EUROCONTROL

PRR 2018

Performance Review Report

An Assessment of Air Traffic Management in Europe during the Calendar Year 2018

Performance Review Commission

May 2019

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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Notice

The PRC has made every effort to ensure that the information and analysis contained in this document are as accurate and complete as possible. Only information from quoted sources has been used and information relating to named parties has been checked with the parties concerned. Despite these precautions, should you find any errors or inconsistencies we would be grateful if you could please bring them to the PRU's attention.

The PRU's e-mail address is pru-support@eurocontrol.int

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FOREWORD by the PRC Chairman

In 1997, the PRC was created to advise the EUROCONTROL States on how to address the issues causing flight delays, as well as any other issues that were affecting European ATM performance.

Its remit was to, "monitor ATM performance, set targets and advise the EUROCONTROL States, in order to ensure the effective management of the European ATM System through strong, transparent and independent performance review." In doing so, EUROCONTROL implemented a key recommendation of the ECAC Institutional Strategy 1997.

Twenty years later, flight delays and other ATM performance issues are again a significant problem. So what did the PRC do during that time to help optimise European ATM performance?

The answer is that the PRC has been doing much pioneering work. It created and managed the EUROCONTROL performance review system, a world-first at the time, which significantly improved transparency and which has been emulated worldwide:

- In 1999 the Single European Sky (SES) I regulations contained the basis for an EU-wide performance scheme. These regulations, adopted in 2004, were reinforced in the SES II legislation. The European Commission designated the PRC, supported by the PRU, as the Performance Review Body of the SES until 31 December 2016. Although this designation has ended, the ongoing co-operation and close links continue and are fostered.
- In 2000, the US FAA created a performance-based organization (FAA ATO) to focus solely on efficient operation of the ATC system.
- In 2005, the ICAO Global Air Traffic Management Operational Concept (Doc 9854) required ATM performance to be considered at External/Internal/System and Technology levels.
- In 2007, ICAO revised its Manual on Air Navigation Services Economics (Doc 9161) introducing the PRC's cost efficiency performance framework.
- In 2009, ICAO published its Manual on Global Performance of the Air Navigation System (Doc 9883) which defined a performance review approach, based on the one developed by the PRC.
- In 2018, the ICAO 13th Air Navigation Conference actively promoted a global performance-based approach, in line with the PRC's work.

The PRC has received two international awards for its work.

As an advisory body to the EUROCONTROL States, the PRC has assisted States and other key stakeholders e.g. ANSPs, airports and airspace users, to understand 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.

For instance, as early as 2014 the PRC flagged up in its PRR that some capacity plans were insufficient and recommended that the States and ANSPs concerned should work with the Network Manager to avoid exponential delays in the coming years.

The PRC as an advisory body can only caution, warn and advise. It is up to the decision-makers to act on that expert advice.

One very powerful PRC activity is its ATM Cost-effectiveness (ACE) benchmarking work. While the direct impact of the annual ACE reports is difficult to measure, the PRC has observed that improvements in unit costs coincided with the starting of its ANSP cost-effectiveness benchmarking work and the spotlight it placed on ANSPs' costs.

The PRC constantly reviews its activities, and has adapted them over the past 20 years in order to remain relevant and credible. It takes particular care to avoid duplication with the work of the Performance Review Body. Instead, it focusses on complementary research projects, and on assisting stakeholders on request.

Throughout the 20 years of its existence, one thing has remained constant: namely that the PRC Members are completely and totally independent of States, the Provisional Council, the EUROCONTROL Agency, ATM Stakeholders or any interested party. This independence has proven to be the key to the success of EUROCONTROL's performance review system, established "to put greater emphasis on performance and cost-effectiveness, in response to objectives set at a political level".

I hope that you enjoy reading this PRR 2018. Should you wish to comment on any aspect of the report, or to contact the PRC, please send an email to pru-support@eurocontrol.int.

More contact details are published on the inside-back cover of this report.

Ralph Riedle

Chairman

Performance Review Commission

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Performance Review Report covering the calendar year 2018 (PRR 2018)

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This report of the Performance Review Commission analyses the performance of the European Air Traffic Management System in 2018 under the Key Performance Areas of Safety, Capacity, Environment and Cost-efficiency.

Keywords

Air Traffic Management	Performance Measurement	
Performance Indicators	ATM	ANS

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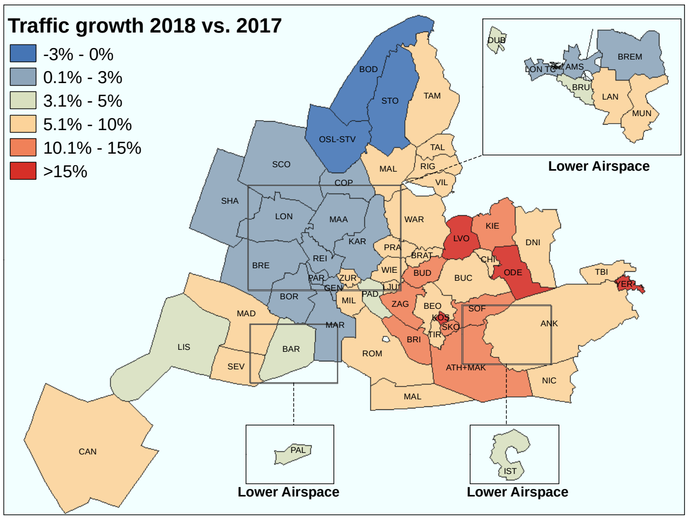
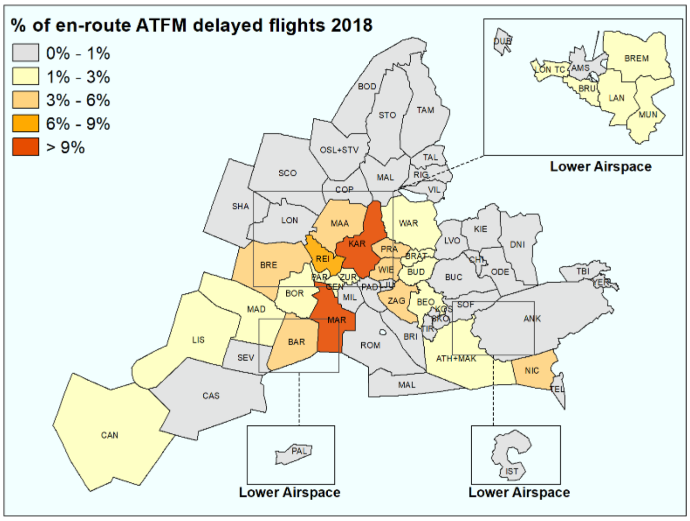
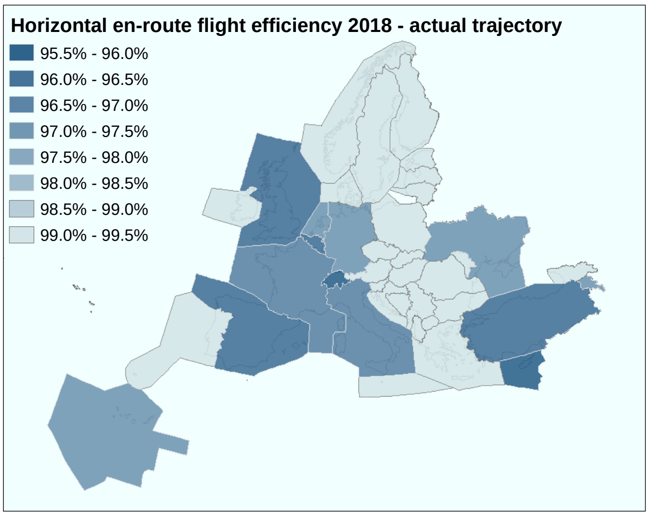
TRAFFIC GROWTH (FLIGHTS) BY AREA CONTROL CENTRE (2018)



SHARE OF EN-ROUTE ATFM DELAYED FLIGHTS BY AREA CONTROL CENTRE (2018)



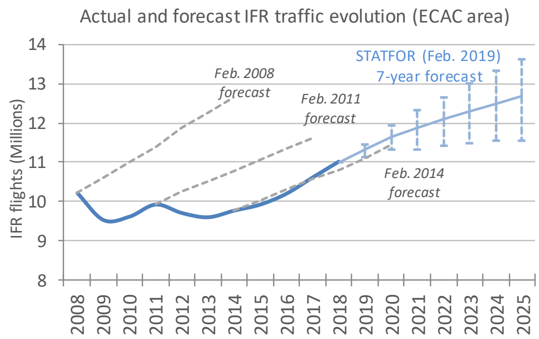
HORIZONTAL EN-ROUTE FLIGHT EFFICIENCY - ACTUAL TRAJECTORY (2018)



ATM Performance in 2018 - Synopsis

	Key Performance Indicator	Data & commentary

TRAFFIC



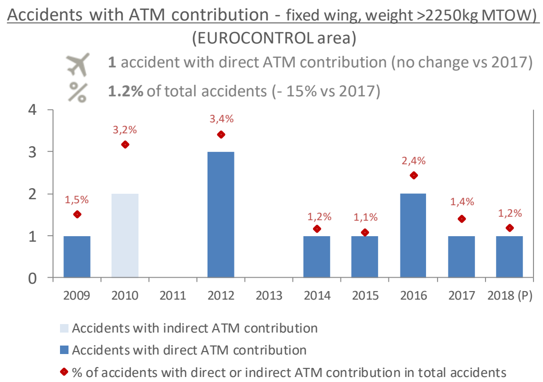
IFR flights	ECAC area	Variation
2018	11.0 M	+ 3.8% ↑

Air traffic in the ECAC area continued to grow for the fifth consecutive year in 2018.

On average IFR flights increased by 3.8% over 2017 which was slightly above the baseline scenario forecast by STATFOR in the February 2018 forecast.

For 2019, the latest STATFOR forecast (Feb. 2019) predicts a baseline growth of 2.8% at system level.

SAFETY

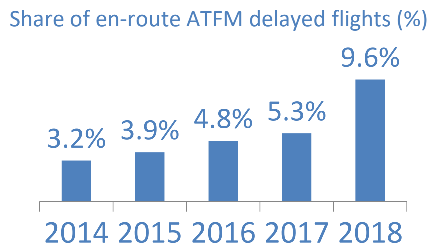


Accidents with direct ANS contribution	Eurocontrol area	Variation
2018 (preliminary)	1	+/-0.0%pt.

There was only one reported accident with direct ATM contribution and none with indirect ATM contribution in 2018 (P). The share of accidents with ATM contribution (direct or indirect) in total air traffic accidents is 1.2%.

There were 62 125 ATM-related incidents, reported through the EUROCONTROL AST mechanism, out of which 43 889 were operational and 18 236 were technical.

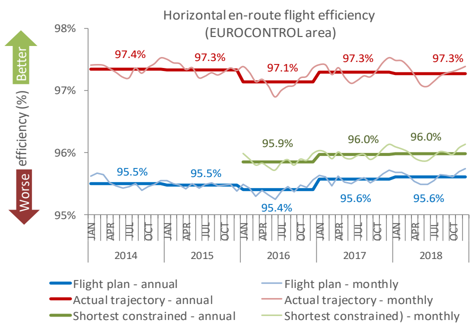
CAPACITY



En-route ATFM delayed flights	Eurocontrol area	Variation
2018	9.6 %	+4.2 %pt. ↑

Total en-route ATFM delays more than doubled compared to 2017 (+104%). As a result 9.6% of the flights were delayed by en-route ATFM regulations and average en-route ATFM delay increased to 1.74 minutes per flight in 2018

ENVIRONMENT

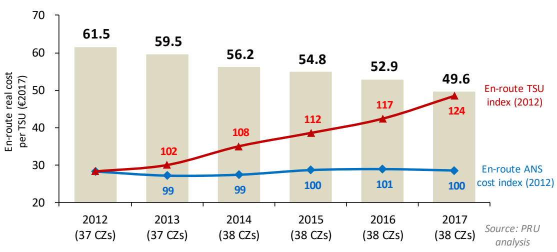


En-route flight efficiency (actual)	Eurocontrol area	Variation
2018	97.3%	+/-0.0%pt.

Horizontal en-route flight efficiency remained at the same level as in 2017 despite the further increase in traffic in 2018.

The newly computed shortest constrained route shows that the routes made available by the ANSPs are on average 1.3% longer than the actual trajectories flown.

COST-EFFICIENCY



En-route ANS costs per TSU ($€_{2017}$)	Eurocontrol area	Variation
2017	49.6	-6.2% ↓

In 2017, en-route ANS costs reduced by -0.4% while en-route service units grew by +6.2%. This resulted in a -6.2% decrease in en-route unit costs compared to 2016.

This report assesses the performance of Air Navigation Services (ANS) in the EUROCONTROL area for the calendar year 2018 for all key performance areas, except for cost-efficiency, which analyses performance in 2017 as this is the latest year for which actual financial data are available.

TRAFFIC

Air traffic in the EUROCONTROL area continued to grow for the fifth consecutive year in 2018. On average IFR flights increased by 3.8% over 2017 which was slightly above the baseline scenario forecast by STATFOR in the February 2018 forecast. Consequently, peak traffic load continued to rise in 2018 and reached the highest level of traffic on record on September 7th when the system handled more than 37 thousand flights.

As in previous years, flight hours and distance grew at a higher rate than IFR flights which - together with the further increase in the average take-off weight - led again to a higher en-route service unit growth (used for charging purposes) in 2018 (+6.1% vs. 2017).

All of the 41 Air Navigation Service Providers (ANSPs) included in the analysis reported a traffic increase compared to 2017. In absolute terms, DFS (Germany), DHMI (Turkey), ENAIRE (Spain), HungaroControl (Hungary), ENAV (Italy) and BULATSA (Bulgaria) showed the highest year on year growth in 2018.

For 2019, the latest STATFOR forecast (Feb. 2019) predicts a baseline growth of 2.8% at system level (Low: 1.2%; High 4.1%) and an average annual growth rate of 2.0% between 2019 and 2025.

The continued traffic growth contributed to a further decrease in overall service quality in 2018. Following the trend observed over the past five years, the share of flights arriving within 15 minutes of their scheduled time decreased by 3.9 percent points to 75.7% in 2018 which is the lowest level over the past 10 years. At the same time, the average departure delay (all delay causes included) increased by 2.3 minutes from 12.1 minutes per departure in 2017 to 14.4 minutes in 2018.

SAFETY

Notwithstanding the further increase in traffic, Safety in the EUROCONTROL area remains high.

As pointed out by the PRC in PRR 2015, with the safety reporting environment changing over the next few years, the aviation community has to accept that there will be a transition phase. During this time, in order to maintain and improve European reporting, it will be highly important that the actors directly involved in safety data collection work together in order to create an optimum solution.

To the PRC’s knowledge, the AST reporting mechanism is likely to be discontinued from 2020 onwards. Should this happen, it would jeopardise the PRC’s continued assessment of the KPAs from the Safety perspective.

Under the EUROCONTROL/EASA Work Programme, one of the key tasks is to improve the quality and completeness of the ATM-related safety data held in the ECR. However, time is running out as in agreement with EASA, the AST mechanism will only continue operating until the end of RP2. The last AST safety data, for 2019 reporting cycle, is due to be available at the end of March 2020.

Following the discontinuation of the AST mechanism as from the beginning of RP3 the ECR will remain the only source of safety data in the ATM domain that could be used for the verification of the adherence to the safety KPIs in the framework of the Performance Scheme for Air Navigation Services and Network Functions. The maturity of the ATM related safety data available in the ECR needs to be improved and DECMA/ACS/SAS and EASA, under the scope of the EUROCONTROL/EASA Work Programme, are working together to identify actions that could lead to the improvement of the ECR data quality.

The lack of quality and completeness of the ECR as well as inherent difficulties in performing a pan-European comparison, even if the PRC is given access, would present an issue for the future.

The new methodology of calculating safety risk has been presented for the first time. The concept of a CRI as a cumulative risk value calculated aggregating all reported, assessed and severity classified safety-related incidents, has potential to become a proxy of exposure to risk within certain airspace for top management information and decision making. Overall idea behind CRI is that the performance of safety system can be analysed within three important broad categories: the airspace environment, the quality of reporting system with reporting entity, measured risks within the system, and human perception of risk.

Preliminary analysis shows that CRI has an ability to allow reporting on the safety performance of the whole European ATM system, but also on the level of its individual entities, e.g. Member States or even at the level of service providers. Moreover, scaling possibility allows measurement of CRI of individual types of safety occurrences as well.

The CRI however, should not be construed as an absolute measuring stick. It is only as good as the fidelity of the data that supports it. In general, specific probabilities of occurrence are not precisely known, and there is some subjectivity in the assessment of severity of the occurrence.

OPERATIONS
(EN-ROUTE)

As was the case for traffic, en-route ATFM delays increased for the fifth consecutive year in 2018. However the increase was clearly disproportional in 2018. While air traffic increased by 3.8% over 2017, total en-route ATFM delays more than doubled in 2018 (+104%) to reach 19 million minutes. More than 1 million flights were delayed by en-route ATFM regulations in the EUROCONTROL area in 2018 which corresponds to 9.6% of all flights (+4.2 percentage points vs. 2017). As a result average en route ATFM delay increased from 0.88 to 1.74 minutes per flight in 2018.

As was the case in previous years, Capacity attributed delays (37.4%) remain the main portion of en-route ATFM delays, followed by Weather attributed delays (25.4%), ATC Staffing (23.0%) and ATC disruptions/industrial actions (7.5%). The evolution of en-route ATFM delays shows a real jump in delays attributed to ATC staffing (+186% vs 2017), adverse weather (+124%) and ATC Capacity (+76%) in 2018. Almost 80% of all en-route ATFM delays in 2018 were generated between May and September.

Although it is evident that the problem will not be solved in 2019, ATC staffing is clearly an issue which needs to be urgently addressed – even more so considering the demographic profile in some ANSPs and the long lead times before new recruits can actively control traffic.

The analysis showed that the European core area where traffic density is highest remains the problem area. In 2018, DSNA (France) generated 31.2% of all en-route ATFM delays in the EUROCONTROL area, followed by DFS (26.9%), Maastricht (7.8%), and ENAIRE (6.8%).The most delay generating ACCs in 2018 were Karlsruhe (21.3%), Marseille (15.2%), Maastricht UAC (7.8%), Reims (6.7%), Brest (5.4%), Vienna (4.3%) and Barcelona (3.8%). Karlsruhe UAC and Marseille ACC together generated more than one third (36.5%) of all en-route ATFM delays in 2018.

Of particular concern is that 14 of the 20 most constraining sectors in 2018 are collapsed sectors. The PRC has previously highlighted that a collapsed sector imposes additional capacity constraints that exacerbate external capacity factors such as high demand, adverse weather or military activity.

Horizontal en-route flight efficiency remained at the same level as in 2017 despite the continued traffic growth in 2018. The efficiency of actual trajectories stayed at 97.3% while the efficiency of filed flight plans was notably lower at 95.6% in 2018.

In addition to the flight efficiency based on planned and actual trajectory, this PRR introduces a new indicator based on the Shortest Constrained Routes which removes influences from airspace users' flight planning and therefore focuses on constraints imposed by Air Navigation Service Providers. The results show that the shortest constrained route, made available by the ANSPs, is on average 0.4%

shorter than the routes filed in flight plans submitted by the airspace users. However, the shortest constrained route, made available by the ANSPs, is still on average 1.3% longer than the trajectories that the aircraft actually fly, which indicates that the ANSPs could be doing more to ensure that the network is made aware of the shortest possible route options and the applicability of constraints on airspace users. While further improving the efficiency of actual trajectories, it would be beneficial in terms of predictability and efficiency to close the observed gap between the planned and the actual trajectories by bringing the operational planning closer to the actual flown trajectory.

Although flight efficiency can never be 100%, the implementation of Free Route Airspace (FRA) which offers a more flexible environment and more choices to airspace users whilst contributing to reduced fuel consumption and emissions. FRA is an enabler to further improve overall flight efficiency but also helps to get planned routes closer to actually flown trajectories.

Over the next years, FRA implementation is expected to bring notable benefits in the dense European core area. However, expected benefits vary by airspace and depend, inter alia, on traffic volume, growth, complexity and other factors. With local FRA implementation progressing, the interface between airspaces and TMAs becomes more important requiring the Network Manager and the ANSPs to work on suitable solutions such as cross-border initiatives.

Vertical en-route flight efficiency deteriorated significantly during summer in 2018. Compared to the same period in 2017, the number of airport pairs impacted by level capping constraints more than doubled in 2018. A large part of the vertical constraints were implemented by the 4ACC initiative.

The initiative was launched in spring 2018 by London, Reims, Maastricht and Karlsruhe, in coordination with the Network Manager and adjacent ACCs to optimise traffic flows and increase overall capacity. Although the initiative prevented an even higher increase in en-route ATFM delays in 2018, from an ANS performance point of view, it is important to consider the bigger picture including the substantial horizontal and vertical flight inefficiencies and related costs imposed on airspace users.

Instead of taking a limited local or regional view, capacity, traffic flows and the application of ATFM regulations need to be managed from a network perspective with the Network Manager, ANSPs and airspace users working collaboratively together to find the best solution for the network as a whole.

OPERATIONS (@ AIRPORTS)

The analysis of the top 30 European airports in terms of traffic showed an average increase in traffic of 3.6% in 2018. Thirteen of the top 30 airports reported a traffic growth above 5% in 2018. Following the increase in declared capacity and associated traffic (+7.7% vs 2017), Frankfurt (FRA) replaced Amsterdam Schiphol (AMS) as the busiest airport in Europe.

Notwithstanding the continued traffic growth, the level of inefficiencies on the arrival flow were reduced in 2018. Overall, 6.0% of the arrivals at the top 30 airports were delayed by airport ATFM regulations in 2018 which is 0.4% percentage points less than in 2017. Different from the negative trend observed en-route, average airport ATFM delays at the top 30 European airports decreased from 1.24 to 1.13 minutes per arrival in 2018, mainly driven by the significant reduction in arrival ATFM delays at Sabiha Gökçen Airport (SAW). On the other hand, the already comparatively high airport arrival ATFM delays at Lisbon and Barcelona airports further increased in 2018 which was partly linked to substantial traffic growth in 2018.

Average additional ASMA time (airborne holdings) at the top 30 airports in 2018 also decreased from 2.18 to 2.07 minutes per arrival. Although London Heathrow (LHR) remained the airport with by far the highest additional ASMA time (7.7 minutes per arrival), the overall reduction was mainly due to significant improvements at Heathrow (LHR) (reduction of almost 1 minute in 2018) following the implementation of the “enhanced Time Based Separation” (eTBS) in March 2018.

The effects of congestion are observed across the top 30 airports in 2018 on the departure management with a general increase of the additional taxi-out times and ATC pre-departure delays.

The continued A-CDM implementation in Europe also proved to be an enabler for improved situation awareness and performance which further increases the predictability and safety of the European network. Notwithstanding a higher number of ATFM regulated flights in 2018, overall ATFM slot adherence at the top 30 airports improved further, also due to a significant improvement at Amsterdam Schiphol (AMS) airport after becoming the 28th full A-CDM airport in May 2018.

Vertical flight efficiency during climb and descent at the top 30 airports remained in 2018 at the same level as in 2017. On average, inefficiencies (expressed in average time flown level per flight) were more than 5 times higher in descent than in climb with notable differences by airport. Whereas vertical flight efficiency during descent at Helsinki (HEL) and Oslo (OSL) is clearly above average, the flights arriving at Frankfurt (FRA), Paris Charles de Gaulle (CDG), London (LHR) and Paris Orly (ORY) showed the highest inefficiencies with more than 5 minutes of level flight on average in 2018.

Although the focus is presently on the en-route capacity crisis, the continued growth in demand combined with the lack of capacity at several European airports is likely to result in a substantial degradation of performance in the future, as observed at Lisbon (LIS) airport in 2018. While ANS has no direct influence on infrastructural measures such as new runways, it can help improve airport performance and capacity resilience through operational enablers (A-CDM, eTBS, CDO, RECAT-EU, etc.).

ECONOMICS

In 2017, the latest year for which actual financial data is available, en-route ANS cost per en-route service unit (TSU) at Pan-European system level amounted to 49.6 €$_{2017}$. This is -6.2% lower than in 2016 since the TSUs grew by +6.2%, while en-route ANS costs slightly reduced (-0.4%).

An analysis of long-term trends in en-route costs, service units and unit costs covering 30 en-route charging zones between 2003 to 2017 shows that the en-route unit costs reduced by -2.8% per year, on average. This remarkable ANS cost-efficiency improvements at Pan-European system level over the 15 year period mainly reflect the fact that en-route TSUs grew significantly faster (+3.5% p.a.) than States cost-bases (+0.6% p.a.).

In 2017, the European terminal ANS unit costs amounted to 178.1 €$_{2017}$ per terminal service unit (TNSU), which is -4.3% lower than the previous year. This performance improvement reflects robust growth in TNSUs (+4.1%) in the context of slightly decreasing terminal ANS costs (-0.4%). Terminal ANS unit costs are expected to further reduce by -0.7% per annum and amount to 175.5 €$_{2017}$ by 2019. Should these forecasts materialise, the terminal ANS unit costs will be some -9.0% lower than in 2015 at the beginning of the reference period.

