 2014 and 2015.

Figure 5-17 shows that in 2015, ATCO employment costs per ATCO-hour (+1.8%) rose slightly faster than ATCO-hour productivity (+1.4%), and as a result ATCO employment costs per composite flight-hour increased by +0.5%. In the meantime, unit support costs fell by -1.9% since support costs remained close to 2014 levels (-0.3%) while the number of composite flight-hours increased (+1.7%). As a result, in 2015 unit ATM/CNS provision costs reduced by -1.2% at Pan-European system level.

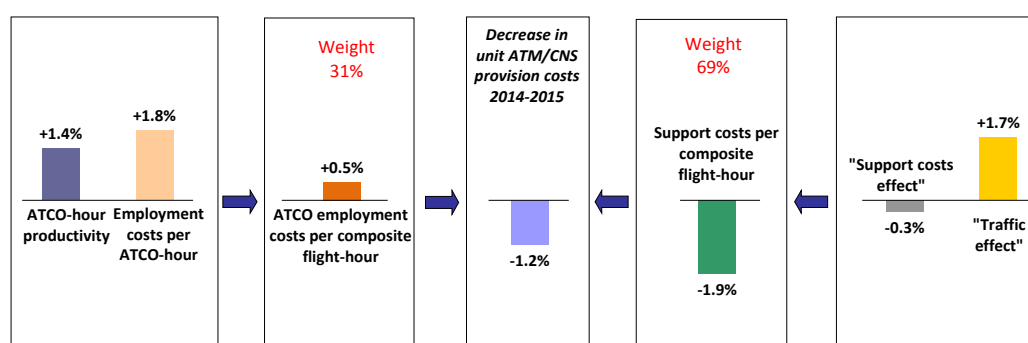


Figure 5-17: Breakdown of changes in cost-effectiveness, 2014-2015 (€2015)

More details on the changes in unit ATM/CNS provision costs at ANSP and Pan-European system levels are available in the ACE 2015 Benchmarking Report.

## 5.5 Conclusions

PRR 2016 analyses performance in 2016 for all key performance areas, except for cost-efficiency, which analyses performance in 2015 as this is the latest year for which actual financial data are available. On the other hand, PRR 2016 also presents an outlook for 2016-2019 in terms of cost-efficiency trends.

The **en-route cost-efficiency performance** Pan-European system (39 States) improved in 2015 since real en-route unit costs decreased from 50.4 €<sub>2009</sub> to 49.2 €<sub>2009</sub> per service unit (TSU) which corresponds to a -2.4% reduction compared to 2014. This reduction is mainly due to the fact that traffic (+3.9%) rose faster than en-route ANS costs (+1.5%).

Over the 2009-2015 period, en-route unit costs reduced by -3.3% p.a. since traffic volumes rose by +3.1% p.a. while en-route costs remained fairly constant (-0.2% p.a.). This performance improvement should be seen in the light of (a) the cost-containment measures initiated in 2009-2010 in response of the traffic downturn arising from the economic recession, and (b) for SES States, the implementation of the Performance Scheme and the incentive mechanism embedded in the charging scheme which contributed to maintain a downward pressure on costs during RP1.

The outlook for 2016-2019 suggests that en-route unit costs are expected to decrease from 49.2 €<sub>2009</sub> in 2015 to 45.8 €<sub>2009</sub> in 2019, representing a decrease of -1.8% p.a. on average until 2019. Overall, at Pan-European level between 2009 and 2019, the trend in total en-route costs is planned to remain flat, while traffic is planned to increase by some +32%, implying substantial cost-efficiency improvements over this 10-years cycle.

European **terminal ANS unit costs** amount to 171.6 €<sub>2009</sub> in 2015, which is the first year of application of the “determined costs” method for terminal ANS. In 2015, 30 States operated 36 Terminal Charging Zones (TCZs) which included a total of 172 airports.

Detailed analysis shows that there are wide differences in the level of unit costs at TCZ level ranging from 955 €<sub>2009</sub> for Belgium Antwerp TCZ to 96 €<sub>2009</sub> for Estonia TCZ. Caution is needed when interpreting these results since several factors on top of performance-related issues can affect the level of terminal unit costs in a specific TCZ. These factors include the number and size of aerodromes included in the charging zone, the use of different cost-allocation between en-route and terminal ANS, differences in traffic levels across TCZs and the scope of ANS provided.

The outlook for 2016-2019 suggests that total terminal ANS costs are planned to slightly decrease (i.e. on average by -0.7% p.a.), while TNSUs are foreseen to increase at an average rate of +1.4% per year. As a result, terminal ANS unit costs are expected to reduce by -2.1% p.a. between 2015 and 2019.