Staff costs, which represent the largest share of en-route and terminal cost-bases, are significantly affected by the level of contributions made by the ANSPs into the employee pension schemes. As shown in the Pension study report commissioned by the PRC, the pension costs incurred by the ANSPs rose by some +25% between 2010 and 2016, despite a decrease in staff numbers. Pension costs per employee also tend to be relatively high for ANSPs contributing to defined benefit schemes. Some of them have already taken measures to limit their exposure to the increasing pension costs by, for example, transitioning from defined benefit to defined contribution schemes. Depending on the situation of individual ANSPs, increasing pension liabilities could become a significant issue in the future which should be monitored locally.

Detailed benchmarking analysis of Pan-European ANSPs indicates that, in 2017, gate-to-gate ATM/CNS provision costs increased by +1.0% over the preceding year and amounted to some €8.2 Billion at system level. At the same time traffic, expressed in composite flight-hours, rose by +4.8%. As a result, gate-to-gate unit ATM/CNS provision costs decreased (-3.6%) for the fifth consecutive year.

An indicator of economic costs is also used to account for the quality of service provided by the ANSPs by combining the ATM/CNS provision costs and the estimated costs of ATFM delays. This analysis shows that, at Pan-European system level, unit economic costs decreased by -3.6% in 2017. In the meantime, the ATFM delays generated by the ANSPs rose for the fourth consecutive year (+1.2%). The impact of this increase on the Pan-European system economic cost-effectiveness indicator in 2017 was mitigated by the substantial traffic growth (+4.8%). Analysis on the operational ANS performance provided in this report indicates that ATFM delays substantially rose in 2018. All else being equal, this increase in ATFM delays substantially affects the Pan-European system economic cost-effectiveness performance in 2018.

PRC Recommendations 2018

Recommendation a	***Rationale***
The Provisional Council is invited: a.1) to request Member States to task their ANSPs to: a) support the Network Manager in mitigating existing capacity shortfalls by taking a network centric instead of a local approach; b) work with the Network Manager to ensure that future capacity planning and deployment show sufficient flexibility to meet forecast traffic demand in a cost efficient manner; c) work with the Network Manager and airspace users to identify airspace which is likely to have genuine structural issues in the future and which therefore may require more substantial changes in airspace design; a.2) submit recommendation a.1) to the Permanent Commission for approval.	With the focus mainly on cost savings over the past years, it is evident that the European ANS system benefited from the reduced traffic levels following the economic crisis in 2008. However, with traffic and delay growing again since 2013, shortcomings in proactive capacity planning and deployment are becoming more and more apparent in some areas. The doubling of en-route ATFM delay in 2018 and the negative outlook for 2019 not only detracts from the substantial cost-efficiency improvements over the past years but also underlines the importance of having a balanced approach in performance management. With European airspace being saturated in a number of areas and technical solutions years from deployment, a collaborative, network centric, approach with genuine structural changes in the future will be an important enabler to manage the forecast rising demand levels. Instead of taking a limited local view, capacity, traffic flows and the application of ATFM regulations need to be managed from a network perspective with the Network Manager, ANSPs and airspace users working collaboratively together to find the best solution for the network as a whole. This recommendation is in line with Recommendation 1 of the European Commission's Wise Persons Group on European ATC.

Recommendation b	***Rationale***
The Provisional Council is invited to take the necessary steps to ensure that its recommendation at PC/49 (2018) is implemented. It read: "*The Provisional Council requested the Director General and the Member States to strengthen the ATFCM process by developing and adopting strict procedures for attributing ATFM delay causes, instead of the current guidelines*	There does not appear to have been any progress on the Provisional Council's request. The PRC notes that significant inconsistencies in the attribution of delays, especially in regard to collapsed sectors, are preventing mitigation and resolution. The attribution of ATFM delays should be based on the following principles: • Primary focus for mitigating or resolving capacity constraints should be on identifying any ANSP-internal constraints that prevent the deployment of maximum declared capacity (e.g. ATC staffing, equipment or

that lead to inconsistencies and opacity in monitoring capacity performance."	airspace management); • Attribution of delays to external causes (e.g. weather or 3rd party strike) should only be used in cases where no ANSP-internal capacity constraints prevent the deployment of maximum capacity; • Attribution of delays to ATC capacity should not be used for collapsed sectors or when the regulated capacity is less than the maximum declared capacity of the sector.

Recommendation c	***Rationale***
The Provisional Council is invited: c.1) to request Member States to urge their ANSPs to support the PRC in: a) studying capacity issues in congested airspace particularly the flexible use of airspace (FUA) and the integration of drone operations; b) getting a picture of ANSPs' future ATC staffing plans c.2) to submit recommendation c.1) to the Permanent Commission for approval.	In 2018, 37% of en-route ATFM delays were attributed to ATC capacity and 23% of total en-route ATFM delays were attributed to ATC staffing. The PRC would like to study relevant issues identified in PRR 2018. This could be useful for the implementation of Recommendation 6 of the European Commission's Wise Persons Group on European ATC.

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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 Navigation Services (ANS) system through a strong, transparent and independent performance review system*", per Article 1 of its Terms of Reference [1]. More information about the PRC is given on the inside cover page of this report.

This Performance Review Report (PRR 2018) has been produced by the PRC with its supporting unit the Performance Review Unit (PRU). It gives an independent holistic view of ANS performance in all EUROCONTROL Member States across all key performance areas. Its purpose is to provide policy makers and ANS stakeholders with objective information and independent advice concerning the performance of European ANS in 2018, based on analysis, consultation and information provided by relevant parties. PRR 2018 also describes other activities undertaken by the PRC in 2018 as part of its work-programme.

Through its PRRs, the PRC seeks to assist all stakeholders in understanding 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.

As in previous years, stakeholders were consulted on the draft Final Report and were invited to provide comments for the PRC's consideration before the report was finalised and the PRC prepared its recommendations arising out of PRR 2018. The consultation phase was from 22.03-12.04 2019.

On the basis of PRR 2018 and stakeholders' comments, the PRC will develop and provide independent advice on ANS performance and propose recommendations to the EUROCONTROL States.

1.1.1 PRC work-programme 2018

In addition to its annual PRR, the PRC produces an annual ATM Cost-Effectiveness (ACE) Benchmarking report, which presents yearly factual data and analysis on cost-effectiveness and productivity for Air Navigation Service Providers (ANSPs) in Europe.

During 2018, the PRC was involved in the following activities:

- Participation 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;
- identification of future improvements in performance; and
- ensuring widespread circulation of best practices for ATM performance.

Based on the work of the PRC and the international benchmarking activities, some of the indicators used in the PRR are also promoted by ICAO as part of the update of the Global Air Navigation Plan (GANP). More information on the GANP indicators is available online in the ICAO performance objective catalogue [2].

The PRC's activities avoid duplication and unnecessary overlaps with those of the Performance Review Body of the Single European Sky.

To allow easy access and to make information available more quickly, the PRC has developed a web page dedicated to European ANS performance review. The web page provides up to date information on ANS performance in the EUROCONTROL area including performance methodologies, specific studies and data for download.

1.1.2 Report scope and structure

Unless otherwise indicated, PRR 2018 relates to the calendar year 2018 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".

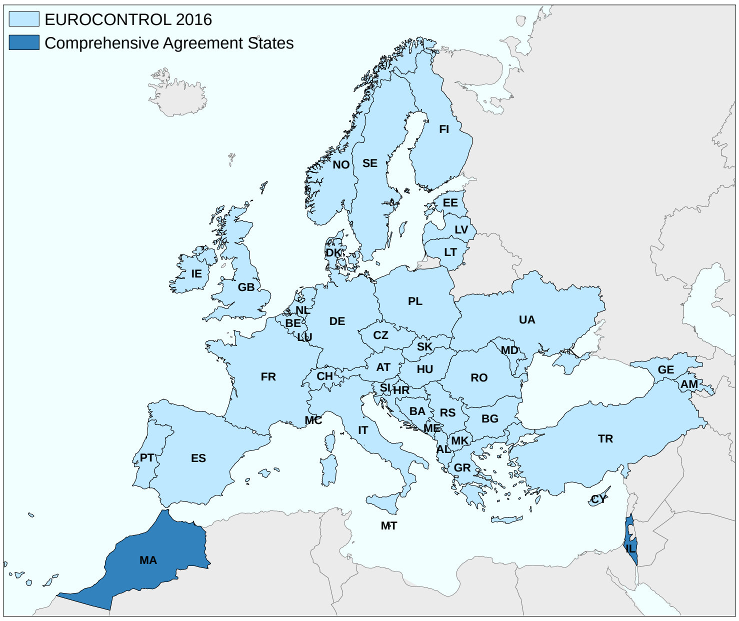


Figure 1-1: EUROCONTROL States (2018)

Note that the constitutional name of the FYROM is the Republic of North Macedonia, with effect from 12 February 2019.

Data for Israel and Morocco have been included where feasible in the PRR 2018 analyses. The PRC is helping them to optimise their data collection and validation methods. This work is being done under the agreement signed by EUROCONTROL with Israel and Morocco in 2016, with a view to fully integrating both States into its working structures.

PRR 2018 is structured in five chapters addressing the Key Performance Areas: Capacity, Cost-efficiency, Efficiency, Environmental sustainability and Safety.

Chapter 1- Introduction and context: General context including a high level review of air traffic demand and punctuality trends in the EUROCONTROL area.

Furthermore, the chapter provides an estimate of the total ANS related costs. The chapter also addresses the environmental component of ANS performance.

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 2018.

Chapter 4 - ANS Performance @ airports: Review of the operational ANS Performance of the top 30 airports in terms of traffic in 2018.

Chapter 5 - ANS Cost-efficiency: Analysis of ANS cost-efficiency performance in 2017 (the latest year for which actual financial data were available) and performance outlook, where possible.

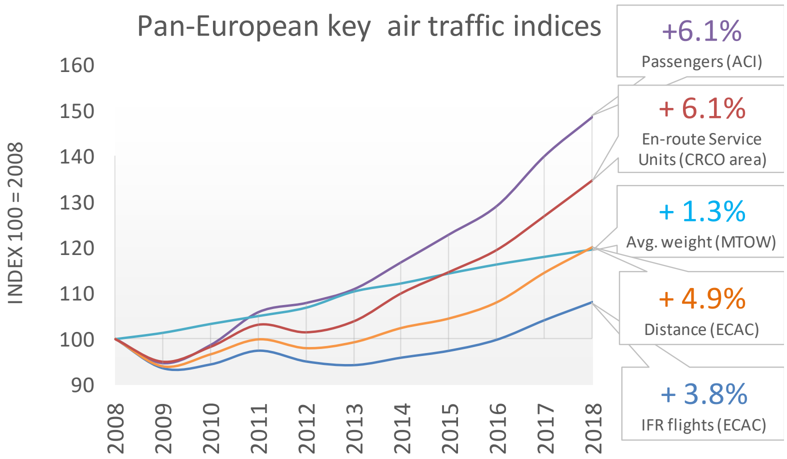
1.2 European air transport key indices

+3.8% vs 2017 **IFR traffic continued to grow for the fifth consecutive year in 2018**

The evolution of the European air traffic indices[1] in Figure 1-2 shows that the positive trend observed over the past five years also continued in 2018. Controlled flights in the ECAC area[2] increased by +3.8% in 2018 which was slightly above the baseline growth of +3.3% predicted by STATFOR in the 7-year forecast [3].

At ECAC level, the number of flights increased by +14.6% over the past five years which corresponds to 1.4 million additional flights in 2018 compared to 2013.

As in previous years, flight hours and distance (+4.9% vs. 2017) grew at a higher rate than IFR flights which - together with the further increase of the average take-off weight (+1.3% vs. 2017) - led again to a higher en-route service unit[3] growth in 2018 (+6.1% vs. 2017).



Sources: Performance Review Unit
ACI; STATFOR; CRCO

Figure 1-2: European air traffic indices (2008-2017)

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1 Note that the individual indices can refer to slightly different geographical areas.

2 The European Civil Aviation Conference (ECAC) is an intergovernmental organization which was established by ICAO and the Council of Europe. ECAC now totals 44 members, including all 28 EU, 31 of the 32 European Aviation Safety Agency member states, and all 41 EUROCONTROL member states.

3 Used for charging purposes based on aircraft weight factor and distance factor.

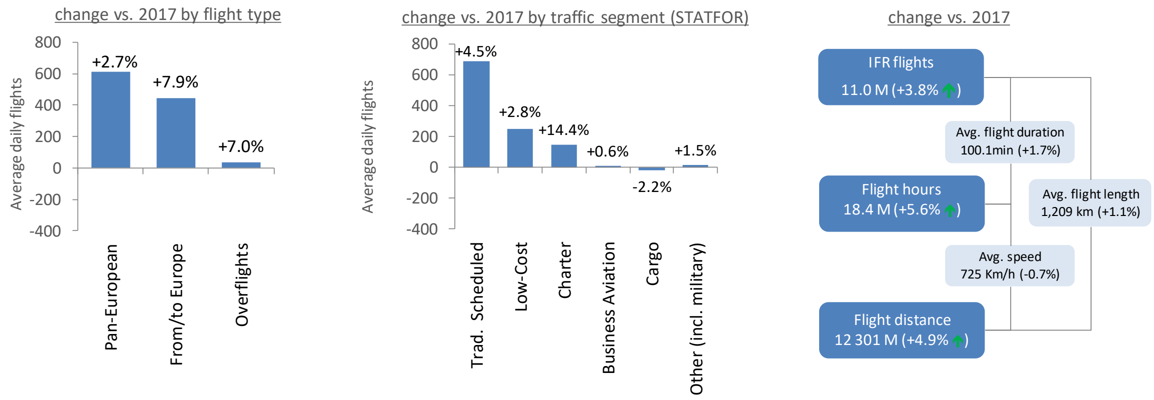


Figure 1-3: Year on year change versus 2017

Figure 1-4 shows the number of average daily flights by Air Navigation Service Provider (ANSP) in 2018 at the bottom and the change compared to 2017 in absolute (grey bars) and relative (red lines) terms at the top. The figure is sorted according to the average daily flights in 2018.

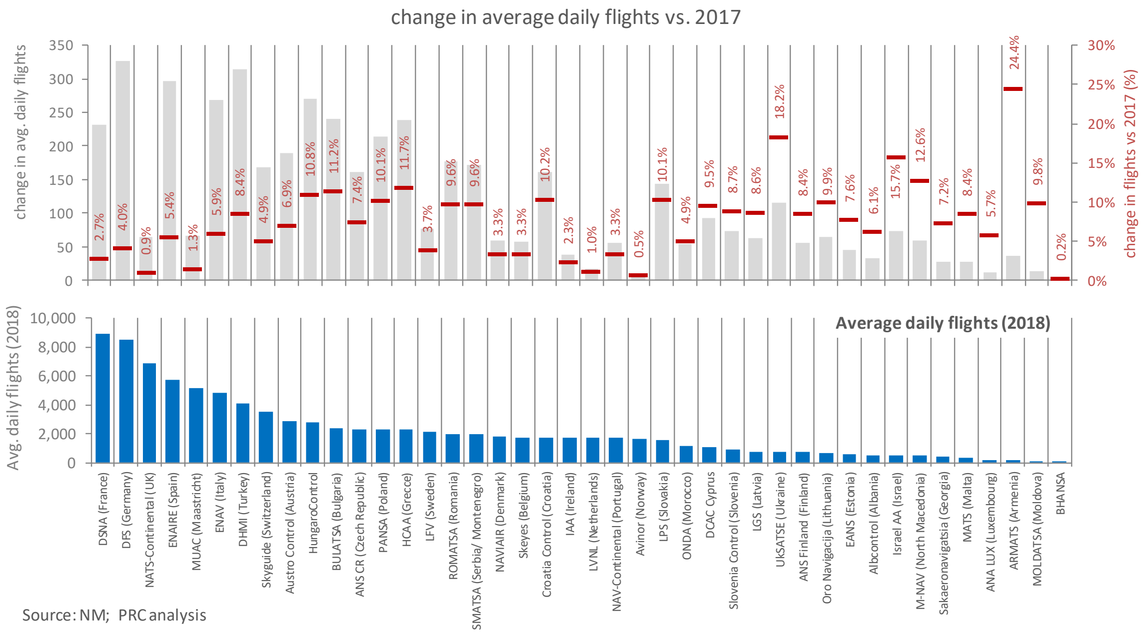


Figure 1-4: Traffic evolution by ANSP (2018/2017)

In absolute terms, DFS (Germany), DHMI (Turkey), ENAIRE (Spain), HungaroControl (Hungary), ENAV (Italy) and BULATSA (Bulgaria) showed the highest year on year growth in 2018.

Figure 1-5 illustrates the traffic growth in relative terms by Area Control Centre (ACC) which confirms the contrasted picture already observed at ANSP level.

The map shows a continued strong growth in Eastern Europe with a substantial traffic recovery in Ukraine.

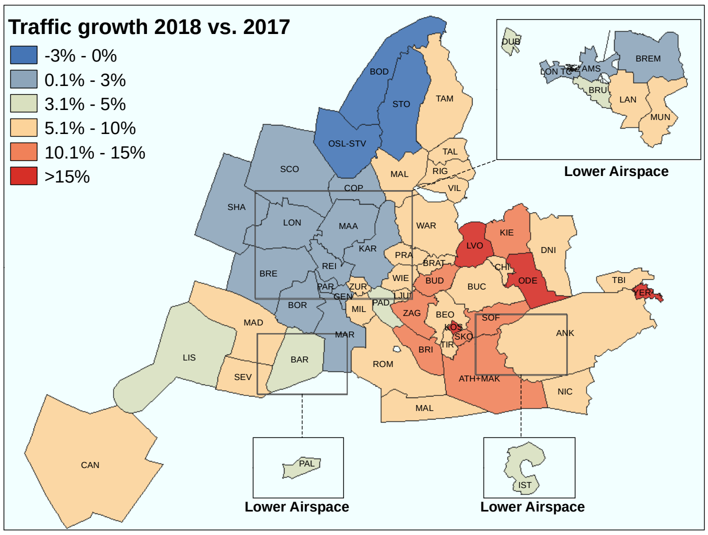


Figure 1-5: Traffic growth by ACC (2018)

Traffic forecast

The latest STATFOR 7-year forecast [4] in Figure 1-6 predicts flights in the ECAC area to grow by 2.8% in 2019 (Low: 1.2%; High 4.1%). The average annual growth rate (AAGR) between 2019 and 2025 is forecast to be at 2.0% (baseline).

+15.2%

more traffic in 2025 compared to 2018 levels in the STATFOR baseline scenario (+1.7 million flights)

At ECAC level, the growth predicted by STATFOR by 2025 corresponds to an additional 1.7 million flights (+15.2% vs. 2018) in the baseline scenario and 2.6 million additional flights (+23.9% vs. 2018) in the high traffic scenario.

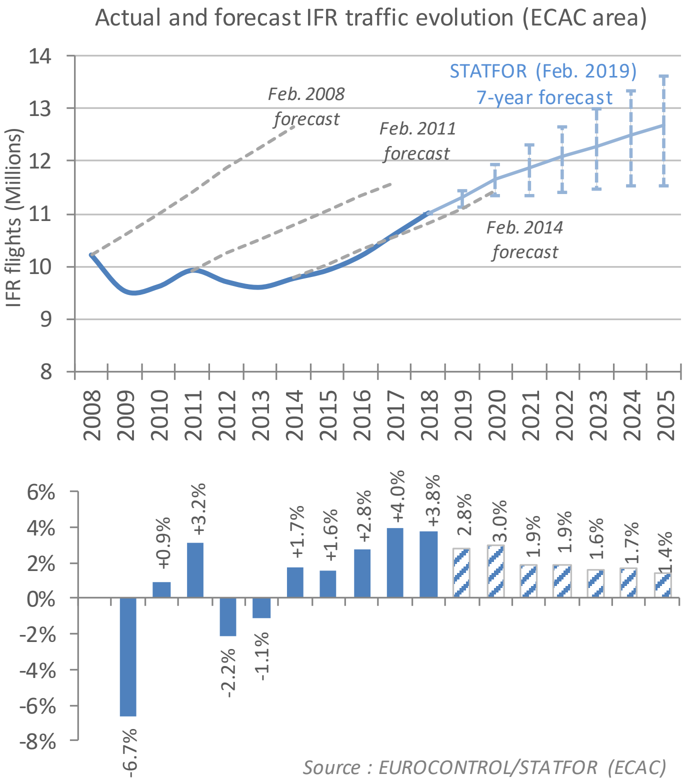


Figure 1-6: Evolution of European IFR flights (2008-2025)

With the European aviation system already struggling with satisfying the existing demand, the delay forecast for 2019 is grim and for the longer term the latest Challenges of Growth study [5] warns that in the most likely scenario some 1.5 million flights cannot be accommodated by the system by 2040.

The forecast growth is not distributed evenly across the ECAC area. Assuming the STATFOR baseline scenario [4], Germany, Turkey and France are expected to handle more than 1200 additional flights per day in 2025 (brown bar).

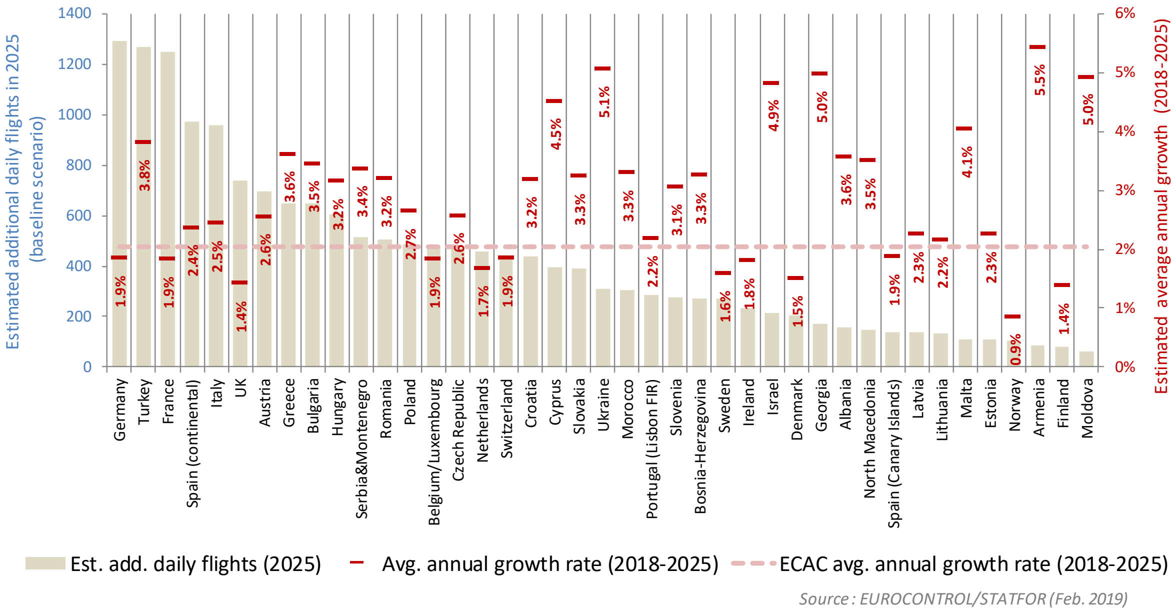


Figure 1-7: Forecast traffic growth 2018-2025

Traffic characteristics

7 Sep. 2018

peak traffic day in 2018 with the European ANS system handling for the first time more than 37 thousand flights

Figure 1-8 shows the evolution of the average daily flights in the EUROCONTROL area between 2008 and 2018. The distribution of average daily traffic shows that peak traffic load continued to rise notably in 2018, reaching the highest level on record on 7 September 2018 when the system handled 37101 controlled flights. The peak day in 2018 was 23.0% higher than an average day.

Not only did peak traffic increase notably over the past three years, but it is clearly visible that the traffic on all days increased which shifted the entire distribution upwards.

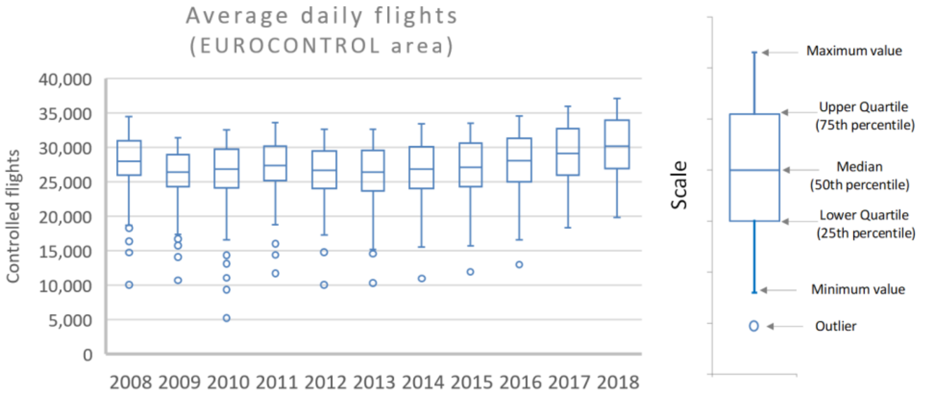


Figure 1-8: Evolution of daily traffic levels (EUROCONTROL area)

With fuel efficiency being higher at higher altitudes, it is not surprising that the main share of the controlled flight hours in area is concentrated in the upper airspace (see Figure 1-9).

The traffic growth observed over the past years has put further pressure on the upper airspace in the already congested European core area.

Figure 1-10 shows the traffic variation by day of the week at system level in 2018. On average, traffic levels were lowest on weekends and the highest levels were observed on Thursdays and Fridays.

It is worth pointing out that local traffic patterns can differ notably compared to the system level due to changes in traffic patterns on weekends (fewer short haul and domestic flights usually serving business travellers).

Some ACCs, experience notably higher traffic demand on weekends (Canarias, Lisbon, Brest) which paradoxically generates higher system-wide average delay levels on weekends, despite less total flights in the system.

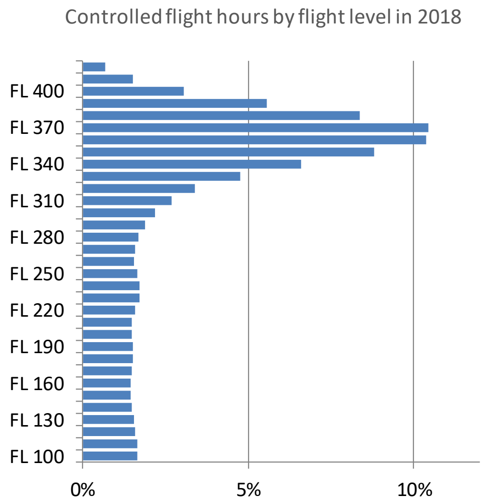


Figure 1-9: Controlled flight hours by FL (2018)

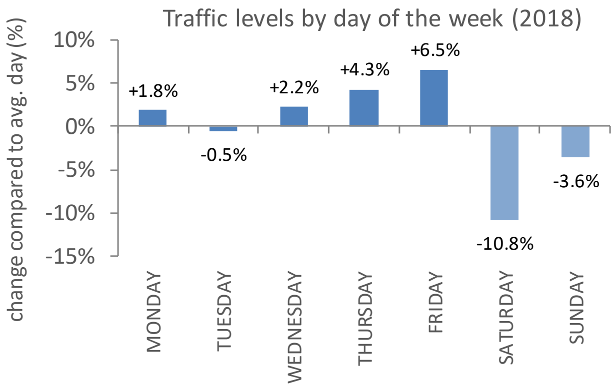


Figure 1-10: Traffic levels by day of the week (2018)

Even though the relationship between "**traffic complexity**" and ANS performance is in general not straightforward, complexity is a factor to be taken into account when analysing ANS performance.

High density (concentration of traffic in space and time) can lead to a better utilisation of resources but high structural complexity (intensity of potential interactions between traffic) entails higher ATCO workload and potentially less traffic.

Overall, complexity has been increasing continuously since 2013 in the EUROCONTROL area, which corresponds to the observed increase of traffic during the same period (see Figure 1-11). The seasonal pattern with complexity being higher in summer is also clearly visible.

As can be seen in Figure 1-12, complexity tends to be highest on the lower flight levels (FL) due to the numerous horizontal and vertical interactions and decreases with altitude until FL 300 (the increase at FL220 is due to Turboprop flights operating at this level). Above this level, horizontal interactions increase again which reflects the fact that jet aircraft are cruising with few vertical interactions at this altitude.

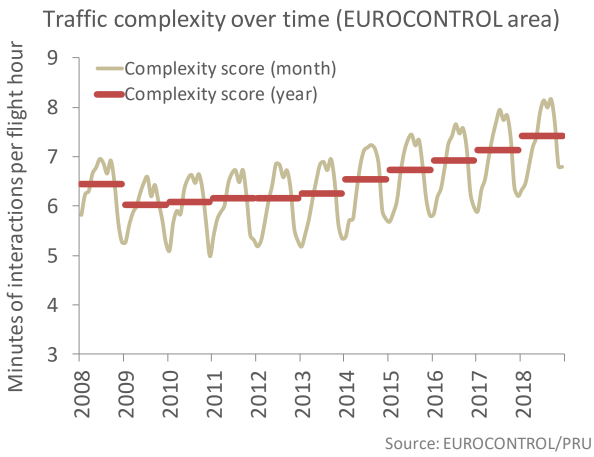


Figure 1-11: Complexity over time (EUROCONTROL)

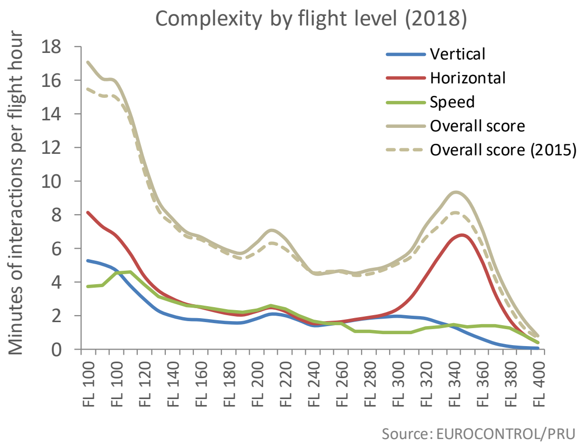


Figure 1-12: Complexity by flight level (EUROCONTROL)

The main share of the flight hours is in the upper airspace (see also Figure 1-9) but it is more dispersed whereas in the lower levels there are less flight hours but concentrated around airports, which explains the higher level of structural interactions per flight hour.

The map in Figure 1-13 shows the annual complexity scores by ACC in 2018. As can be expected, the highest complexity levels are observed in the core area where traffic is most dense.

It is important to point out that the figures in this section represent annual averages. Complexity values at other granularity levels (daily, hourly) or at local level can differ markedly from annual averages or trends (e.g. weekend traffic might be higher in some ACCs).

Traffic 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.

More information on the methodology and more granular data are available from the ANS performance data portal.

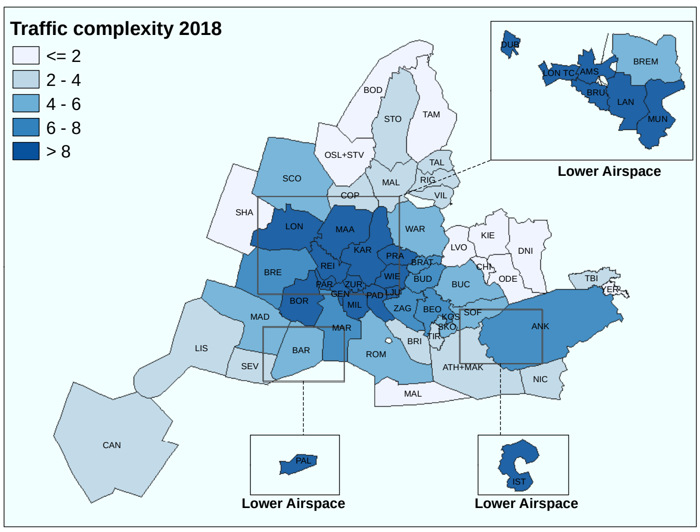


Figure 1-13: Traffic complexity by ACC (2018)

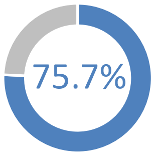
1.3 Air transport punctuality

Arrival punctuality in 2018 dropped significantly from 79.6% in 2017 to 75.7%

From a passenger perspective, punctuality is a commonly used service quality indicator. It is defined as the percentage of flights arriving (or departing) within 15 minutes of the scheduled time.

Arrival punctuality dropped significantly from 79.6% in 2017 to 75.7% in 2018.

Previous analyses have shown that arrival punctuality is primarily driven by departure delay at the origin airport with only comparatively small changes once the aircraft is airborne.



of flights arrived within 15 min of scheduled time in 2018 (-3.9% pt. vs 2017)

To better understand the drivers of departure delays[4] and the contribution of ANS towards operational performance, Figure 1-15 provides a causal breakdown of the delays reported by airlines.

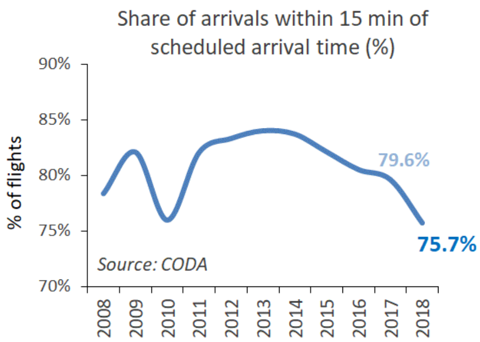


Figure 1-14: Evolution of arrival punctuality

Average departure delay in the EUROCONTROL area increased in 2018 by 2.2 minutes per flight to 14.4 minutes.

A significant increase in air traffic flow measures (mainly en-route related) contributed substantially to the observed deterioration in overall arrival punctuality in 2018. As a result, the relative share of ANS related departure delay increased from 16.6% in 2017 to 19.4% in 2018.

Reactionary delay from previous flight legs accumulate throughout the day and are by far the largest delay category (46.4% in 2018), followed by local turn around delays (31.4%). The network sensitivity to primary delays[5] increased in 2018 from 0.80 to 0.87 leading to the observed further increase in the relative share of reactionary delays.

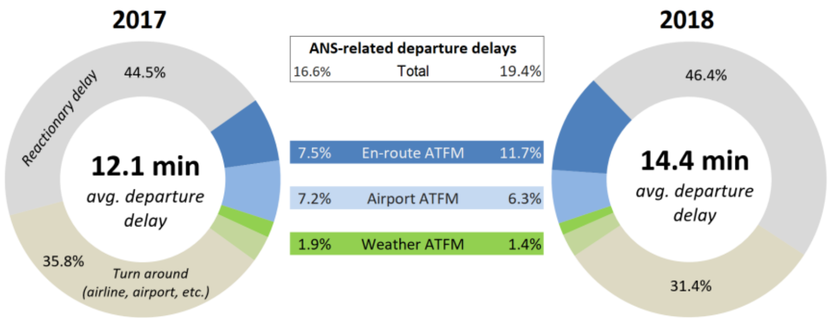


Figure 1-15: ANS contribution towards departure total departure delays

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)[6].

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4 Departure delays can be further classified as "primary" delay (directly attributable) and "reactionary" delay (carried over from previous flight legs).

5 Measured as minutes of reactionary delay for each minute of primary delay.

6 The Central Office for Delay Analysis (CODA) publishes detailed monthly, quarterly, and annual reports on more delay categories (see https://www.eurocontrol.int/articles/coda-publications).

1.4 Environmental sustainability

The PRC acknowledges that environmental sustainability is an important political, economic and societal issue and the entire aviation industry has a responsibility to minimise its impact on the environment. ANS performance clearly affects the environmental impact of aviation which can be broadly divided into the impact on (i) global climate, (ii) local air quality (LAQ), and (iii) noise.

There are however limits as not all aspects of the environmental impact of aviation can be influenced by ANS. In fact, environmental performance objectives for ANS can even be conflicting as noise abatement procedures at airports might lead to longer trajectories and hence additional emissions.

In view to the close links between operational efficiency which can be influenced by ANS and the resulting environmental impact the environmental component of ANS performance is highlighted in the respective sections throughout the report, where appropriate. This section provides some background information ANS performance in the overall environmental discussion.

Emissions and ANS performance

approx. CO_2 emissions from European aviation

The environmental impact of aviation on climate results from greenhouse gas (GHG) emissions including CO_2, NOx, and contrails, generated by aircraft engine exhaust. Whereas CO_2 emissions are directly proportional to the fuel burn, NOx emissions are more difficult to quantify as they depend on engine settings and prevailing atmospheric conditions. Moreover, the radiative forcing effect of non-CO_2 emissions depends on altitude, location, and time of the emission.

In 2010 ICAO adopted a comprehensive agreement to reduce the impact of aviation emissions on climate change. It represented a significant step towards a sustainable air transport future. In 2007, ICAO adopted a resolution which included a global goal of 2% annual fuel efficiency improvement. International aviation was the first sector to agree on a 2% annual fuel efficiency improvement, while stabilizing its global CO_2 emissions at 2020 levels – with carbon neutral growth from 2020.

In Europe, it is estimated that all aviation emissions account for approximately 3.5-5% of total anthropogenic CO_2 emissions [6]. Emissions from aviation have been included in the EU emissions trading system (EU ETS) since 2012. The original legislation adopted in 2008 covered all flights in and out of the European Economic Area (EEA). However, the EU decided to limit the obligations for 2012-2016 to flights within the EEA, in order to support the development of a global measure by ICAO for reducing aviation emissions.

In 2016, the ICAO 39th Assembly approved a global market-based measure to limit and offset emissions from the aviation sector under the name of Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

CORSIA's purpose is to offset any annual increase in total carbon emissions from international civil aviation above 2020 levels in order to achieve the global aspirational goal of carbon neutral growth from 2020 onwards. Domestic carbon emissions from aviation will be addressed under the Paris Agreement which enters into force in 2020.

The EU has decided to maintain the geographic scope of the EU ETS limited to intra-EEA flights from 2017 onwards [6]. The EU ETS for aviation will be reviewed to reflect any international developments relating to CORSIA.

With the relative share of fuel cost in airline operational costs increasing there is a strong focus on increasing fuel efficiency. By far the main contribution to decouple CO_2 emissions growth from air traffic growth is expected to come from technology developments (more efficient aircraft, advances in airframe and engine technology), market based measures, alternative low carbon fuels, and subsequent fleet renewals.

The ANS-related impact on climate is closely linked to operational performance (fuel efficiency) which is largely driven by inefficiencies in the four dimensional trajectory and associated fuel burn (and emissions). Hence, the focus in ANS performance review has been traditionally on the monitoring of ANS-related operational efficiency by flight phase which served as a proxy for environmental performance since the distance or time saved by operational measures can be converted into estimated fuel and CO_2 savings (see Figure 1-16). For every tonne of fuel reduced, an equivalent amount of 3.15t of CO_2 is avoided. Operational efficiency gains tend to deliver reduced environmental impact per unit of activity, as well as reduced costs.

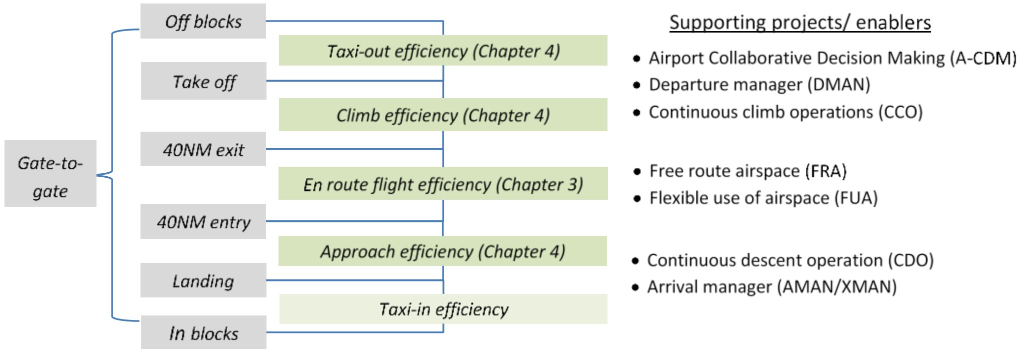
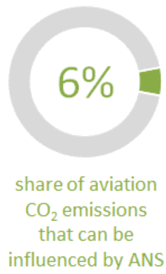


Figure 1-16: Gate-to-gate efficiency by phase of flight

Figure 1-17 provides a breakdown of estimated gate-to-gate excess CO_2 emissions as a percentage of the unimpeded gate-to-gate trajectory in the EUROCONTROL area. The estimated "benefit pool" that can be influenced by ANS is based on a comparison of actual flight trajectories to a theoretical reference trajectories[7].



It is important to point out that the calculated inefficiencies are not entirely attributable to ANS. In fact the inefficiencies (separation minima, adverse weather, avoidance of 'Danger Areas', interdependencies) cannot and should not be reduced to zero (shortest is not automatically the wind optimum route) so that the reference trajectory can in practice not be achieved at system level.

The analysis shows that the benefit pool that can be partly influenced by ANS is approx. 6% of the total aviation related CO_2 emissions in Europe or approximately 0.2-0.3% of anthropogenic CO_2 emissions in Europe[8].

ANS performance improvements help reducing operational inefficiencies. The ambition of the 2018 European ATM Master Plan [7] to reduce the share of excess gate-to-gate CO_2 emissions to 2.3% by 2035 is very challenging, particularly in a context of increasing traffic levels.

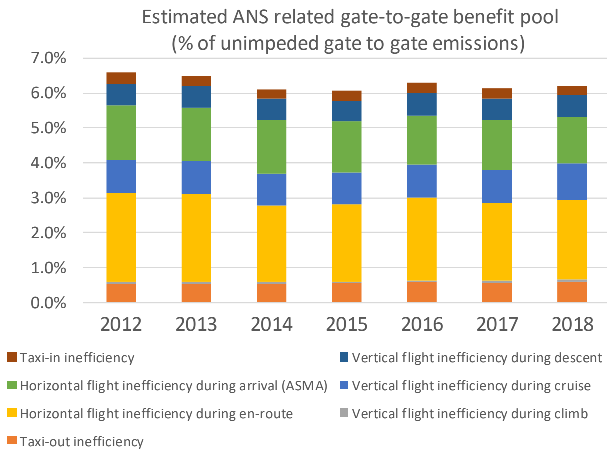


Figure 1-17: Estimated ANS-related gate-to-gate benefit pool (CO_2 emissions)

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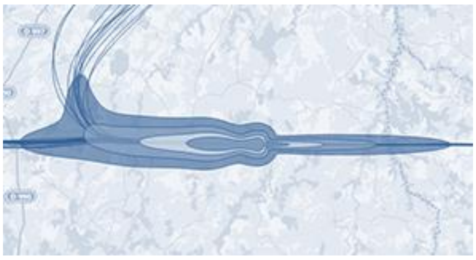
7 The theoretical (unachievable) reference trajectory is characterised by: zero additional taxi-out time, no level-off during climb (full fuel CCO), no sub-optimal cruise level, en-route actual distance equal to great circle distance (ISA conditions), no level-off during descent (full fuel CDO), no additional time in the Arrival Sequencing and Metering Area (ASMA), zero additional taxi-in time. Note that the EUROCONTROL area average is slightly lower than the sum of the individual flight phases as some of the inefficiencies take place outside of the EUROCONTROL area.

8 Note that the EUROCONTROL area average is slightly lower than the sum of the individual flight phases as some of the inefficiencies take place outside of the EUROCONTROL area.

Noise and ANS performance



Aircraft noise is generally recognised as the single largest environmental issue at airports.

Airports face the challenge to balance the need to increase capacity in order to accommodate future air traffic growth with the need to limit negative effects on the population in the airport vicinity. Political decisions on environmental constraints can impact operations in terms of the number of movements, route design, runway configuration and usage and aircraft mix (engine types etc.).

The European Environment Agency estimates that around 3 million people are exposed to aircraft noise above 55dB [8].

Regulation (EU) No 598/2014 lays down rules on the process to be followed for the introduction of noise-related operating restrictions in a consistent manner on an airport-by-airport basis, in accordance with the ICAO Balanced Approach which breaks down the affecting factors into (1) land use planning, (2) reduction of noise at source, (3) aircraft operational restrictions and (4) noise abatement operational procedures [9].

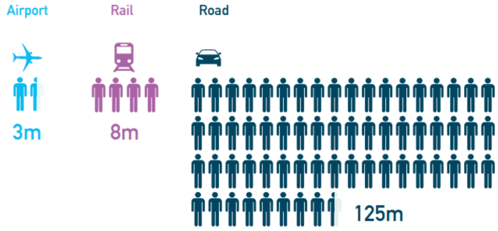


Figure 1-18: Population exposed to noise above 55dB in Europe (in millions) [8]

Noise emissions from aircraft operations are airport-specific and depend on a number of factors including aircraft type, number of take-offs and landings, route structure, runway configuration, and a number of other factors. Moreover, there can also be trade-offs between environmental restrictions when different flight paths reduce noise exposure but result in less efficient trajectories and hence increased emissions.

Accordingly, the noise management at airports is generally under the responsibility of the airport operators which coordinate and cooperate with all parties concerned to reduce noise exposure of the population while optimising the use of scarce airport capacity. Noise restrictions are usually imposed by Governments or local authorities and the level of compliance is monitored at local level.

Although it is acknowledged that aircraft noise is an important issue at airports, the main factors affecting noise emissions at and around airports are not under the direct control of ANS.

The areas where ANS can contribute to the reduction of aircraft noise are mainly related to operational procedures (continuous climb/descent operations (CCO/CDO) etc. [9]) but the main contributions for reducing noise are expected to come from measures with long lead times outside the control of ANS (land use planning, reduction of noise at source).

Generally the management of noise is considered to be a local issue which is best addressed through local airport-specific agreements developed in coordination and cooperation with all relevant parties. Due to the complexity of those local agreements, there are presently no commonly agreed Europe-wide indicators specifically addressing ANS performance in the noise context.

[9] In some States arrival and departure procedures are owned by airports, not the ANSP, and Government policy is that noise is the primary consideration when making changes below 7,000 ft.

1.5 Total economic assessment (en-route)

The estimated total ANS-related en-route costs in this section combine direct en-route ANS provision costs with estimated indirect costs due to en-route ATFM delays in the EUROCONTROL area.

The ANS costs in this section were derived from Chapter 5, where a more detailed analysis of ANS cost-efficiency is available.

Before zooming in on the evolution of total estimated ANS related en-route costs, Figure 1-19 provides a longer term perspective between 2008 and 2018. While the data on en-route ANS cost for 2018 is not yet available, the actual 2018 traffic and en-route ATFM delay figures level are included.

As a result of the economic crisis starting in 2008 air traffic decreased significantly in 2009. The lower traffic levels resulted in a notable decrease of en-route ATFM delays until 2013 when traffic (and also delays) started to grow again.

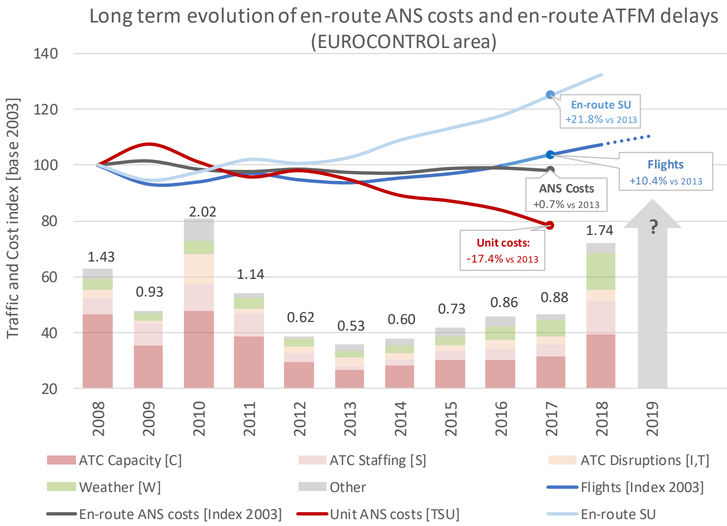


Figure 1-19: Long term evaluation of en-route ANS performance

Between 2013 and 2017, flights increased by +10.4% while en-route service units grew at a notably higher rate due to a continuous increase in average flight length and aircraft weight. Over the past ten years, total en-route ANS costs remained almost flat primarily due to cost containment measures implemented following the crisis in 2008 and the binding cost-efficiency targets put in place as part of the Single European Sky Performance Scheme as of 2012.

-16.5%

reduction of en-route ANS unit costs between 2013 and 2017

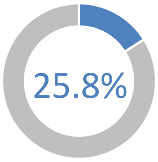
The flat en-route ANS cost base combined with the strong traffic growth decreased en-route ANS unit costs by -16.5% between 2013 and 2017. Compared to 2003, ANS unit cost decreased even by 33.1% (see also Chapter 5). However, with traffic continuing to grow markedly in 2018, en-route ATFM delays increased disproportionally (+104% vs 2017) and the latest delay forecast for 2019 suggests an even higher delay level than in 2018.

With the focus mainly on cost savings over the past years, it is evident that the European ANS system benefited from the reduced traffic levels following the economic crisis in 2008. However, with traffic and delay growing again since 2013, shortcomings in proactive capacity planning and deployment are becoming more and more apparent.

The total estimated en-route ANS-related costs in Figure 1-20 provide a more complete picture of the en-route ANS performance by combining the ANS costs and the estimated costs of en-route ATFM delay to airspace users. As also detailed in Chapter 5, the en-route ANS cost figures up to 2017 reflect actuals whereas the costs for 2018 are based on the latest available planned/forecasted figures, which might change.

The estimated delay costs[10] to airspace users are based on a study from the University of Westminster [10]. This estimate does not consider costs for on-board equipment nor does it provide a full societal impact assessment which would include, for instance, also the cost of delay to passengers and environmental costs. Inevitably, there are margins of uncertainty in delay costs estimates, which should therefore be handled with caution. The full University of Westminster report is available for download on the PRC website

As can be expected from Figure 1-19, estimated en-route ATFM delay related costs more than doubled to reach 1.9 billion Euro in 2018.



in 2018, en-route ATFM delay costs are estimated to be equivalent to 25.8% of en-route ANS provision costs

The estimated costs of en-route ATFM delay corresponds to more than one quarter (25.8%) of total en-route ANS costs in 2018.