Detailed benchmarking analysis focusing on ANSPs cost-efficiency at Pan-European system shows that in 2015 the **gate-to-gate unit economic costs** increased by +3.2%, breaking a trend of 4 years of consecutive decreases. This increase is mainly due to higher ATFM delays unit costs in 2015 (+38.8%) while unit ATM/CNS provision costs reduced by -1.2% compared to 2014.

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- 1 Article 1 of the PRC's Terms of Reference, adopted in 2003.
  - 2 EUROCONTROL STATFOR 7-year forecast, February 2016, <https://www.eurocontrol.int/articles/forecasts>.
  - 3 EUROCONTROL STATFOR 7-year forecast, February 2017, <https://www.eurocontrol.int/articles/forecasts>.
  - 4 Safety Review Commission, "Annual Safety Report for 2013", (February, 2014).
  - 5 Performance Review Commission, Performance Review Report 2015 (PRR 2015). An assessment of Air Traffic Management in Europe during the calendar year 2015 (June 2016).
  - 6 ["Acceptable Level of Safety Performance \(ALoSP\) implementation in EUROCONTROL Member States", Report commissioned by the PRC, June 2017.](#)
  - 7 EUROCONTROL, "Challenges of growth 2013" report
  - 8 GANP Resources: <http://www.icao.int/airnavigation/Pages/GANP-Resources.aspx>
  - 9 European airline delay cost reference values – updated and extended values (University of Westminster), Final report (Version 4.1), (December, 2015). Available at the PRC web-page (<http://www.eurocontrol.int/prc/publications>).
  - 10 ["Review of Civil Military Coordination and Cooperation Arrangements", Report commissioned by the PRC, December 2016.](#)
  - 11 Commission Regulation (EC) No 1794/2006 of 6 December 2006 laying down a common charging scheme for air navigation services amended by Commission Regulation (EC)
  - 12 Commission Implementing Regulation (EU) No 391/2013 of 3 May 2013 laying down a common charging scheme for air navigation services.
  - 13 ATM Cost-effectiveness (ACE) 2015 Benchmarking Report. Report commissioned by the Performance Review Commission (May 2017)

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## About the Performance Review Commission

The Performance Review Commission (PRC) provides independent advice on European Air Traffic Management (ATM) Performance to the EUROCONTROL Commission through the Provisional Council.

The PRC was established in 1998, following the adoption of the European Civil Aviation Conference (ECAC) Institutional Strategy the previous year. A key feature of this Strategy is that *"an independent Performance Review System covering all aspects of ATM in the ECAC area will be established to put greater emphasis on performance and improved cost-effectiveness, in response to objectives set at a political level"*.

Through its reports, the PRC seeks to assist stakeholders in understanding from a global perspective why, where, when, and possibly how, ATM performance should be improved, in knowing which areas deserve special attention, and in learning from past successes and mistakes. The spirit of these reports is neither to praise nor to criticise, but to help everyone involved in effectively improving performance in the future.

The PRC holds 5 plenary meetings a year, in addition to taskforce and ad hoc meetings. The PRC also consults with stakeholders on specific subjects.

Mr. Laurent Barthelemy  
Mr. Juan Bujia-Lorenzo  
Captain Hasan Erdurak

Ms. Marja Hutchings  
Mr. Antero Lahtinen **Vice Chairman**  
Mr. Ralph Riedle **Chairman**

PRC Members must have senior professional experience of air traffic management (planning, technical, operational or economic aspects) and/or safety or economic regulation in one or more of the following areas: government regulatory bodies, air navigation services, airports, aircraft operations, military, research and development.

Once appointed, PRC Members must act completely independently of States, national and international organisations.

The Performance Review Unit (PRU) supports the PRC and operates administratively under, but independently of, the EUROCONTROL Agency. The PRU's e-mail address is [pru-support@eurocontrol.int](mailto:pru-support@eurocontrol.int)

The PRC can be contacted via the PRU or through its website <http://www.eurocontrol.int/prc/publications>.

## PRC PROCESSES

The PRC reviews ATM performance issues on its own initiative, at the request of the deliberating bodies of EUROCONTROL or of third parties. As already stated, it produces annual Performance Review Reports, ACE reports and ad hoc reports.

The PRC gathers relevant information, consults concerned parties, draws conclusions, and submits its reports and recommendations for decision to the Permanent Commission, through the Provisional Council. PRC publications can be found at <http://www.eurocontrol.int/prc/publications> where copies can also be ordered.



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