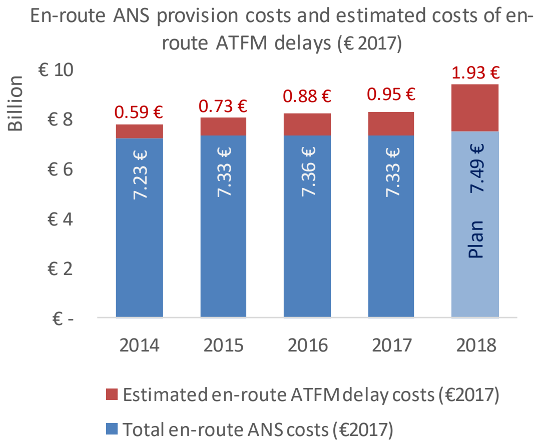


Figure 1-20: En-route ANS provision costs and estimated costs of en-route ATFM delays (B€ 2017)

The significant increase in en-route ATFM delay in 2018 not only detracts from the substantial cost-efficiency improvements over the past years but also shows the importance of having a balanced approach in performance management.

The strong focus on cost-efficiency over the past years seems to have led to a lower prioritisation of capacity and staff planning in some ANSPs. The impact is already becoming visible and it is likely to have a lasting negative effect in terms of performance over the coming years considering the relatively long lead times to train new ATCOs and deploy additional capacity.

It is therefore important to ensure that cost-efficiency measures are carefully balanced with capacity planning to avoid exponential increases in delays and related economic costs borne by airspace users. In the short term, a close collaboration between the Network Manager, ANSPs and airspace users is required to find a balanced system wide solution to mitigate the effects of the serious capacity shortfall in some areas (see also Chapter 4).

ANS-related inefficiencies in operations impact on airspace users in terms of cost of time and fuel. Estimating the costs of such inefficiencies is a complex task requiring expert judgement and assumptions based on published statistics and accurate data. The PRC is working on establishing a more complete picture of the total economic costs for ANS by also including the costs of operational inefficiencies (gate-to-gate) and flight cancellations in future editions of this report.

10 The estimated costs due to ATFM en-route delays are based on the University of Westminster study. Cost assumptions include direct costs (fuel, crew, maintenance, etc.) the network effect (i.e. cost of reactionary delays) and airline related passenger costs (rebooking, compensation, etc.). Costs related to the EU emission trading scheme are not included.

2 Safety

SYSTEM TREND (AST REPORTING)	2017	2018(P)	Trend	% change
Accidents and incidents				
Total number of reported Accidents with ATM Contribution	1	1	→	0
Total number of reported ATM incidents	55 288	62 125	↑	12
Total number of reported OPS incidents	39 001	43 889	↑	12
Total number of reported Severity A+B	827	930	↑	12
Separation Minima Infringements (SMI)				
Total number reported	2368	2542	↑	7.3
Total number of reported Severity A+B	287	341	↑	18.8
Runway incursions (RI)				
Total number reported	1454	1704	↑	17.2
Total number of reported Severity A+B	104	99	↓	-4.8
Unauthorised penetration of airspace (UPA)				
Total number reported	5012	6531	↑	30.3
Total number of reported Severity A+B	87	92	↑	5.7
ATM Specific Occurrences				
Total number reported	16 534	18 236	↑	10.3
Total number of reported Severity AA+A+B	326	298	↓	-8.6

Notwithstanding the further increase in traffic, Safety in the EUROCONTROL area remains high

2.1 Introduction

This chapter reviews the Air Navigation Services (ANS) safety performance of the EUROCONTROL Member States between 2008 and 2018 (note that 2018 data is only preliminary).

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

This section shows the safety performance in the **EUROCONTROL area** between 2013 and 2018(P), based on AST data (reported occurrences) 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).

2.2 Safety performance snap shot

The analysis of accidents covers accidents involving aircraft above 2250 kg Maximum Take-Off Weight (MTOW), irrespective of whether the ATM domain contributed to the event or not.

As opposed to the accident analysis, there is no MTOW limit (2250 kg) for the ATM-related incidents.

Controlled flight hours
~18.1 million flight hours (+5.8%)
EUROCONTROL Member States, 2018

Number of all incident reports
62,125 (12%)
EUROCONTROL Member States, 2018

Number of ATM accidents
1 (0%)
EUROCONTROL Member States. 2018

Number of OPS incident reports
43,889 (12%)
EUROCONTROL Member States, 2018

Accidents

Based on preliminary data, there were 84 accidents in the EUROCONTROL area in 2018, of which 9 were fatal accidents (11%).

As was the case in 2017, there was only one reported accident with direct[11] ATM contribution and none with indirect[12] ATM contribution in 2018.

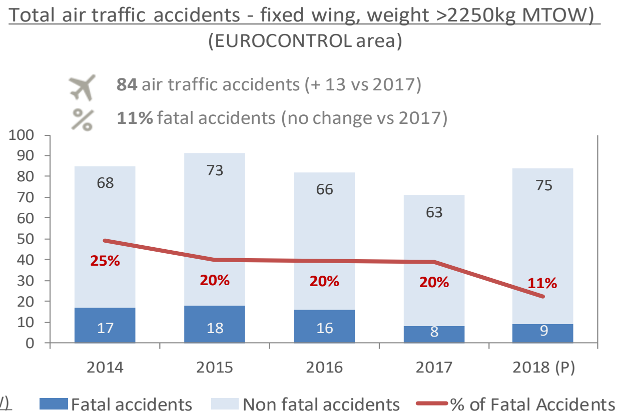


Figure 2-1: Total air traffic accidents (2014-2018P)

Due to the increase in total air traffic accidents the share of accidents with ATM contribution decreased slightly from 1.4% in 2017 to 1.2% in 2018 (preliminary).

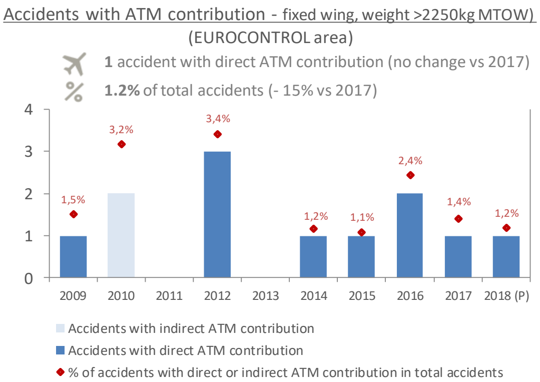


Figure 2-2: Accidents with ATM contribution (2009-2018P)

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11 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.

12 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.

Incidents

The PRC has made use, with gratitude, of the data provided by EUROCONTROL DECMA/ACS/SAS Unit.

Figure 2-3 shows share of incidents reported via AST in 2018, based on preliminary data.

In 2018, there were a total of 62,125 ATM-related incidents, reported through the EUROCONTROL AST mechanism, out of which 43,889 were operational and 18,236 were technical. Operational incidents accounted for 71% of all reported occurrences in 2018.

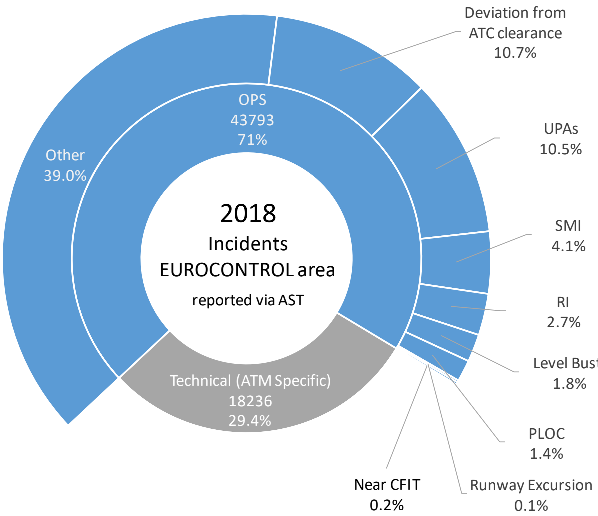

Figure 2-3: Incidents reported via AST in EUROCONTROL area (2018 preliminary data)

Figure 2-4 shows the evolution of the number of reported occurrences between 2014 and 2018(P), including a breakdown by operational and technical occurrences.

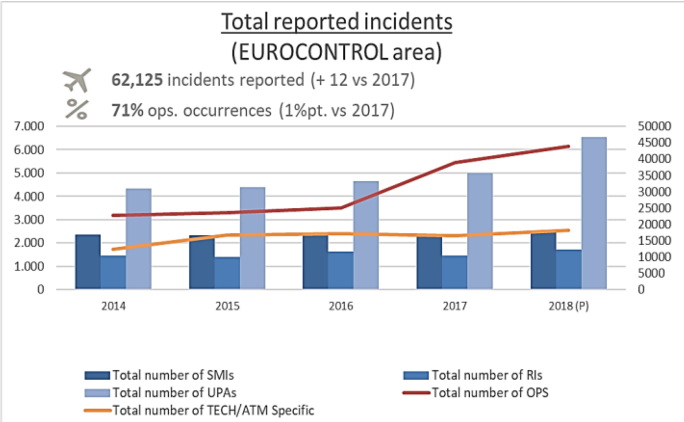

Figure 2-4: Total reported incidents (2014-2018P)

The increase in the number of reported occurrences as of 2017 is mainly due to alignment of the AST reporting with the Occurrences Reporting Regulation 376/2014 (i.e. more types of occurrences became mandatory to report).

Zooming in on the 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), Table 2-1 shows the EUROCONTROL area overall occurrence rates (as reported by all 37 reporting States) for SMI, RI and UPAs in 2018.

SMI	**13.4** (13.8 in 2017) **Separation Minima Infringements per 100 thousand flight hours**
RIs	**0.9** (0.8 in 2017) **Runway incursions per 10 thousand movements**
UPAs	**34.7** (29.2 in 2017) **Unauthorised penetration of airspace per 100 thousand flight hours**

Table 2-1: Occurrence rates (SMI, RI, UPA) in the EUROCONTROL area (2018P)

In 2018 (based on preliminary data), the EUROCONTROL area SMI and UPA rates were approximately 13.4 and 34.7 SMIs or UPAs respectively per 100 000 flight hours. The rate of the EUROCONTROL area RIs in 2018 was 0.9 RIs per 10 000 movements. The distribution of all three rates is skewed with a small number of States having high occurrence rates compared to the rest of the States.

Complementary to Table 2-1, Figure 2-5 shows the underlying distribution of occurrence rates of all 37 reporting EUROCONTROL Member States for the three categories of occurrences SMI, RI and UPAs compared to the EUROCONTROL area overall rate.

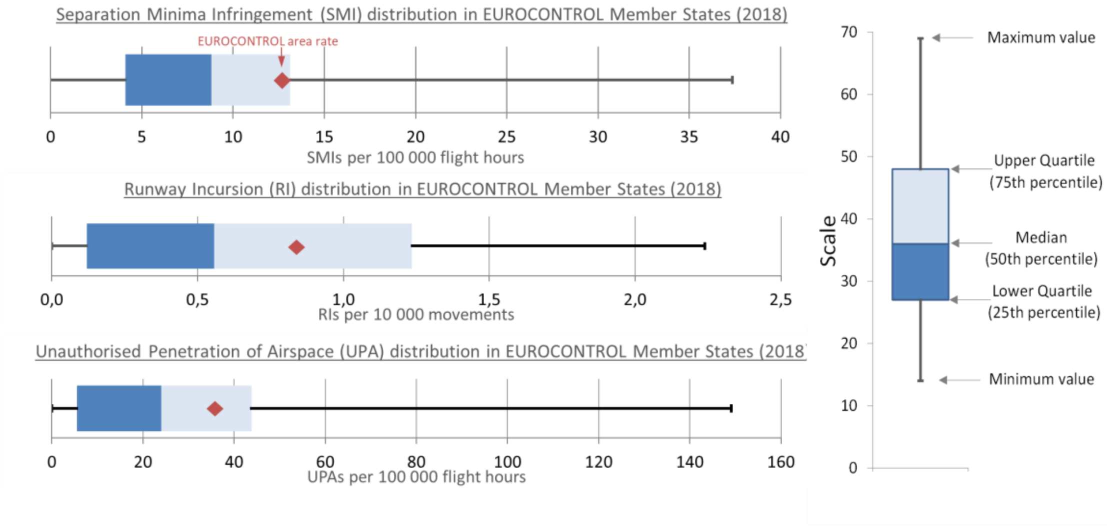

Figure 2-5: Occurrence rates EUROCONTROL area (2018)

2.3 Safety data after 2020

To the PRC's knowledge, the AST reporting mechanism is likely to be discontinued from 2020 onwards. Should this happen, it would jeopardise the PRC's continued assessment of the KPAs from the Safety perspective. Accordingly, the PRC has held discussions with the Agency and other relevant parties with a view to ensuring:

(i) continued access to a reliable source of ATM-related safety data for its work post-2020 and identified a possibility and;

(ii) a suitable reporting mechanism post-2020 for non-EU States is being discussed by the Agency (DECMA/ACS/ECP) with those States. In addition, it should be noted that PC/50 (November 2018) "*agreed to keep pan-European needs under review in further discussions between EASA and the Agency*."

Under the EUROCONTROL/EASA Work Programme, one of the key tasks is to improve the quality and completeness of the ATM-related safety data held in the European Central Repository (ECR). However, time is running out as, in agreement with EASA, the AST mechanism will only continue operating until the end of RP2. The last AST safety data, for the 2019 reporting cycle, is due to be available at the end of March 2020.

Besides being the main source of the PRC safety performance overview, currently, the verification of the adherence to the safety KPIs in the framework of the Performance Scheme for Air Navigation Services and Network Functions is ensured through cooperation between the Agency, EC and EASA based on the AST outcome.

Following the discontinuation of the AST mechanism as from the beginning of RP3 the ECR will remain the only source of safety data in the ATM domain that could be used for the verification of the adherence to the safety KPIs in the framework of the Performance Scheme for Air Navigation Services and Network Functions. The maturity of the ATM related safety data available in the ECR needs to be improved and DECMA/ACS/SAS and EASA, under the scope of the EUROCONTROL/EASA Work Programme, are working together to identify actions that could lead to the improvement of the ECR data quality.

It is to be noted that due to reasons related to the data structure and size of the two repositories the comparison is restricted to a limited number of ATM-related occurrences (e.g. SMI, RI, UPA) covering the 2017-2018 reporting years. Even for this limited scope, a one to one comparison of the records available in AST and ECR is not feasible.

The preliminary analysis of the 2017 safety data shows important differences in the number of occurrences contained in the two databases. The difference is related to either safety data missing in the ECR (SMI 8%, RI 11% and UPA 11%) and also due to duplicates found in the ECR that are related to the reporting philosophy of the EU376/2014 (SMI 25%, RI 19%, UPA 9%).

EASA has the capability to clean, to some extent, those duplicates, when running queries at the ECR level (by using some intelligence that is particular for each reporting country). This capability is not available to local users who would like to query the ECR data to compare their safety performance with the European average. Nor is it available to other pan European programmes, which require validation using safety data.

Another important aspect is related to the fact that the EC is the owner of the safety data, hence EASA cannot alter its content even when incorrect information is identified. This state of affairs presents the threat of misleading any trend analysis conducted at pan-European level. EUROCONTROL and EASA are working to address this issue. They will issue a progress report before the end of 2019.

2.4 ALoSP recent developments

The PRC is following up developments regarding ALoSP with EUROCONTROL. The recent ongoing discussions between EASA and EUROCONTROL include possibility of inclusion of ALoSP into the next edition of the Joint Work Programme.

At the same time, in area of Safety Management, EASA is through its Safety Management Technical body (SM TeB) starting an initiative to collect information on implementation of ALoSP in Member States in order to gather the views and experience from the States and propose consolidated input of the best practices at the ICAO Safety Management (SM) Panel held in April 2019.

Recently, PRU has presented the results of the PRC study at the SM TeB meeting in February 2019. At the same time, EUROCONTROL has offered to pick up on ALoSP issue together with EASA and jointly tackle conclusions and recommendations regarding ALoSP of the ICAO AN-Conf/13 as there is an opportunity to build and voice a common European position regarding ALoSP development and practices at the aforementioned ICAO SM Panel.

2.5 Risk exposure – Composite Risk Index

Risk is the potential for mishaps or other adverse variation in the cost, schedule, or safety performance of the ATM system. Safety risk therefore can be explained as the potential for mishaps that could result in injury, fatality, equipment or system damage or total loss.

All safety programs desire accurate risk quantification in order to provide a meaningful expression of risk. One factor which complicates risk quantification is that there is never one single risk associated with a system or event.

A possible way to define and accept the total safety risk of any system is using the concept of a composite risk estimate. Current methods of obtaining this composite risk estimate use summing techniques to add the individual risks associated with the system and produce a single number. This method seems natural, however, it is often difficult to determine particular occurrence probabilities or to quantify their severity.

Moreover, although risk in general can be quantified, as it represents a combination of probability and severity of specific occurrence happening, the human perception of risk often influences how risk is addressed. For example, on the level of decision makers the risk perception does not necessarily map directly to probability and severity in a linear fashion. Furthermore, information about severity and probability of occurrences is sometimes not available which makes the computation of risk difficult or impossible.

For all these reasons, the concept of a Composite Risk Index (CRI) to measure the performance of the European ATM systems as a whole or also its individual entities (service providers or Member States) is proposed. The CRI as a measure of risk exposure is based on probability and severity that considers the human perception of equivalent risk.

In simple words, the CRI could be seen as a proxy of safety risk within one airspace or a State, which is based on reported / historical safety information. It presents a cumulative risk value calculated by aggregating all reported, assessed and severity classified safety-related incidents to form an index.

The methodology is available online at: https://ansperformance.eu/methodology/cri-pi

Preliminary results

The CRI normalised for all EUROCONTROL Member States for 2018 (for which data was available) is calculated and shown in Figure 2-6 (blue bars).

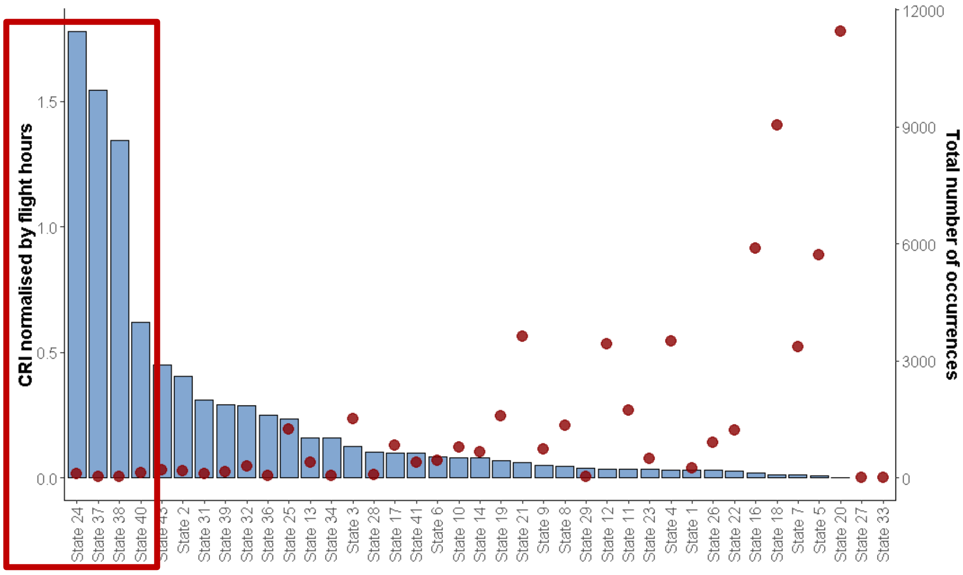

Figure 2-6: CRI normalised per flight hours for all EUROCONTROL Member States (2018)

The CRI results normalised by flight hours (CRInorm) indicate that over 75% of the EUROCONTROL Member States have a CRInorm below 0.25. Only four States have a CRInorm above 0.5.

One possible reason for this positive result could be the reporting culture of the States. Therefore, CRInorm was also correlated with the total number of reports by each State (red dots). Figure 2-6 shows that the States with a good reporting culture tend to have a low CRInorm (blue bars).

Using the CRI index, it is possible to follow the trend of safety performance, as CRI can be used as a quick indicator of the status of either safety performance based on the type and severity of historical reported occurrences but also as an indicator of reporting culture.

The trend of the normalised CRI over the past four-years is shown in Figure 2-7.

Besides the fact that CRI methodology can be customised to local environment, i.e. Weights can be re-modelled using local safety data, and the CRI methodology can be scaled up or down to satisfy monitoring of individual entities.

Moreover, the nature of the CRI computation also allows the calculation and monitoring of the CRI of a single specific type of occurrence, e.g. the key risk occurrences within an airspace or organisation.

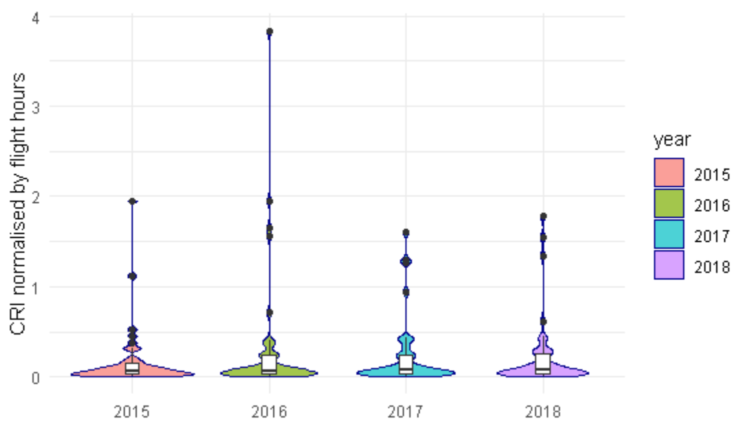

Figure 2-7: Normalised CRI 2015-2018

2.6 Conclusions

As pointed out by the PRC in PRR 2015, with the safety reporting environment changing over the next few years, the aviation community has to accept that there will be a transition phase. During this time, in order to maintain and improve European reporting, it will be highly important that the actors directly involved in safety data collection work together in order to create an optimum solution.

To the PRC's knowledge, the AST reporting mechanism is likely to be discontinued from 2020 onwards. Should this happen, it would jeopardise the PRC's continued assessment of the KPAs from the Safety perspective.

Under the EUROCONTROL/EASA Work Programme, one of the key tasks is to improve the quality and completeness of the ATM-related safety data held in the ECR. However, time is running out as in agreement with EASA, the AST mechanism will only continue operating until the end of RP2. The last AST safety data, for 2019 reporting cycle, is due to be available at the end of March 2020.

Following the discontinuation of the AST mechanism as from the beginning of RP3 the ECR will remain the only source of safety data in the ATM domain that could be used for the verification of the adherence to the safety KPIs in the framework of the Performance Scheme for Air Navigation Services and Network Functions. The maturity of the ATM related safety data available in the ECR needs to be improved and DECMA/ACS/SAS and EASA, under the scope of the EUROCONTROL/EASA Work Programme, are working together to identify actions that could lead to the improvement of the ECR data quality.

The lack of quality and completeness of the ECR as well as inherent difficulties in performing a pan-European comparison, even if the PRC is given access, would present an issue for the future.

The new methodology of calculating safety risk has been presented for the first time. The concept of a CRI as a cumulative risk value calculated aggregating all reported, assessed and severity classified safety-related incidents, has potential to become a proxy of exposure to risk within certain airspace for top management information and decision making. Overall idea behind CRI is that the performance of safety system can be analysed within three important broad categories: the airspace environment, the quality of reporting system with reporting entity, measured risks within the system, and human perception of risk.

Preliminary analysis shows that CRI has an ability to allow reporting on the safety performance of the whole European ATM system, but also on the level of its individual entities, e.g. Member States or even at the level of service providers. Moreover, scaling possibility allows measurement of CRI of individual types of safety occurrences as well.

The CRI however, should not be construed as an absolute measuring stick. It is only as good as the fidelity of the data that supports it. In general, specific probabilities of occurrence are not precisely known, and there is some subjectivity in the assessment of severity of the occurrence.

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3 Operational en-route ANS Performance

System Trends	2018	Trend	change vs. 2017
IFR flights controlled	10.9M	↑	+3.8%
Capacity			
En-route ATFM delayed flights	9.6%	↑	+4.2 %pt.
Average en-route ATFM delay per flight (min.)	1.74	↑	+0.86 min
Total en-route ATFM delay (min.)	19.0M	↑	+104%
Environment/ Efficiency			
Average horizontal en-route efficiency (flight plan)	95.6%	→	+/-0.0%pt
Average horizontal en-route efficiency (actual)	97.3%	→	+/-0.0%pt.

En-route ATFM delays increased by 104% in 2018

3.1 Introduction

This chapter reviews operational en-route ANS performance in the EUROCONTROL area in 2018.

En-route ATFM delays increased by 104% in 2018: reaching 19 million minutes (36.1 years) while traffic increased by 3.8% over the same period.

The European ANS system operated with an average en-route delay above 1 minute per flight for more than half of the year (184 days). The total number of en-route ATFM regulations implemented by the Network Manager on behalf of the ANSPs increased from 37 900 in 2017 to 50 200 in 2018.

with average en-route ATFM delay > 1minute (+84 vs. 2017)

Together with the 6.4 million minutes airport ATFM delay, the total ATFM delay reached 25.4 million minutes which is equivalent to 48.3 years[13] of ATFM delay in 2018. Airport ATFM delays are addressed in Chapter 4 of this report.

Section 3.2 analyses ANS-related operational en-route efficiency by evaluating constraints on airspace users' flight trajectories, including en-route ATFM delays and horizontal and vertical flight efficiency.

Flexible use of airspace is addressed in Section 3.3.

[13] Total flight hours in the EUROCONTROL area in 2018 were approximately 2100 years.

3.2 ANS-related operational en-route efficiency

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

3.2.1 En-route air traffic flow management (ATFM) delays

The analysis in this section focuses on constraints imposed on aircraft operators through the implementation of en-route ATFM regulations. Figure 3-2 provides a system wide overview including a breakdown of en-route ATFM delays, according to the delay classifications, as reported by the local flow management positions (FMPs).

The high level picture

Figure 3-1 shows the total minutes of ATFM delay (y-axis) together with the number of ATFM delayed flights (x-axis) in the EUROCONTROL area by reference location type (airport vs. en-route).

Airport delays: It can be seen that, apart from an increase in 2015, airport ATFM delays have stayed at a similar level over the past 4 years.

En-route ATFM delays: In contrast, there has been a continuous increase in en-route ATFM delays, and a significant increase in 2018.

The remainder of this section evaluates en-route ATFM delays in more detail. Airport ATFM delays are addressed in more detail in Chapter 4 of this report.

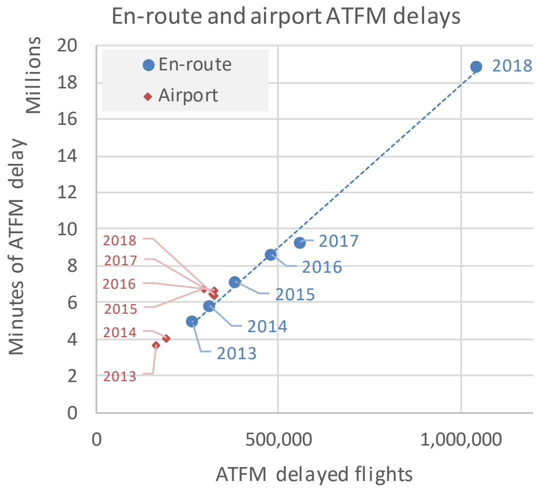


Figure 3-1: Evolution of ATFM delays

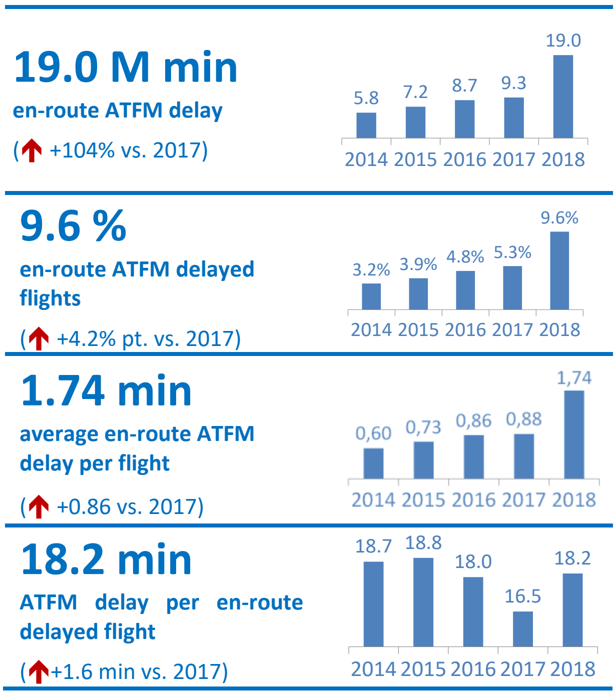


Figure 3-2: En-route ATFM delays in the EUROCONTROL area

Total en-route ATFM delays more than doubled in 2018 (+104%) to reach 19 million minutes while traffic increased by just +3.8% over the same period.

More than 1 million flights were delayed by en-route ATFM regulations in the EUROCONTROL area in 2018 which corresponds to 9.6% of all flights (+4.2 percentage points vs. 2017).

As a result average en route ATFM delay increased from 0.88 to 1.74 minutes per flight in 2018.

At the same time, the average en-route ATFM delay per delayed flight increased from 16.5 to 18.2 minutes per flight.

What were the reasons for the increase in en-route ATFM delay?

28 July 2018

worst day in 2018 with 29% of all flights delayed by en-route ATFM delays (mainly adverse weather)

As was the case in previous years, Capacity attributed delays (37.4%) remain the main portion of en-route ATFM delays, followed by Weather attributed delays (25.4%), ATC Staffing (23.0%) and ATC disruptions/industrial actions (7.5%).

	delayed flights		delay per delayed flight		Total delay minutes		
	2018	vs 2017	2018	vs 2017	2018	% of total	vs 2017
ATC Capacity [C]	4.3%	1.7%	15.0	0.4	7.1 M	37.4%	3.1M
ATC Staffing [S]	2.3%	1.3%	17.4	3.5	4.4 M	23.0%	2.8 M
ATC Disruptions [I,T]	0.4%	0.1%	32.5	-0.6	1.4 M	7.5%	0.5 M
Weather [W,D]	1.9%	0.9%	23.4	2.9	4.8 M	25.4%	2.7 M
Other [all other codes]	0.6%	0.2%	17.8	2.8	1.3 M	6.6%	0.6 M
Total	**9.6%**	4.2%	**18.2**		**19.0 M**	**100%**	

Figure 3-3: En-route ATFM delays by attributed delay category (Overview)

In 2018, 4.3% of all flights were delayed by en-route ATFM regulations attributed to ATC capacity.

186%

increase in en-route ATFM delays attributed to ATC staffing in 2018

The evolution of en-route ATFM delays by attributed delay category in Figure 3-4 shows a real jump in delays attributed to ATC staffing (+186% vs 2017), adverse weather (+124%) and ATC Capacity (+76%) in 2018.

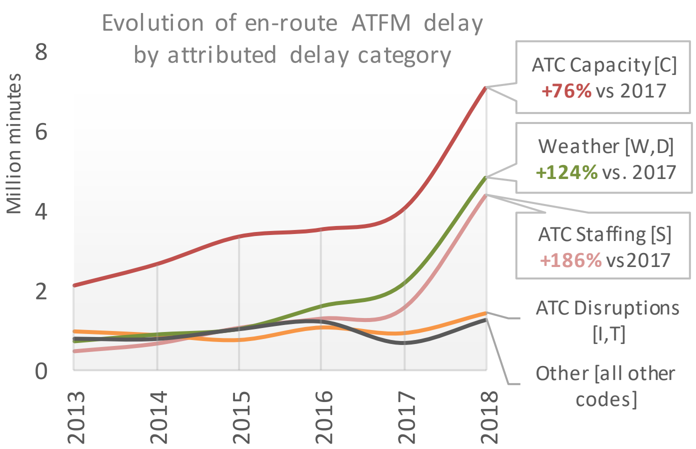


Figure 3-4: En-route ATFM delay by attributed delay category

The critical period is clearly the summer period when traffic levels are highest.

In July 2018 (the month with the highest number of flights) almost every fifth flight (19%) was delayed by en-route ATFM delays.

The summer months combine a high level of en-route ATFM delay attributed to ATC capacity and ATC staffing with significant delay attributed to bad weather conditions.

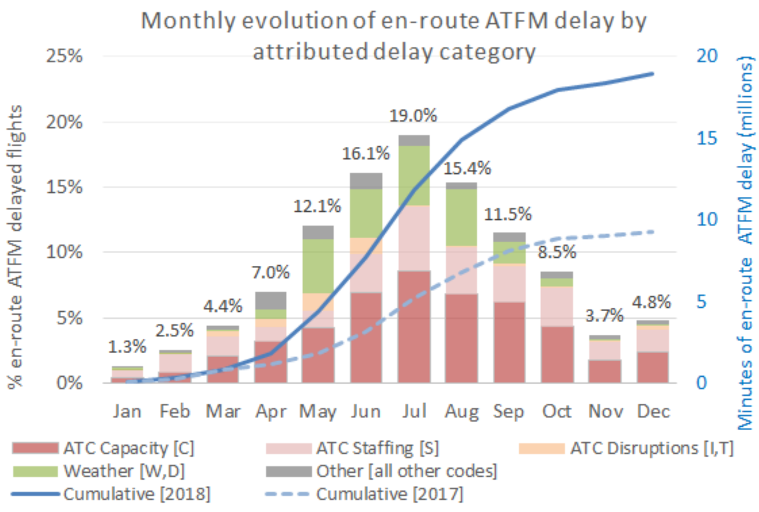
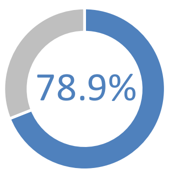


Figure 3-5: Monthly evolution of en-route ATFM delay by attributed cause



of all en-route ATFM delays in 2018 were generated between May and September

In fact, 78.9% of all en-route ATFM delays in 2018 were generated between May and September. Almost three quarters (74.2%) of the ATC capacity and staffing attributed delays were generated during that period and as far as delays attributed to adverse weather are concerned the share goes even up to 94.1%.

What were the most constraining en-route locations in 2018?

In 2018, DSNA (France) generated 31.2% of all en-route ATFM delays in the EUROCONTROL area, followed by DFS (26.9%), Maastricht (7.8%), and ENAIRE (6.8%).

In 2018 a number of high volume ACCs in the core area imposed significant constraints on aircraft operators. This resulted in a dramatic deterioration of network performance and a doubling of en-route ATFM delays to 19 million minutes.

The most delay generating ACCs in 2018 were Karlsruhe (21.3%), Marseille (15.2%), Maastricht UAC (7.8%), Reims (6.7%), Brest (5.4%), Vienna (4.3%) and Barcelona (3.8%).

Karlsruhe UAC and Marseille ACC together generated more than one third (36.5%) of all en-route ATFM delays in 2018.

Figure 3-7 shows the days with an average en-route ATFM delay per flight > 1 minute by ACC in 2018.

Within the EUROCONTROL area the level of en-route delay per flight was above 1 minute for more than half of the year in 2018 (184 days).

At Karlsruhe UAC there were 244 days when the average en-route ATFM delay per flight >1 min in 2018.

Between May and September Karlsruhe UAC had only 2 days with an average en-route ATFM delay below 1 minute.

The map in Figure 3-8 shows the share of flights delayed by en-route ATFM regulations within each ACC in 2018.

In Karlsruhe UAC and Marseille ACC more than 10% of the flights were delayed by en-route ATFM delays in 2018 despite a comparatively moderate year on year traffic growth of 0.4% and 2.4% respectively.

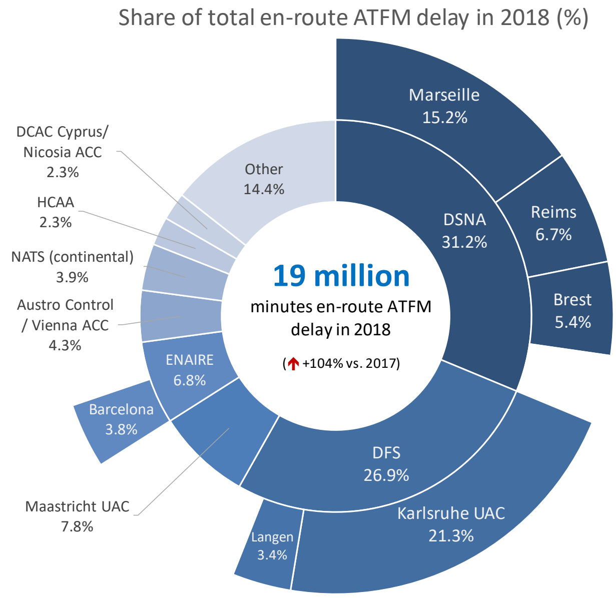


Figure 3-6: Share of total en-route ATFM delay in 2018 (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2018
Karlsruhe UAC	2	9	16	25	29	30	31	31	30	23	6	12	244
Marseille AC	0	0	3	5	12	16	31	29	16	23	6	4	145
Reims	0	0	1	4	18	28	27	23	5	4	0	3	113
Nicosia	0	1	1	7	1	12	22	28	15	6	5	7	105
Barcelona AC+AP	0	1	0	4	11	10	19	18	11	8	4	2	88
Brest	1	0	5	5	10	13	24	10	6	8	1	3	86
Maastricht	1	0	2	4	15	17	24	11	6	3	0	2	85
Wien	0	0	0	0	10	12	20	18	16	1	1	1	79
Zagreb	0	0	0	0	4	11	20	22	14	2	0	0	73
Praha	0	0	0	1	1	10	11	12	8	11	1	4	59
Canarias	1	6	11	2	1	3	2	2	0	5	8	10	51
Athinai+Macedonia	0	0	0	0	1	11	24	9	3	0	0	0	48
Langen	0	0	0	0	12	12	9	2	9	2	0	0	46
Budapest	0	0	0	0	0	3	13	11	7	1	2	6	43
Zurich	0	0	0	0	3	15	9	5	0	1	0	2	35
Beograd	0	0	0	1	1	10	12	4	1	0	0	1	30
London TC	0	0	1	14	3	5	5	2	0	0	0	0	30
EUROCONTROL area	0	0	5	8	22	30	31	31	29	20	2	6	184

Figure 3-7: Days with average en-route ATFM delay >1 min per flight

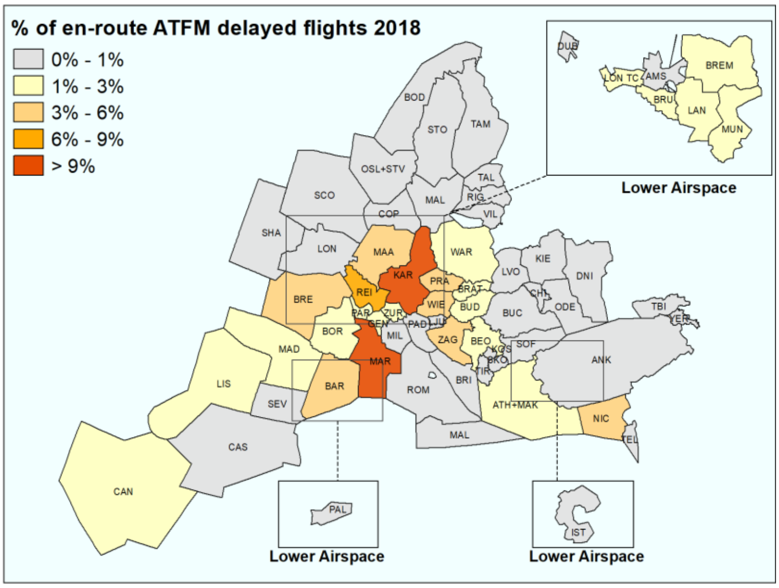


Figure 3-8: Share of en-route ATFM delayed flights by ACC (2018)

Figure 3-9 shows the evolution of the peak throughput in terms of hourly flights and the share of en-route ATFM delayed flights for the 10 most constraining ACCs. All ACCs managed to continuously increase their peak throughput but the deployed capacity was insufficient to meet the demand, leading to sharp increases in the number of flights affected by en-route ATFM delays in 2018. Karlsruhe UAC is a particular case as the peak throughput dropped in 2018 leading to a doubling in the number of delayed flights from 6.9% to 14.2% in 2018.

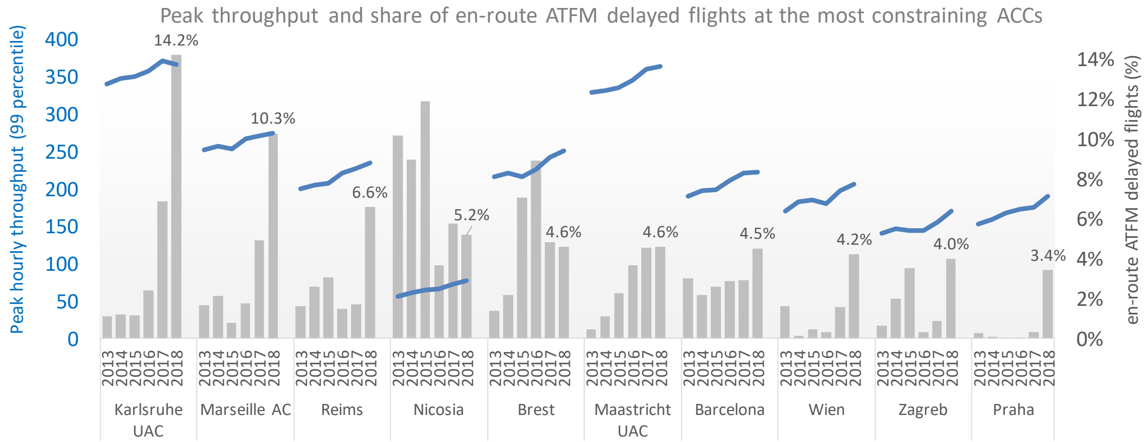


Figure 3-9: Peak throughput and en-route ATFM delayed flights at the most constraining ACCs

Figure 3-10 provides an overview of en-route ATFM delay in each ACC and the evolution compared to 2017.

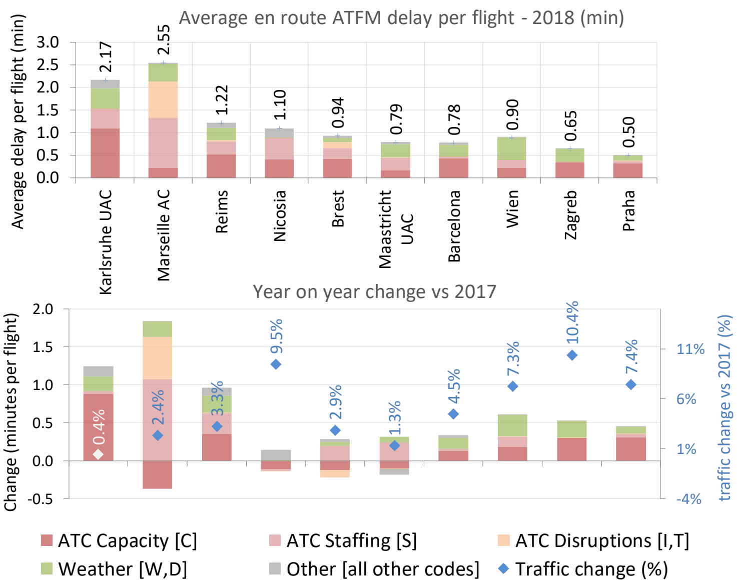


Figure 3-10: En-route ATFM delay per flight by most constraining ACC

At Marseille, ATC Staffing and ATC Disruptions (mainly industrial action) increased notably compared to 2017.

Four of the ten most constraining ACCs in 2018 experienced a traffic growth above 7% compared to 2017.

At Karlsruhe the performance deterioration was mainly attributed to ATC Capacity. However, a more detailed PRC analysis showed that 57% of all ATFM delays at Karlsruhe in 2018 were in collapsed sectors (62% of ATC capacity attributed and 58% of weather attributed delays) which suggests a staffing rather than a capacity issue.

To tackle the traffic growth and the forecasted delays for summer 2018, the “4ACC initiative” was created by the Network Manager, London, Reims, Maastricht and Karlsruhe. The aim of the joint initiative was to optimise the en-route flows through the centres’ airspace as a single entity, to increase overall capacity and throughput. Together with another 11 adjacent ACCs (which were required to accept extra traffic), the implemented measures included re-routing of traffic flows and level capping on certain flights to reduce overall delays at network level.

Using the University of Westminster report [10], which estimated the cost of ATFM delay at €100 per minute in 2014, it is possible to postulate the adverse impact of ATFM delays on airspace users for individual ACCs. Inevitably, there are margins of uncertainty in delay costs estimates, which should therefore be handled with caution. The report is available for download on the PRC website.

The ten most penalising ACCs in terms of total minutes of en route ATFM delay to airspace users in 2018 are listed in Table 3-1 with an approximation of the total financial impact and the impact of the main attributions of delay.

ACC / UAC	Total delay (min)	Cost of delay in millions of €					
		Total	ATC Capacity	ATC Staffing	Weather	Military	Other *
Karlsruhe	4 043 275	400	205	81	84	30	4 (O)
Marseille	2 876 921	288	25	126	43	2	88 (I)
Maastricht	1 482 997	148	32	52	53	4	2 (O), 3 (P)
Reims	1 263 310	126	54	29	28	1	2 (I)
Bordeaux	1 028 973	103	46	27	10	1	10 (I)
Wien	806 448	81	20	16	45		
Barcelona	716 889	72	40	3	24		3 (O), 3 (P)
Langen	649 498	65	30	18	17		
London TC	441 399	44	15	3	6		20 (P)
Nicosia	433 836	43	16	19		8	

**Industrial action (I) / 'Other' (O) / Special event (P)*

Table 3-1: Estimated costs of en-route ATFM delay at the most constraining ACCs in 2018

What were the most constraining ATC sectors?

The PRC has analysed the en-route ATFM regulations applied in 2018 focussing on the location ID of the individual regulations, since this is the ATC sector with the capacity constraint impacting airspace users' operations. The PRC looked at the ATFM delays attributed to ATC capacity, ATC staffing, Airspace Management (including military operations and training), weather and 'Other'.

23% of total en-route ATFM delay in 2018 was generated by the 20 most constraining ATC sectors

The 20 most constraining ATC sectors are depicted in Figure 3-11. Together they accounted for approximately 23% of total en route ATFM delay throughout the network in 2018. Of particular concern is that 14 of the 20 most constraining sectors are collapsed sectors. The PRC has previously highlighted that a collapsed sector imposes additional capacity constraints that exacerbate external capacity factors such as high demand, adverse weather or military activity.

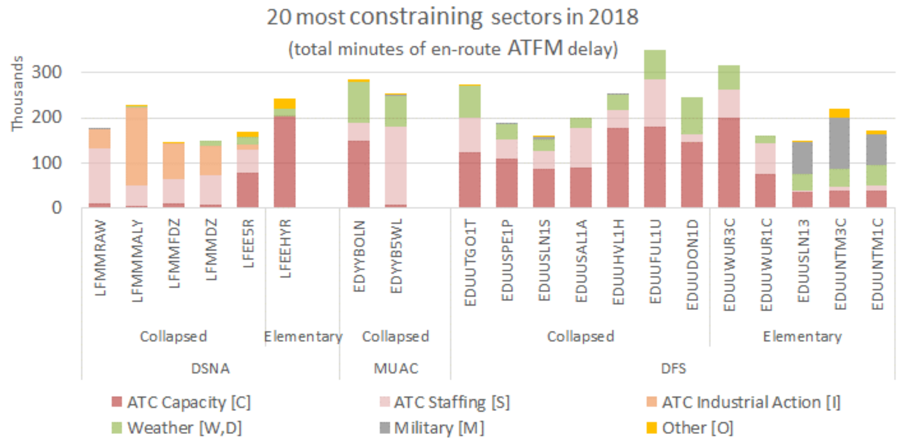


Figure 3-11: 20 most constraining sectors (2018)

It is worth noting that the collapsed sectors above are made up of elementary sectors which may also have additional ATFM delays attributed to them.

For example, there were an additional 460k minutes of en route delay attributed to the 20 individual / combined elements that make up the LFMMRAW sector, giving a combined total of more than 630k minutes of delay in that portion of airspace.

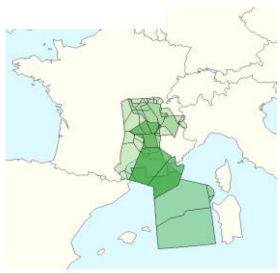


Figure 3-14: Plan of LFMMRAW collapsed sector

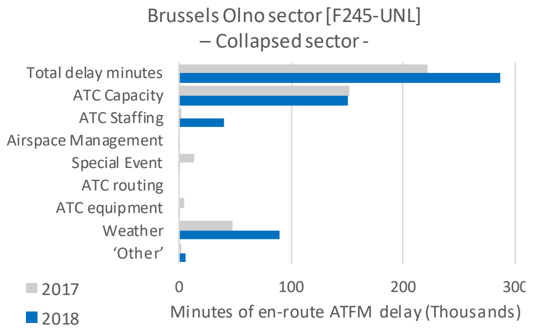
PRC Technical Report on Most Constraining en route ATFM regulations attributed to ATC capacity

In 2018, the PRC published a detailed analysis of the 12 most penalising ATFM regulations attributed, by the ANSPs, to ATC capacity in 2017 [11]. The PRC shared its findings with the relevant ANSPs and invited them to comment and provide information about how they intend to resolve or mitigate such capacity constraints in the future.

The report highlighted many cases where the PRC considered that delays attributed to ATC capacity should have been attributed to other causes including ATC staffing, adverse weather or airspace management (including military operations and training). It also identified cases where the ANSPs should address a significant capacity shortfall in comparison to traffic demand, requiring the planning and implementation of additional capacity.

In general, attributing ATFM delays in a collapsed sector to ATC capacity or adverse weather does not provide the airspace users with visibility on the root cause of the capacity constraint: namely why the sector was collapsed in the first place.

Maastricht: 2018 delays in the **collapsed** OLNO sector increased more than 25% from 2017 figures. Delays attributed to ATC staffing become more visible (≈40k minutes) but are much less than the delays attributed to ATC capacity (≈150k minutes) and delays attributed to adverse weather (≈90k).



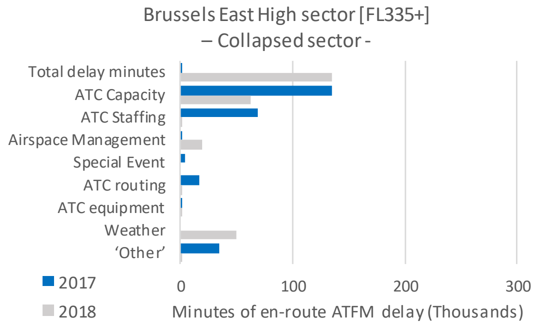


Figure 3-12: Brussels Olno and East High sectors (2018 vs 2017)

In the Brussels East High **collapsed** sector, total delays remained relatively constant year on year at 135k minutes. However, despite being a collapsed sector, delays due to ATC staffing or equipment are negligible, whereas delays attributed to ATC capacity and adverse weather account for over 80% of the total delays. There is a significant increase in delays due to airspace management (military operations and training) which is to be expected in a very busy sector with significant and busy military training areas.

A significant improvement was observed in Delta West High and Delta West Low elementary sectors due to the addition of a third vertical sector (Delta West Medium FL335 – FL365) on 28th March 2018, as part of existing plans to increase capacity in the area. When the 3 new sectors were open separately between April and December, there was only 6k minutes of delay attributed to ATC capacity and 14k attributed to adverse weather. During the same period when the low and medium sector was collapsed, 28k minutes were attributed to ATC staffing and 63k minutes were attributed to adverse weather. It is worth noting that for the same geographical area [Delta West FL 245- FL999] ATFM delays improved from 266k minutes in 2017 to 116k minute in 2018.

Marseille: Total delays in the **collapsed** LFMMSBAM sector, in Marseille ACC increased in 2018 compared to 2017. However the delays attributed to ATC capacity have dramatically reduced, whereas delays attributed to ATC staffing have increased dramatically. This is in line with the DSNA response to the PRC analysis, where they agreed that delays in collapsed sectors should be attributed to ATC staffing since it is

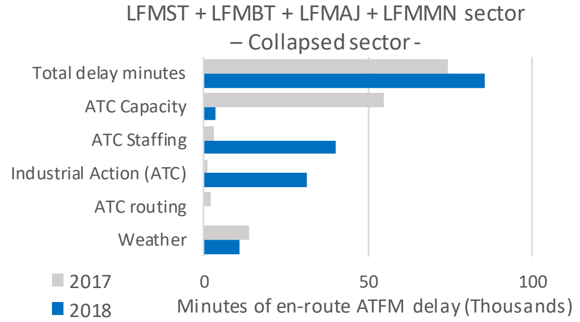


Figure 3-13: Marseille ACC (LFMST, LFMBT, LFMAJ, LFMMN)

the non-availability of staff that prevents the opening of the sectors. Significant delays were attributed to industrial action (ATC) in 2018.

Paris ACC: In Paris ACC, the **collapsed** LFFFLMH sector had increased delays in 2018 compared to 2017. The delays were mainly attributed to adverse weather although it can be argued that adverse weather only exacerbates the original capacity constraint which is caused by collapsing sectors, and that opening individual sectors would have mitigated the impact of adverse weather. It is interesting that no delays were attributed to ATC staffing even though it is a collapsed sector.

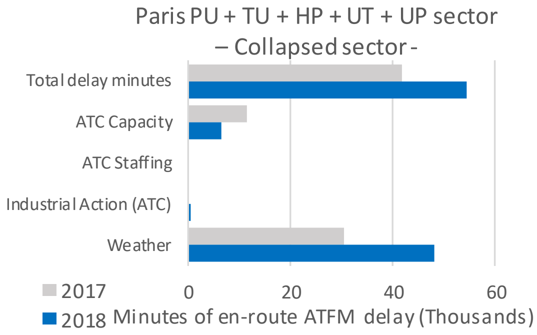


Figure 3-14: Paris ACC (PU+TU+HP+UT+UP sectors)

Nicosia: A mixed result for Nicosia ACC: The **collapsed** LCCCES0 sector saw a significant reduction in total delays for 2018 with the proportion of delays relatively evenly attributed between ATC capacity, ATC staffing and airspace management. DCA Cyprus advised that they intend to vertically split the sector to provide additional capacity but did not provide a date for implementation.

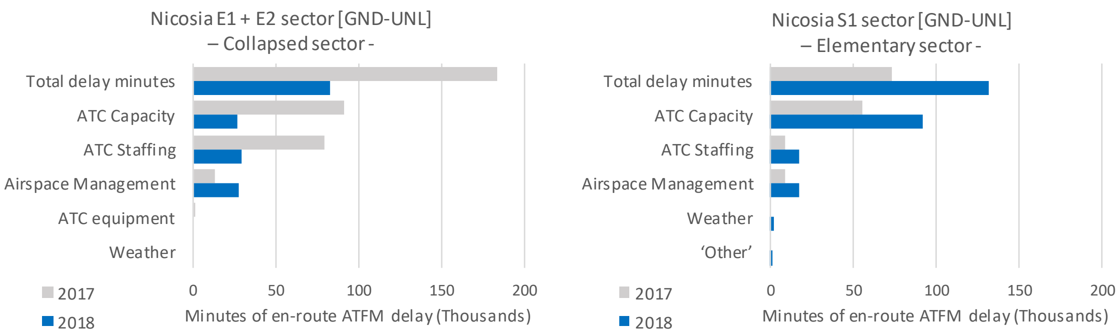


Figure 3-15: Nicosia E1+E2 and S1 sectors (2018 vs 2017)

The elementary LCCCS1 sector experienced a significant increase in delays for 2018 compared to 2017. The increase was mainly attributed to ATC capacity although delays attributed to ATC staffing and airspace management also increased. DCA Cyprus did not provide information on how they intend to increase capacity in this sector.

Canarias ACC: In response to the analysis about the Norte Este elementary sector in Canarias ACC, ENAIRE advised that the sector will be split into two, to manage the traffic flows. The split was expected to be implemented by January 2020, but is now postponed until October of that year. In the meantime, ENAIRE will try to reduce overflights of the sector through the use of re-routing scenarios.

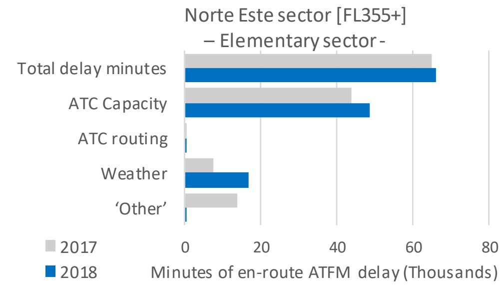


Figure 3-16: Norte Este sector (2018 vs 2017)

The 2018 delays show an increase in delays attributed to adverse weather and a reduction in delays attributed to 'other' causes. However total delays for the sector remain relatively consistent with 2017 figures.

Karlsruhe UAC: Delays in the Soellingen low elementary sector increased by ≈45k minutes in 2018 compared to 2017. This appears to be driven predominantly by delays attributed to airspace management (military operations and training) which increased by ≈50k minutes, year on year, and highlights the importance of effective civil military cooperation.

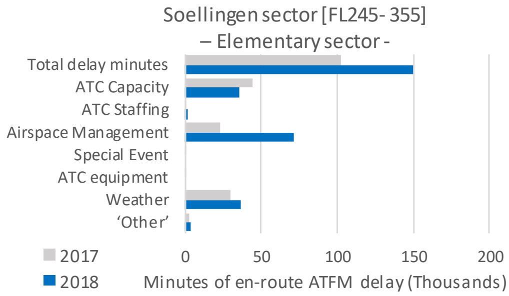


Figure 3-17: Soellingen sector (2018 vs 2017)

3.2.2 En-route flight efficiency

This section evaluates en-route flight efficiency in the EUROCONTROL area. En-route flight efficiency has a horizontal (distance) and vertical (altitude) component.

According to the Air Transport Action Group (ATAG) [12], one third of the operating costs of airlines is spent on fuel 33%, up from 13% in 2001. The proportion is likely to rise further as fuel prices go up. So this alone is a major incentive for the whole industry to focus on.

As fuel burn is directly proportional to emissions, flight efficiency has also a significant environmental impact (see also Chapter 1) and ANS has a role to play in improving performance in Europe.

3.2.2.1 Horizontal en-route flight efficiency

The European ATM system needs to become more efficient to keep up with demand and to reduce operational inefficiencies while coping with increasing traffic levels. Considerations related to capacity, safety and aircraft performance mean that 100% flight efficiency, as measured by the indicator, is not only unattainable but also undesirable.

In addition to the flight efficiency based on planned and actual trajectory, this PRR introduces a new indicator based on the Shortest Constrained Routes (SCRs) calculated by the Network Manager.

The SCRs are the shortest trajectories which could be filed by a flight, taking into consideration the restrictions in the Route Availability Document (RAD) and conditional routes (CDRs) availability[14].

It has long being contended that the indicators based on flight plans and actual trajectories might be unduly influenced by factors which are not under the control of ANSPs, such as airspace users' policies (driving the choice of the flight plan) and external conditions (e.g., weather).

Horizontal en-route flight efficiency

The indicator is expressed as ratio of total distances and is therefore an average per distance (within the areas) and not an average per flight. To keep a gate-to-gate perspective, the indicator uses as reference the great circle distance between origin and destination of the flight and measures the length of trajectories in terms of additional distance with respect to that reference.

The great circle distance is used not because it is the optimal trajectory, but because it provides a well-defined minimum value for the calculation of the additional distances in the different airspaces. As the methodology considers the entire flight trajectory, it is possible to break down the indicator in a local component (additional distance within a given airspace) and an interface component (additional distance related to the whole flight).

More information on methodologies (approach, limitations) and data for monitoring the ANS-related performance is available at: http://ansperformance.eu/.

SCRs are free of those influences and reflect the constraints that have been imposed by ANSPs. This does not mean however that the constraints are unnecessary as most of them will reflect trade-offs made when taking into consideration factors such as capacity and safety.

The high level picture

Figure 3-18 shows the en-route flight efficiency measurements based on the actual trajectory (red), the last filed flight plan (blue), and the shortest constrained routes (green) for the EUROCONTROL area[15] (the SCRs are only available for the period 2016 – 2018). Despite continued increase in traffic in 2018, the three measurements stayed at the same level as in 2017.

[14] More information on the SCR methodology is available online at http://ansperformance.eu/.

[15] The airspace analysed in this section refers to the NMOC area.

The shortest constrained routes are, as would be expected, more efficient than the flight plans. The efficiency of flight plans tend to follow quite closely that of the shortest constrained routes (the gap very slightly narrowed in 2017 with respect to 2016 and stayed the same between 2017 and 2018).

The efficiency of actual trajectories is above the efficiency not only of flight plans, but also of the shortest constrained routes.

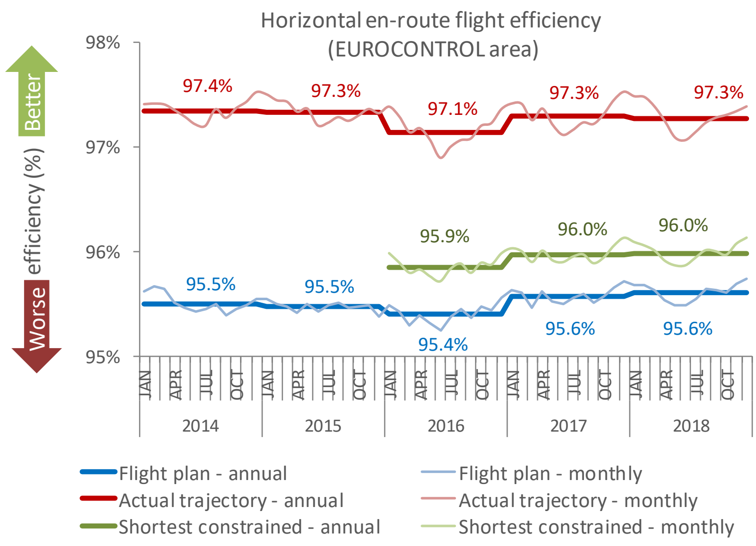


Figure 3-18: Horizontal en-route flight efficiency (EUROCONTROL area)

This indicates that airspace users fly trajectories which are not only shorter than the ones they file, but also shorter than the ones they could file.

1.3%

gap between actual trajectory flown and shortest constraint route (2018)

The results show that the shortest constrained route, made available by the ANSPs, is on average 0.4% shorter than the routes filed in flight plans submitted by the airspace users. However, the shortest constrained route made available by the ANSPs is still on average 1.3% longer than the trajectories that the aircraft actually fly, which indicates that the ANSPs could be doing more to ensure that the network is made aware of the shortest possible route options and the applicability of constraints on airspace users.

This seems to indicate that the constraints imposed by Air Navigation Service Providers (ANSPs) tend to be conservative (otherwise the averages for SCRs and actuals would be closer, as a result of actual trajectories which would be at times shorter and at times longer than SCRs). The observed gap between SCR and actual trajectory raises also the question of the accuracy (rather than the precision) of data presently used for decision-aid tools.

While further improving the efficiency of actual trajectories, it would be beneficial in terms of predictability and efficiency to close the observed gap between the planned and the actual trajectories by bringing the operational planning closer to the actual flown trajectory.

Horizontal en-route flight efficiency by State

Figure 3-19 provides a map showing the values of en-route flight efficiency in the different States, while Figure 3-20 provides an analysis of the different components of the flight efficiency of actual trajectories at State level.

Overall flight efficiency (actual trajectories) is comparatively low in the core area where traffic density is highest.

Furthermore, a lower flight efficiency is observed in Cyprus, UK, Spain (continental) and Turkey. The results for Turkey should be viewed with a note of caution due to data coverage issues.

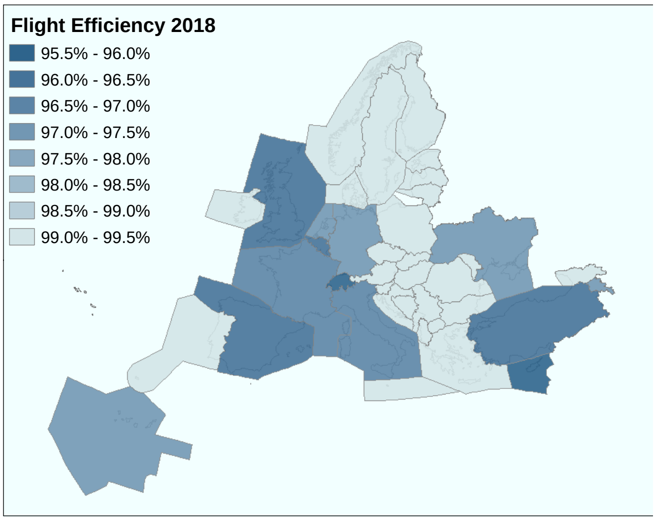


Figure 3-19: Map of horizontal en-route flight efficiency (actual trajectories 2018)

The top of Figure 3-20 shows horizontal en-route flight efficiency and average additional kilometre per flight in 2018, while the bottom shows the total additional distance and the cumulative share (with respect to the total additional distance in the EUROCONTROL area). The local component is always shown in dark red at the bottom of each bar.

Given that flight efficiency is expressed as a percentage with respect to distances, there is no specific consideration of the number of flights. Additional kilometres flown and the average per flight provide an additional perspective and a more complete picture of the contribution to the overall value for the EUROCONTROL area.

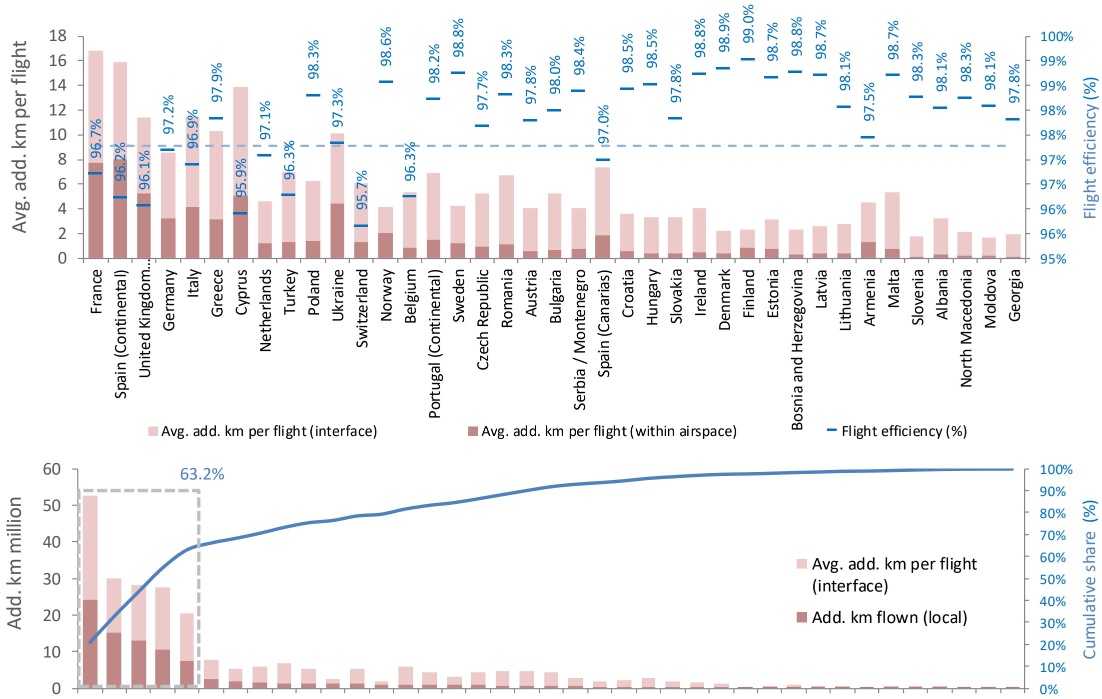
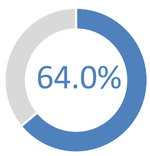


Figure 3-20: Horizontal en-route flight efficiency by State (actual trajectories – 2018)

The values in the bottom part of the figure, which are totals not averaged by flight, are influenced by the amount of traffic (and, partly, the size of the airspace). While it is acknowledged that it might be more challenging to improve flight efficiency in high density airspace the benefit of even small flight efficiency improvements translate into substantial distance, fuel and CO_2 savings (the impact of an improvement in flight efficiency in an airspace on the EUROCONTROL flight efficiency is proportional to the distance flown in that airspace).



of horizontal en route flight inefficiencies in 2018 were related to the network component

In 2018, the five States with the highest level of additional distance flown (combination of inefficiency and traffic volume) accounted for 63.2% of total additional distance or 70.2 million additional km. Of the observed inefficiencies in the five States, 77.5% were related to local inefficiencies within the given airspace. France and Spain combine a lower than average flight efficiency with comparatively long flight segments and high traffic volume.

Overall, almost two third (64.0%) of observed horizontal en-route flight inefficiencies are related to the interface component when states are considered separately. In 2018, 22 of the 39 States included in the analysis had a network component greater than 80%. In general, the more granular the measurement, the more the inefficiency will be attributed to the interface component.

Figure 3-21 shows the changes in terms of average additional distance per flight (primary axis) and the changes in percentage points in terms of flight efficiency (secondary axis) compared to 2017 by State. The most significant improvement in 2018 is observed for Norway, Ukraine, and the Canary Islands.

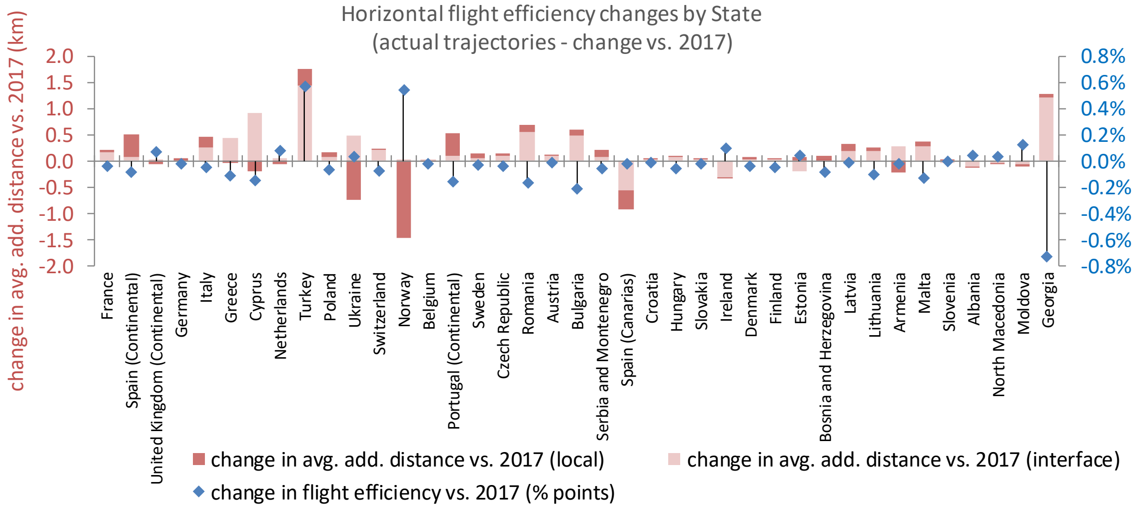


Figure 3-21: Horizontal en-route flight efficiency changes vs 2017 by State

While it is useful to be able to split the flight efficiency in the two components, the focus should be on the total value of flight efficiency, not only the local component. This is because the local component is based on comparison with direct routings within the given airspace, which are not necessarily efficient for the overall flight (that perspective is the one considered by the interface component).

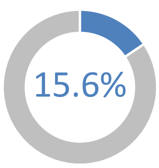
An improvement of flight efficiency (i.e. a shorter route for a flight) can be obtained by an improvement in interface which more than compensates for a decrease in the local extension. Providing the shortest route within an airspace (what is measured by the local component) does not necessarily lead to a shorter route for the flight (what is measured by the flight efficiency indicator).

When considering inefficiencies for larger airspaces, part of the internal interface values will be included in the local inefficiency (while the total additional distance stays the same, the proportions relative to the local component and the interface component change).

Figure 3-22 shows a breakdown of the potential flight efficiency improvements related to the interface between adjacent States.

The highest potential improvement of additional distance relates to flows crossing the border between France and Spain.

The top 20 State interfaces shown in Figure 3-22 together account for 15.6% of total additional distance in 2018.



of the interface related additional km in 2018 are generated by 20 State boundaries

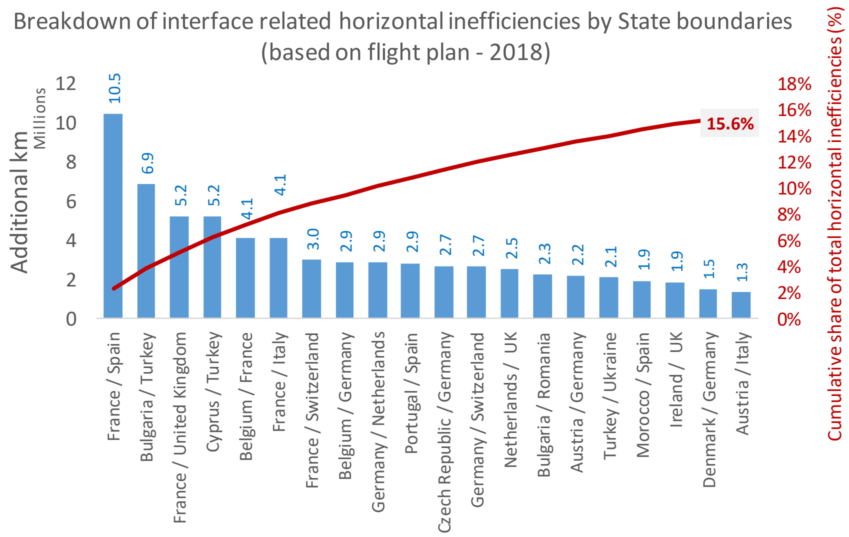


Figure 3-22: Interface related flight inefficiencies by State boundaries (2018)

There is a close link between flight efficiency improvements and the implementation of Free Route Airspace (FRA) at various levels and times in a large part of EUROCONTROL airspace.

PRR 2017 [13] underlined the benefits of FRA: more choices for airspace users and a more flexible environment responding more dynamically to changes in traffic flows.

As highlighted in the EATMP 2018 [14] "*FRA is a way of overcoming the efficiency, capacity and environmental problems facing aviation, representing a key landmark in achieving free routing across the entire European airspace on the road to SESAR business trajectories and 4D profiles. The implementation of this concept of operations will have to be accompanied by the deployment or upgrade of several controller support tools (e.g. medium term conflict detection, conflict resolution assistant, area proximity warning, etc.) which are critical for the successful implementation of free route.*"

Free route airspace,

Free Route Airspace 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. The expected benefits are, inter alia, reduced fuel burn (costs) and gaseous emissions.

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

This is especially the case in the dense European core area which has the highest traffic volume but also the highest variation in terms of horizontal and vertical traffic flows.

As specified in the European ATM Master Plan [7] and supported by Commission implementing regulation (EU) No 716/2014 [15] on the establishment of the Pilot Common Project supporting the implementation of the European ATM Master Plan, Free Route Airspace on a H24 basis should be implemented above flight level 305 throughout the entire EUROCONTROL area by 2022.

Expected benefits vary by airspace and depend, inter alia, on traffic volume, growth, complexity and other factors. Furthermore, flight efficiency improvements may become more and more challenging in view of the continued traffic growth and the existing lack of capacity in some areas.

In addition to the local implementation of FRA, it is also important that ANSPs work actively with the Network Manager and the Deployment Manager to deliver FRA across the entire EUROCONTROL area, including necessary cross-border implementation, the importance of which has been highlighted above in the context of inefficiencies related to State interfaces.

In this context it is important to ensure that the benefits of free route airspace can be fully exploited by airspace users in their flight planning systems. This requires all involved parties to work proactively together to create an efficient communication interface between the ANSPs and NM (airspace availability, military activity) on the one side and the airspace users including their flight plan service providers on the other side.

Work is ongoing to better understand and quantify the individual factors affecting horizontal flight efficiency (flight planning, awareness of route availability, Civil/Military coordination, etc.) in order to identify and formulate strategies for future improvements.

An important step for a better understanding of the constraints imposed on airspace users 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. The measurement based on shortest constrained routes goes in that direction.

3.2.2.2 Vertical en-route flight efficiency

The methodology developed by the PRC [16] has been used to perform a number of case studies. Some of those case studies have been presented and discussed during the PRC's Vertical Flight Efficiency (VFE) Workshop in November 2018. The contents and presentations can be found on the event webpage [17]. More information on the methodology is available on the ANS performance data portal.

To enable stakeholders to get the most important en-route VFE results for an airport pair of their choice, an online report request tool has been implemented. This tool can be accessed through the ANS performance data portal and provides interested parties with a tailor made report for a specific airport pair and AIRAC cycle.

As seen in previous years, vertical en-route flight inefficiency (VFI) follows a cyclical trend with higher inefficiency levels in summer.

Figure 3-23 shows the total VFI (in terms of total additional feet) for AIRAC cycles 06 to 09 (representing the summer periods) since 2015.

A significantly higher amount of inefficiency was observed during the summer of 2018 compared to previous summers. Part of this increase is due to the higher number of movements but also to the amount and impact of altitude restrictions which have increased significantly.

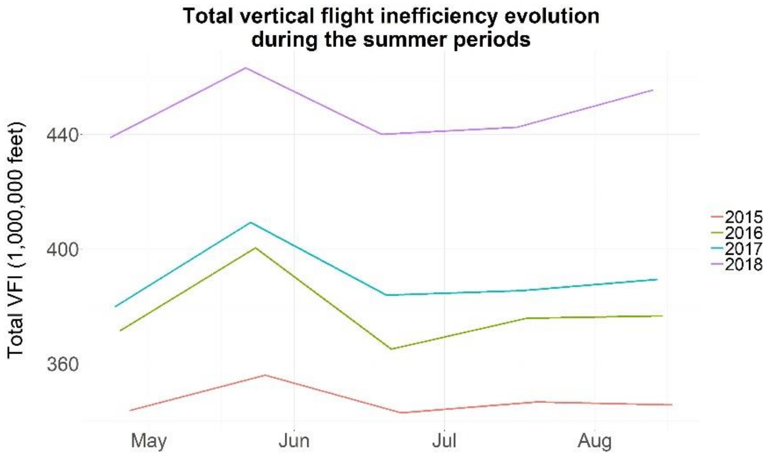


Figure 3-23: Evolution of total en-route vertical flight inefficiency during summer

Figure 3-24 shows the number of airport pairs that are impacted by a level capping constraint detailed in the Route Availability Document (RAD).

It can be seen that there is a considerably higher number of impacted airport pairs since spring 2018.

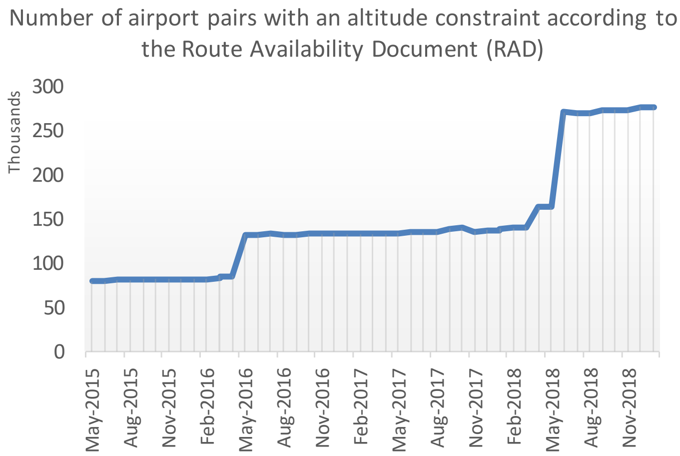


Figure 3-24: Evolution of vertically RAD constrained airport pairs

101% increase in airport pairs impacted by altitude constraints in spring 2018 (RAD restrictions)

The 4ACC initiative was launched in spring 2018, in coordination with the Network Manager and adjacent ACCs. Its aim is to minimise system-wide en-route ATFM delay, through the implementation of measures such as level capping and re-routing.

The 4ACC initiative has had mixed results: compared to the same period in 2017, the number of airport pairs impacted by level capping constraints more than doubled in 2018.

The top 20 airport pairs with the highest amount of total vertical flight inefficiency during AIRAC cycle 1807 (June-July 2018) are shown in Figure 3-25.

The flight levels next to the arrows connecting the departure and arrival airports indicate the altitudes of the RAD constraints on these airport pairs. Seventeen (17) out of the 20 airport pairs were completely or partially below the ACCs involved in the 4ACCs Initiative (London ACC, Reims ACC, Maastricht UAC and Karlsruhe UAC).

Flights on these airport pairs were restricted in terms of their cruising altitude, which allows handling other flights at higher altitudes. This is an example of the trade-off between flight efficiency and capacity, which again indicates the need to take into account all aspects of performance.

During the development of the case studies for the VFE workshop, it became apparent that the interaction between flight efficiency and capacity is a major factor.

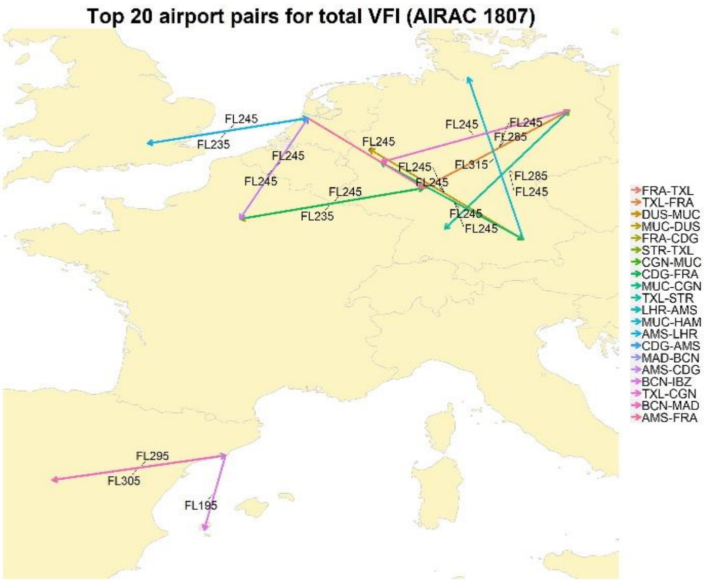


Figure 3-25: Top 20 airports pairs with respect to total VFI

Good coordination amongst all stakeholders is necessary to improve VFE while maintaining safety and capacity.

During the VFE Workshop in November 2018, the participants highlighted again that flight efficiency needs to be balanced against capacity throughout the network, which emphasises the importance of this trade-off.

Furthermore, the following aspects regarding en-route VFE were mentioned and discussed during the workshop:

- Usually operational reasons are causing inefficiencies
- ATC has to understand how aircraft want to fly. New tools and new aircraft can result in different flight profiles
- Airlines can face considerable (financial) penalties associated with constraints to vertical flight efficiency
- Non-operational factors can impact flight efficiency and can be an enabler or impediment to improvement

3.3 Flexible use of airspace

ANS performance and drones

In 2018 the PRC decided to return to the subject of civil military cooperation and coordination by repeating the questionnaire on how States implement the Flexible Use of Airspace to provide optimum benefit for both civil and military airspace users. The PRC decided to include specific questions about how the states accommodate the increasing number of drones or Unmanned Aircraft System (UAS) whilst ensuring the safe, orderly and expeditious flow of other air traffic.

As in 2015, questionnaires were sent to the Airspace Management Cells of Member States and to the associated national supervisory authorities (NSAs), asking about the flow of information between stakeholders on the strategic, pre-tactical and tactical management of airspace to meet the needs of all airspace users.

The PRC received 32 replies from stakeholders, from 17 States. Whilst the PRC is grateful for the responses provided, it is disappointed to note from the replies that very little appears to have been done to address the deficiencies highlighted three years ago in the last FUA survey. There remains a consistent lack of impact assessments regarding segregated or restricted airspace and the effect they have on general air traffic in terms of available ATC capacity and route options; a widespread absence of clear national / regional strategic objectives for both OAT and GAT at ASM level 1, and a haphazard flow of information throughout the ASM process, especially as regards feedback of operational performance to the high level policy makers.

The PRC is particularly concerned that, from the completed questionnaires, several Member States appear to confuse the Free Route Airspace (FRA) operations with the Flexible Use of Airspace (FUA). FRA is only relevant to the flight planning of aircraft and how airspace users are obligated to describe their determined trajectory through a portion of airspace. FUA relates to the management of the airspace by the national authorities, or designated entities, by temporarily segregating or restricting airspace from general air traffic based on actual use and releasing the airspace for general use when no longer required. The implementation of FRA has no bearing on the implementation of FUA and vice versa.

The PRC also notes the lack of replies from Member States about their ability and readiness to handle an increase in demand for the use of drones or UASs. This is concerning since it is already apparent that drones can significantly disrupt the safety and operations of general air traffic as witnessed at Gatwick airport in December 2018.

In 2019, the PRC proposes to complete a separate report on Flexible Use of Airspace, with special emphasis on the accommodation and handling of drones and UASs in congested airspace. The PRC requests the assistance of all Member States in this endeavour and the cooperation of both civil and military stakeholders.

3.4 Conclusions

Air traffic in the EUROCONTROL area continued to grow for the fifth consecutive year in 2018. On average IFR flights increased by 3.8% over 2017 which was slightly above the baseline scenario forecast by STATFOR. Eastern Europe showed a continued strong growth with a substantial traffic recovery in Ukraine. In absolute terms, DFS (Germany), DHMI (Turkey), ENAIRE (Spain), HungaroControl (Hungary), ENAV (Italy) and BULATSA (Bulgaria) showed the highest year on year growth in 2018.

Total en-route ATFM delays more than doubled in 2018 (+104%) to reach 19 million minutes. More than 1 million flights were delayed by en-route ATFM regulations in the EUROCONTROL area in 2018 which corresponds to 9.6% of all flights (+4.2 percentage points vs. 2017). As a result average en route ATFM delay increased from 0.88 to 1.74 minutes per flight in 2018.

As was the case in previous years, Capacity attributed delays (37.4%) remain the main portion of en-route ATFM delays, followed by Weather attributed delays (25.4%), ATC Staffing (23.0%) and ATC disruptions/industrial actions (7.5%). The evolution of en-route ATFM delays shows a real jump in delays attributed to ATC staffing (+186% vs 2017), adverse weather (+124%) and ATC Capacity (+76%) in 2018. Almost 80% of all en-route ATFM delays in 2018 were generated between May and September. In July 2018 (the month with the highest number of flights) almost every fifth flight (19%) was delayed by en-route ATFM delays. Although it is evident that the problem will not be solved in 2019, ATC staffing is clearly an issue which needs to be urgently addressed – even more so considering the demographic profile in some Air Navigation Service Providers (ANSPs) and the long lead times before new recruits can actively control traffic.

In 2018, DSNA (France) generated 31.2% of all en-route ATFM delays in the EUROCONTROL area, followed by DFS (26.9%), Maastricht (7.8%), and ENAIRE (6.8%).The most delay generating ACCs in 2018 were Karlsruhe (21.3%), Marseille (15.2%), Maastricht UAC (7.8%), Reims (6.7%), Brest (5.4%), Vienna (4.3%) and Barcelona (3.8%). Karlsruhe UAC and Marseille ACC together generated more than one third (36.5%) of all en-route ATFM delays in 2018.

The 20 most constraining ATC sectors in 2018 accounted for 23% of total en-route ATFM delays in 2018. Of particular concern is that 14 of the 20 most constraining sectors are collapsed sectors. The PRC has previously highlighted that a collapsed sector imposes additional capacity constraints that exacerbate external capacity factors such as high demand, adverse weather or military activity.

Horizontal en-route flight efficiency remained despite the continued traffic growth at the same level as in 2017. The efficiency of actual trajectories stayed at 97.3% while the efficiency of filed flight plans was notably lower at 95.6% in 2018. In addition to the flight efficiency based on planned and actual trajectory, this PRR introduced a new indicator based on the Shortest Constrained Routes which removes effects from airspace users' flight planning and therefore focuses on constraints imposed by Air Navigation Service Providers.

The results show that the shortest constrained route, made available by the ANSPs, is on average 0.4% shorter than the routes filed in flight plans submitted by the airspace users. However, the shortest constrained route, made available by the ANSPs, is still on average 1.3% longer than the trajectories that the aircraft actually fly, which indicates that the ANSPs could be doing more to ensure that the network is made aware of the shortest possible route options and the applicability of constraints on airspace users.

While further improving the efficiency of actual trajectories, it would be beneficial in terms of predictability and efficiency to close the observed gap between the planned and the actual trajectories by bringing the operational planning closer to the actual flown trajectory.

Although flight efficiency can never be 100%, the benefits of the continued implementation of Free Route Airspace (FRA) in Europe in terms of more flexible environment and more choices to airspace users are expected to further improve flight efficiency. The expected benefits vary by airspace and depend, inter alia, on traffic volume, growth, complexity and other factors. With local FRA implementation progressing, the interface between airspaces and TMAs becomes more important. In 2018, 64% of the en-route flight inefficiencies were related to the interface component requiring the Network Manager and the ANSPs to work on cross-border solutions.

Vertical en-route flight efficiency deteriorated significantly during summer in 2018. Compared to the same period in 2017, the number of airport pairs impacted by level capping constraints more than doubled in 2018. A large part of the vertical constraints were implemented by the 4ACC initiative.

The initiative was launched in spring 2018 by London, Reims, Maastricht and Karlsruhe, in coordination with the Network Manager and adjacent ACCs to optimise traffic flows. Its aim is to minimise system-wide en-route ATFM delay, through the implementation of measures such as level capping and re-routing. Although the initiative prevented an even higher increase in en-route ATFM delays in 2018, from an ANS performance point of view, it is important to consider the bigger picture including the substantial flight inefficiencies and related costs imposed on airspace users.

With European airspace being saturated in many areas and technical solutions years from deployment, a collaborative, network centric, approach with genuine structural changes in the future will be an important enabler to manage the forecast rising demand levels.

Instead of taking a limited local view, capacity, traffic flows and the application of ATFM regulations need to be managed from a network perspective with the Network Manager, ANSPs and airspace users working collaboratively together to find the best solution for the network as a whole.

4 Operational ANS Performance @ Airports

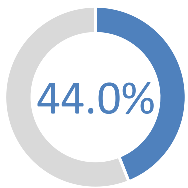
SYSTEM TREND (TOP 30 AIRPORTS IN TERMS OF TRAFFIC)	2018	Trend	change vs. 2017
Average daily movements (arrivals + departures)	23 626	↑	+3.6%
Arrival flow management (per arrival)			
Average Airport Arrival ATFM Delay	1.13	↓	-0.11 min
Average Additional ASMA Time (without Turkish airports)	2.07	↓	-0.11 min
Average time flown level during descent (without Turkish airports)	3.1	→	+0.1 min
Departure flow management (per departure)			
Average additional Taxi-out Time (without Turkish airports)	4.2	↑	+0.3 min
Average time flown level during climb (without Turkish airports)	0.6	→	+0.1 min

All indicators but additional taxi out time improved or remained stable at the top 30 airports in 2018

4.1 Introduction

The provision of sufficient airport capacity is one of the key challenges for future air transport growth. This chapter provides a review of operational ANS performance at major European airports. The evaluation of future airport capacity requirements (e.g. new runways, taxiways, etc.) is beyond the scope of this report.

The 2018 Challenges to Growth study [5] warns about the airport capacity shortage expected in 2040, when 1.5 million flights will not be able to fly, despite the optimistic capacity plans for the airports (only the top 20 airports are planning a growth of 28% in terms of movements). The report also states that even with 1.5M flights lost to the capacity gap, a typical summer day in 2040 will have 16 airports as congested as Heathrow is now.



share of total arrivals at the top 30 airports in the EUROCONTROL area

This chapter evaluates the top 30 airports in terms of IFR movements in 2018, which have the strongest impact on network-wide performance. Together the top 30 airports accounted for 44.0% of all arrivals in the EUROCONTROL area in 2018.

Any unusual performance observed at an airport not included in the top 30 airports is commented on in the respective sections of the chapter. Due to the lack of available data in some areas, the Turkish airports could not be reflected in all analyses throughout this chapter. Work is in progress to establish the data flow and the PRC looks forward to seeing the Turkish airports in all analyses in future reports.

Further information on the underlying methodologies and data for monitoring the ANS-related performance at the top 30 and all other reviewed airports is available online on the ANS performance data portal.

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fully integrated A-CDM airports in 2018 improving the predictability of operations

Improving operational performance at airports requires the joint effort of all involved stakeholders. Airport Collaborative Decision Making (A-CDM) helps to optimise the overall efficiency at airports through improved predictability of operations. A-CDM focuses especially on aircraft turn-round and pre-departure sequencing processes.

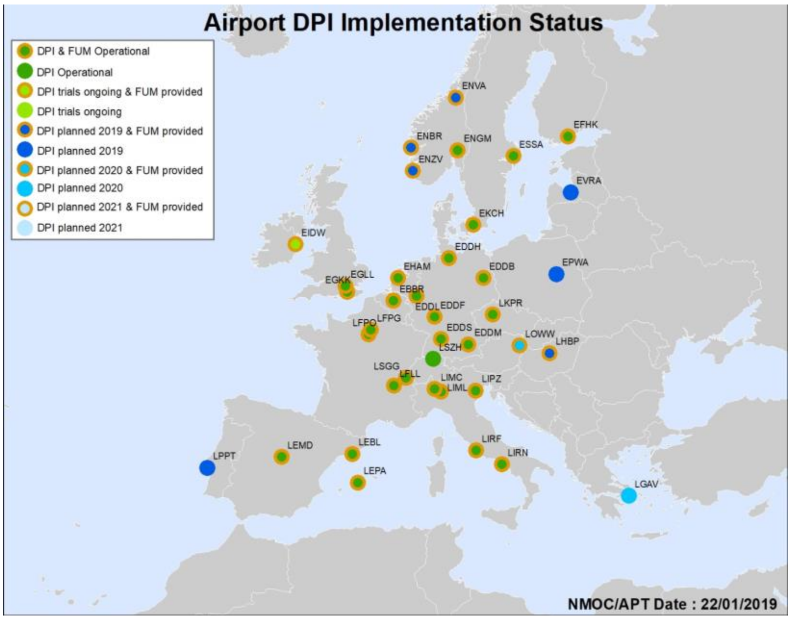
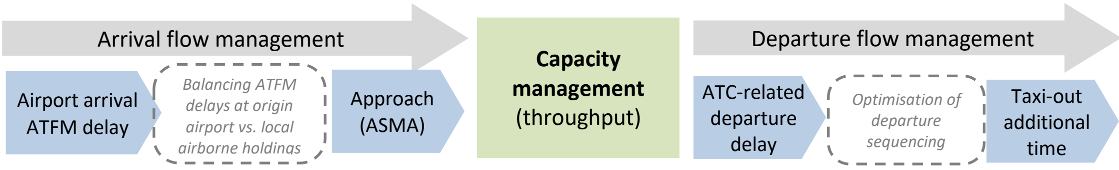


Figure 4-1: Airport DPI Implementation status (2018)

The sharing of Departure Planning Information (DPI) messages with the Network Manager also helps to improve the predictability of the network through more accurate take-off information.

In 2018, a total of 28 airports provided DPI messages to the Network Manager with Amsterdam Schiphol Airport joining as the 28th full A-CDM airport in May 2018. Approximately 30% of the departures in the EUROCONTROL area originate from an A-CDM airport and new additions (Warsaw and Lisbon) are planned for 2019 which will further improve local performance and network predictability.

The following sections evaluate ANS-related inefficiencies on the departure and arrival traffic flow at the top 30 airports. The performance indicators used in this chapter are summarised in Figure 4-2.



	Arrival flow management	Departure flow management
Related indicators	• Airport ATFM arrival delay [ICAO GANP KPI 12] • Additional Arrival Sequencing and Metering Area (ASMA) time [ICAO GANP KPI 08] • Average level time in descent	• ATC-pre departure delay • Additional taxi-out time [ICAO GANP KPI 02] • ATFM slot adherence [ICAO GANP KPI 03] • Average level time in climb
Expected benefits	• Reduction of airborne terminal holdings • Support to fuel efficient descent trajectory • Maximise airport throughput	• Minimise ANS-related departure delays • Optimise push back time sequencing • Optimum taxi routing (distance & time) • Adherence to ATFM departure slots
Supporting projects/ initiatives	• Continuous descent operation (CDO) • Performance based navigation (PBN) • Arrival manager (AMAN/XMAN) • RECAT EU	• Airport Collaborative Decision Making (A-CDM) • Departure manager (DMAN) • Continuous climb operations (CCO)

Figure 4-2: ANS-related operational performance at airports (overview)

For the interpretation of the analyses in this chapter it should be borne in mind that the results are driven by 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 sometimes difficult.

While ANS at airports is not often the root cause for a capacity/demand imbalance (e.g. adverse weather, policy decisions in the airport scheduling phase, traffic demand variation, airport layout), the way traffic is managed has an effect on airspace users (time, fuel burn, costs), the utilisation of available capacity and the environment.

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.

4.2 Traffic evolution @ the top 30 European airports

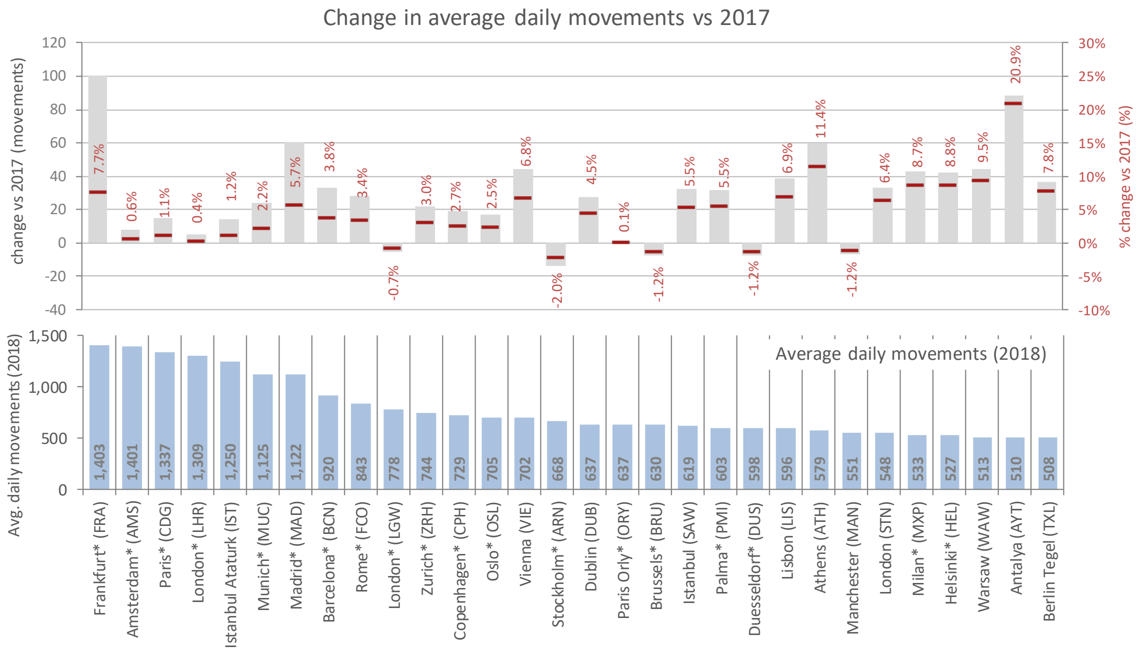
Average daily movements (arrival + departure) at the top 30 airports in 2018 increased by 3.6% compared to 2017, which corresponds to 828 additional movements each day.

13
of the top 30 airports reported a traffic growth above 5% compared to 2017

Figure 4-3 shows the evolution of average daily IFR movements at the top 30 airports in absolute and relative terms[16]. Antalya (AYT), with a significant traffic increase of +20.9% vs 2017 joins the top 30 while Geneva (GVA) is no longer among the top 30 airports in 2018.

Thirteen of the top 30 airports showed a traffic growth above 5% in 2018. Five airports reported a reduction in traffic levels in 2018: Stockholm (ARN), Brussels (BRU), Manchester (MAN), Düsseldorf (DUS) and London Gatwick (LGW).

Following the increase in declared capacity and associated traffic (+7.7% vs 2017), Frankfurt (FRA) replaced Amsterdam Schiphol (AMS) as the busiest airport in Europe, as the rate of traffic growth at Amsterdam decreased compared to previous years (+0.6% vs 2017).



** A-CDM implemented airport* Source: Network manager; PRC analysis

Figure 4-3: Traffic variation at the top 30 European airports (2018/2017)

The number of passengers at the top 30 airports in 2018 increased by 5.9% compared to the previous year. According to ACI Europe [18], the highest year-on-year passenger growth was observed at Antalya (+21.1%), followed by Warsaw (+12.8%), Milan Malpensa (+11.5%), Athens (+11.2%) and Vienna (+10.8%).

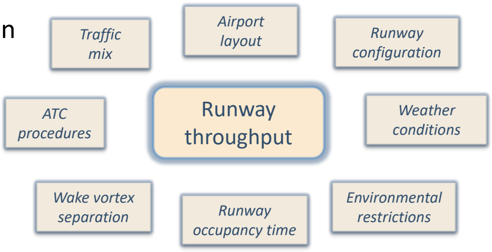
16 The ranking is based on IFR movements, which is different from commercial movements (ACI Europe statistics).

4.3 Capacity management (airports)

Airport capacity is one of the major constraints to future traffic growth in Europe. Some major European airports are already operating close to their maximum capacity throughout most of the day. If capacity decreases (due to exogenous events such as adverse weather, etc.) the impact on such airports becomes more severe in terms of operational inefficiencies.

Airport operations depend upon a number of factors which all affect airport and runway capacity to some degree. In addition to physical constraints, such as airport layout, there are "strategic" factors such as airport scheduling and "tactical" factors which include, inter alia, the sequencing of aircraft and the sustainability of throughput during specific weather conditions.

Safe operations of aircraft on the runway and in surrounding airspace is the dominant constraint of runway throughput. Airport layout and runway configuration, traffic mix, runway occupancy time of aircraft during take-off and landing, separation minima, wake vortex, ATC procedures, weather conditions and environmental restrictions - all affect the throughput at an airport.



A number of initiatives to further increase airport capacity including, inter alia, time based separation and improved wake vortex separation standards, are being implemented at a number of capacity-constrained airports across Europe.

It is acknowledged that the analysis in this section only provides a high-level indication of operations at the top 30 airports. This analysis does not allow direct comparisons to be made between those airports. A more detailed analysis would need to consider factors such as, inter alia, runway layout, mode of operation, and available runway configurations and societal factors such as noise and environmental policies.

In particular the runway layout and its operational configuration influences the airport runway system capacity. Dependent on the number of runways and their orientation, varying capacities apply. Accordingly, airports might be susceptible to degradation of the runway system capacity given operational constraints (e.g. prevailing wind conditions, specific noise abatement procedures, environmental constraints).

The PRC acknowledges that the aforementioned influencing factors need to be considered in a detailed assessment of the airport's capacity resilience.

Performance trade off - capacity vs noise @ airports

Noise emissions are generally recognised as the most significant environmental impact at airports. Noise levels are automatically monitored at many airports in compliance with the noise indicators and contour maps specified in the EU Environmental Noise Directive [28].

From a capacity management perspective, airports face the challenge of balancing the need for increased capacity with the need to limit negative effects on the population in the vicinity of the airport. This can include trade-offs between environmental restrictions when different flight paths reduce noise exposure but result in less efficient trajectories and hence increased emissions.

While ANS clearly has a role to play, the main influencing factors such as quieter engines, land use planning or political decisions are outside the control of ANS.

Noise management at airports is therefore generally considered to be a local issue with limited scope for ANS-related performance improvements.

Figure 4-4 compares the declared peak arrival capacities (brown bars) to actual throughput at the top 30 airports in 2018 (06:00-22:00 local time) to provide an understanding of the distribution of the arrival throughput.

The "peak service rate[17]" is used as a proxy to evaluate the peak throughput that can be achieved in ideal conditions and with a sufficient supply of demand. The box plots give an indication of the degree of dispersion of the arrival throughput at the airport. The wider the ranges, the more spread out the distribution of the arrival throughput.

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17 The peak service rate (or peak throughput) is a proxy for the operational airport capacity provided in ideal conditions. It is based on the cumulative distribution of the movements per hour, on a rolling basis of 5 minutes.

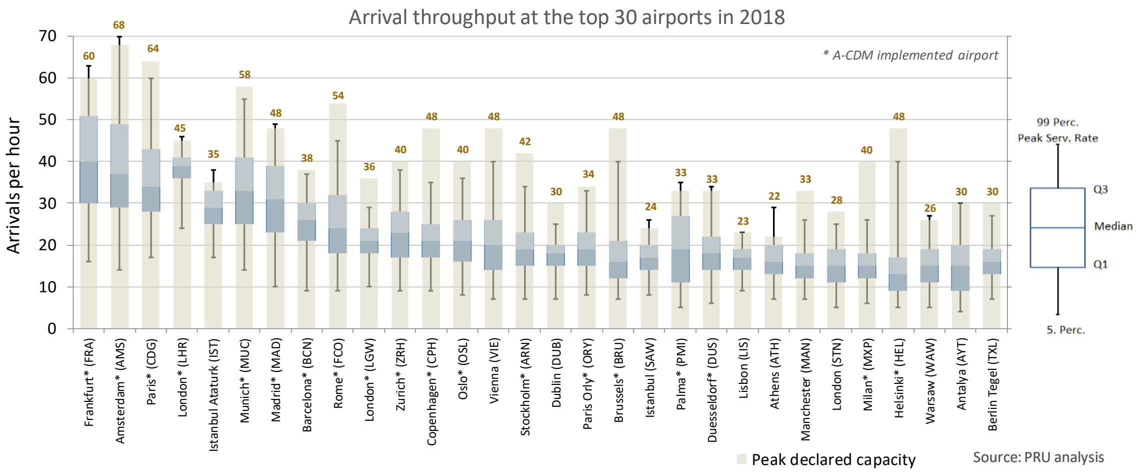


Figure 4-4: Arrival throughput at the top 30 airports (2018)

London Heathrow, both Istanbul airports and Lisbon show a comparatively narrow distribution with a compact interquartile range (blue box) relatively close to the declared peak arrival capacity, which suggests a constant high traffic demand throughout most of the day. A new airport in Lisbon has been agreed but it will not be operational until 2022 according to plans.

+100

extra daily movements at Frankfurt (FRA) airport on average in 2018

Figure 4-5 shows the historic evolution of the total hourly throughputs between 2008 and 2018 (median and peak service rate). The substantial growth of both Istanbul airports in terms of peak and median throughput over the past 10 years is clearly visible, although that growth slowed down in the last 5 years. The narrow gap between peak and median throughput indicates again a narrow distribution or a continuous operation close to the peak capacity.

Together with the Istanbul airports, Frankfurt showed the highest increase in peak throughput over the past few years while the median throughput remained stable. The opening of the new runway in 2011 (for arrivals only) allowed to accommodate higher arrival peaks which in turn help to reduce arrival ATFM delays. The declared peak arrival capacity has been updated in 2018 to 60 arrivals per hour (vs. 55 arrivals per hour in 2017) which enabled the airport to deal with 100 additional daily movements on average compared to 2017.

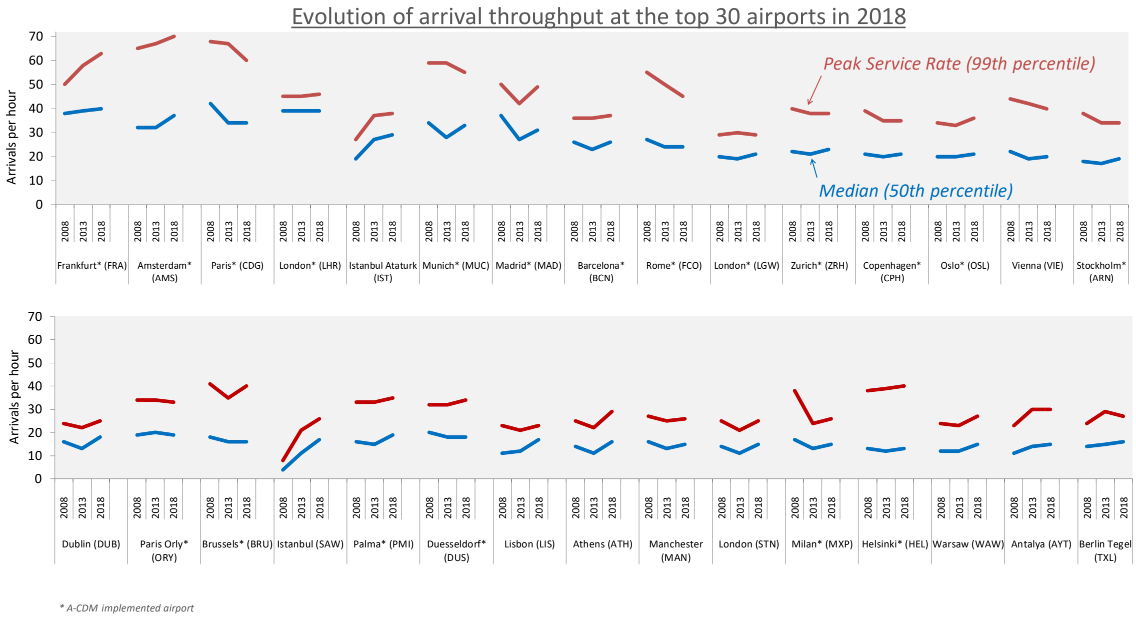


Figure 4-5: Evolution of hourly movements at the top 30 airports (2008-2018)

Where multiple airports serve major cities, the airports are often operating in close proximity to each other which add to complexity and which can also impact on ANS performance.

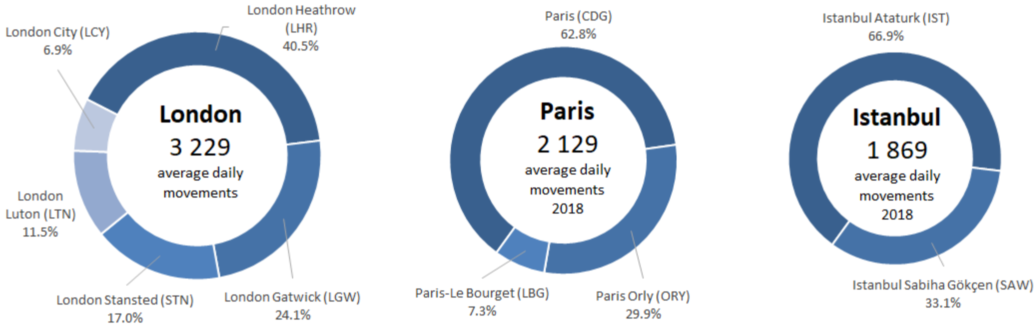


Figure 4-6: Movements at major European airport systems (2018)

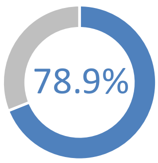
When all London airports are combined there were on average 3 229 daily movements reported for the airport system in 2018. This corresponds to 2.3 times the movements of Frankfurt (FRA) the busiest single airport in Europe in 2018.

Work is in progress to better address the local factors at airports (runway layout etc.) but also the wider operating environment as part of an airport system serving a city.

4.4 ANS-related operational efficiency at and around airports

4.4.1 Arrival flow management

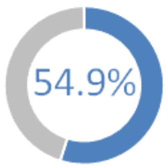
ANS-related inefficiencies on the arrival flow are measured in terms of arrival ATFM delay and additional time in the arrival sequencing and metering area (ASMA time). Whereas ATFM delays have an impact in terms of delay on the ground, additional ASMA time (airborne holdings) has also a direct impact in terms of fuel burn and emissions.



of all en-route ATFM delays in 2018 were generated between May and September

In 2018, the top 30 airports generated 78.7% of all airport arrival ATFM delay in the EUROCONTROL area.

Overall, 6.0% of the arrivals at the top 30 airports were delayed by airport ATFM regulations in 2018 which is 0.4% percentage points less than in 2017 but notably higher than the EUROCONTROL average (3.3% of arrivals). Different from the negative trend observed en-route, average airport ATFM delays at the top 30 European airports decreased from 1.24 to 1.13 minutes per arrival in 2018, driven by the significant reduction in arrival ATFM delays at Sabiha Gökçen Airport (SAW).



of airport arrival ATFM delays in 2018 were attributed to weather

Figure 4-7 shows the arrival ATFM delay (left of figure) and the additional ASMA time (right of figure) per arrival at the top 30 European airports in 2018.

The main reason for airport ATFM regulations in 2018 was adverse weather (54.9%) which increased by 2.9 percent points (pp) compared to 2017. The second largest category was airport capacity (29.8%) which decreased by 7.8 pp, again mainly due to the continued substantial improvement at Sabiha (SAW) since 2015.

Amsterdam Schiphol (AMS) airport also showed a significant year on year improvement in airport ATFM arrival delays with a reduction of 1.1 minutes per arrival in 2018.

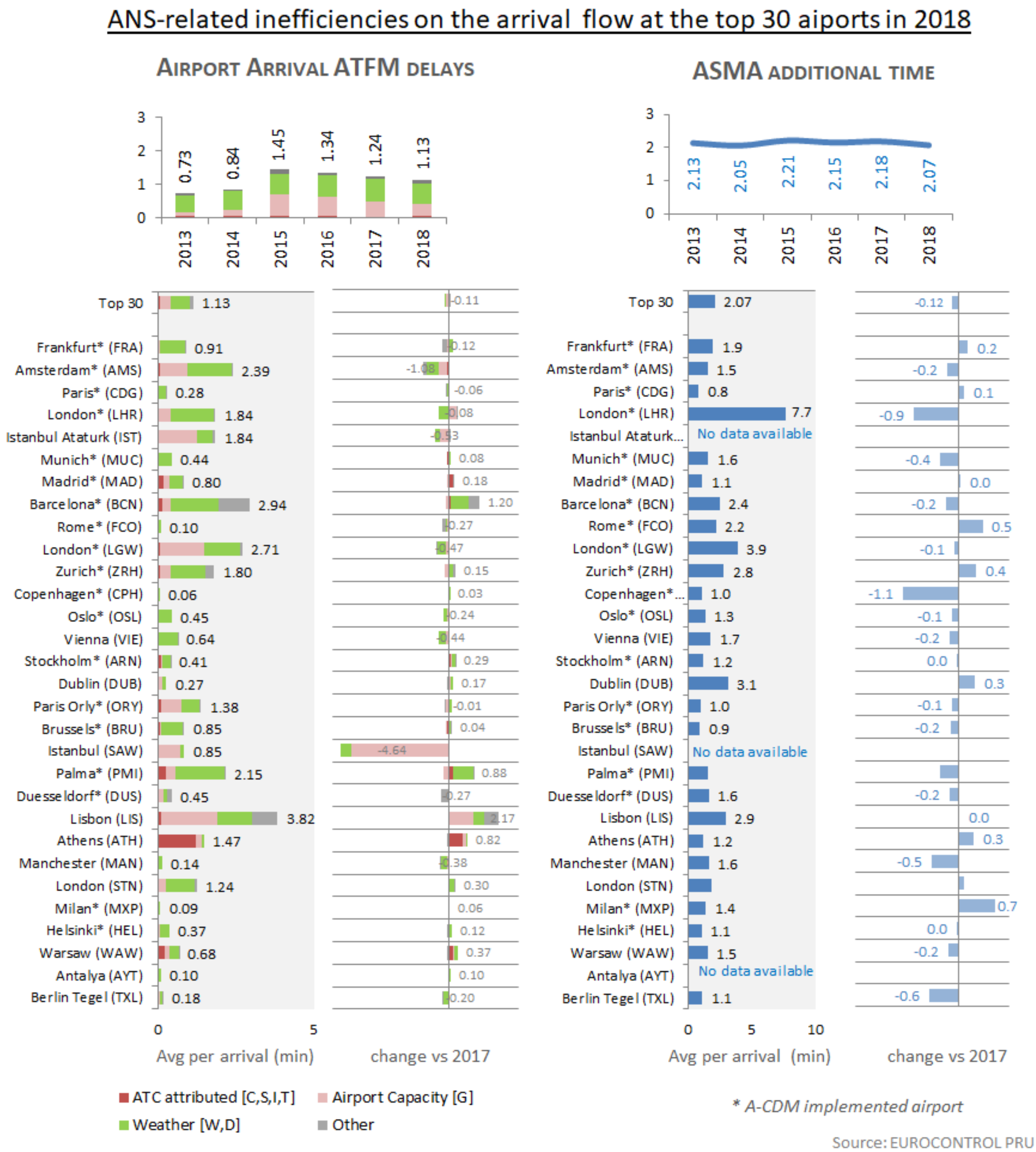


Figure 4-7: ANS-related inefficiencies on the arrival flow at the top 30 airports in 2018

On the other side, the already comparatively high airport arrival ATFM delays at Lisbon and Barcelona airports further increased in 2018 which was partly linked to substantial traffic growth in 2018. Due to the high continued traffic increase, Lisbon airport operates often close to its peak capacity which reduces the buffer for contingencies.

Average additional ASMA time (airborne holdings) at the top 30 airports in 2018 also decreased from 2.18 to 2.07 minutes per arrival. Copenhagen (CPH) showed the most notable improvement (-1.1 min vs 2017) in 2018. Despite a notable reduction of almost 1 minute in 2018, London Heathrow remained the airport with the highest average additional ASMA time in Europe (7.7 min per arrival), followed by London Gatwick (3.9 min) and Dublin (3.1 min). Lisbon does not show deterioration in the additional ASMA time, regardless of the increase in traffic and saturation level.

Figure 4-8 combines airport arrival ATFM delays and ASMA additional time in order to provide a combined view of ANS-related operational inefficiencies on the arrival flow (the bubble size relates to the combined impact per arrival).

London Heathrow (LHR) shows clearly the highest inefficiency on the arrival flow which is linked to the continuous high throughput close to the peak capacity and a deliberate decision taken during the airport scheduling process to maximise runway throughput.

In 2018, London Heathrow (LHR), London Gatwick (LGW) and Amsterdam (AMS) showed a notable improvement in the efficiency on the arrival flow.

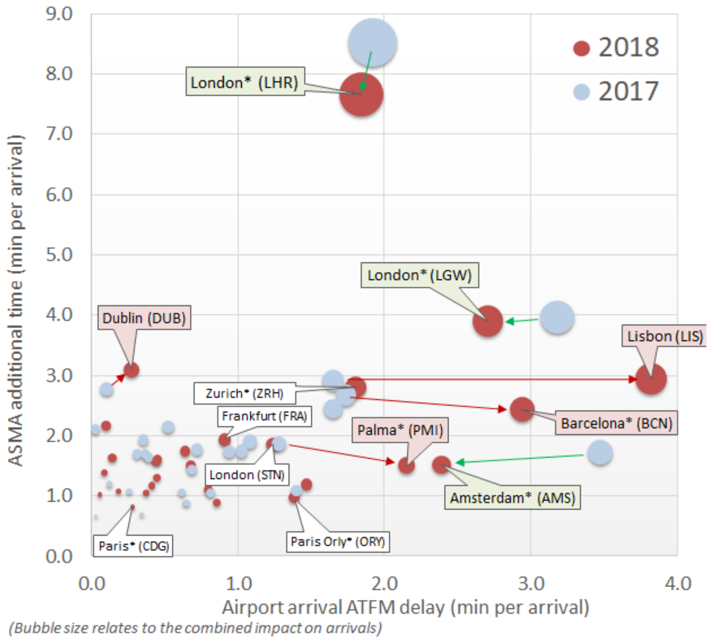


Figure 4-8: Evolution of ANS related operational inefficiencies on the arrival flow

London (LHR) shows clear benefits after the implementation in March 2018 of the "enhanced Time Based Separation" (eTBS) using the latest European Wake Vortex Reclassification (RECAT-EU) both for arrivals and departures.

A notable deterioration in the operational efficiency on the arrival flow was observed for Lisbon (LIS), Barcelona (BCN), Palma (PMI), and Dublin (DUB). The higher inefficiencies in 2018 need to be seen in the context of strong continued traffic growth at the aforementioned airports.

Regional Greek airports

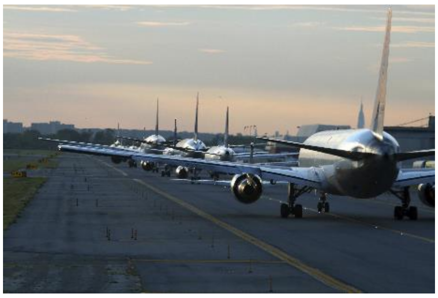
Together, eight regional Greek airports generated more airport ATFM delay than London Gatwick (LGW) in 2018

Although not included in the top 30 airports, the PRC has highlighted in previous reports the high airport ATFM delays at a number of Greek regional airports which have a notable impact on the network in summer.

In 2018, Mikonos, Santorini, Zakinthos, Khania, Heraklion, Kefallinia, Rodos and Kos airports taken together, accounted for 6.5% of all airport arrival ATFM delay in 2018 (402k minutes) which was more than the delay generated by London Gatwick in 2018.

There is a need to improve the performance at those airports which are all fully coordinated during summer in order to improve overall network predictability.

4.4.2 Departure flow management



This section analyses ANS-related operational 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 slot adherence improved further despite a significant increase in ATFM regulated departures in 2018

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). Adherence to ATFM slots helps to ensure that traffic does not exceed regulated capacity and increases overall traffic flow predictability.

Continuing the trend observed over the past 5 years, the share of ATFM regulated departures at the top 30 European airports increased further from 17.0% in 2017 to 24.5% in 2018 (brown bar).

Notwithstanding the higher number of ATFM regulated departures at the top 30 airports, the share of flights departing outside the ATFM slot tolerance window further decreased from 7.5% in 2017 to 6.5% in 2018 which is positive in terms of network predictability.

ATFM slot adherence at the top 30 airports (2018)

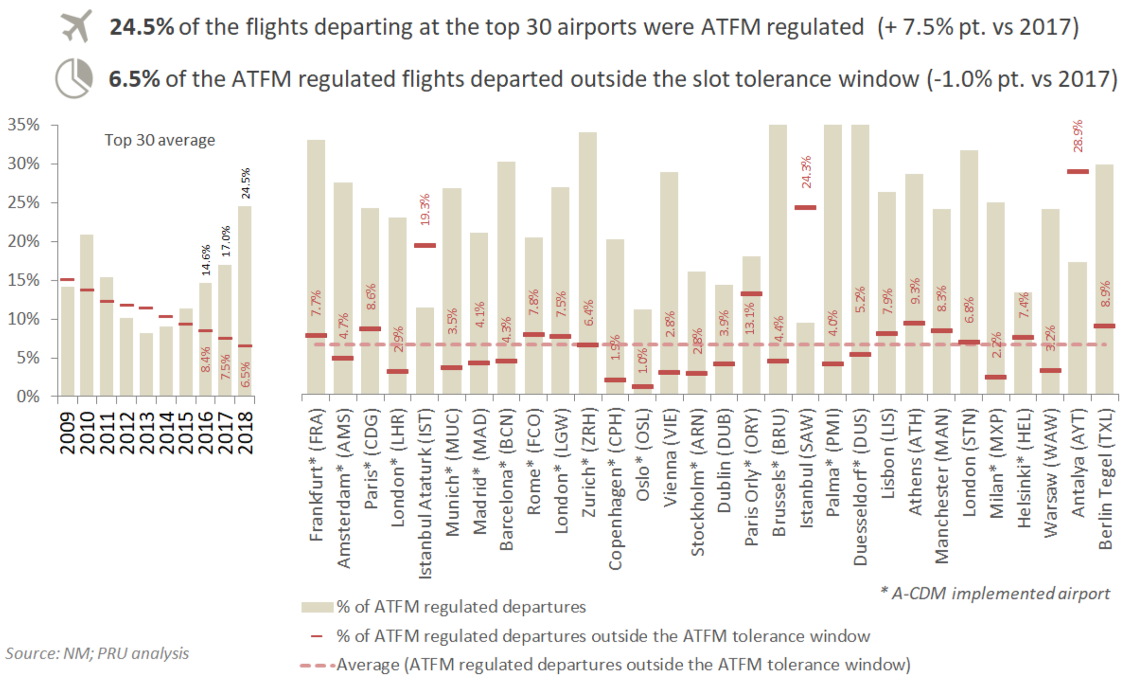


Figure 4-9: ATFM slot adherence at airport (2018)

ATFM slot adherence at Amsterdam Schiphol airport improved by **9.2 %** points following A-CDM implementation in May 2018

Although with a comparatively small share of ATFM regulated departures (due to a higher share of departures flying to EUROCONTROL's out of area airspace), the Turkish airports showed by far the highest share of departures outside the ATFM slot tolerance window in 2018. At the moment there are no clear plans about a possible A-CDM implementation at these airports that might improve the ATFM slot adherence.

After becoming the 28th full A-CDM airport in May 2018, ATFM slot adherence at Amsterdam Schiphol airport improved by 9.2 percent points which further increases the predictability and safety of the European network.

4.4.2.2 ANS-related inefficiencies on the departure flow

21

airports showed an increase in additional taxi out time in 2018

Figure 4-10 shows the local ATC departure delays (top of figure) and the taxi-out additional time at the top 30 airports in 2018. Different from the additional ASMA time, the average additional taxi-out time increased from 3.9 minutes in 2017 to 4.2 minutes per departure in 2018 (excluding the Turkish airports for which no data was available).

Overall, 21 of the 27 airports for which data was available reported an increase in additional taxi out time in 2018. The highest levels of average additional taxi-out times were observed at London (LHR), London (LGW), Rome (FCO), Dublin (DUB) and Barcelona (BCN) with the most notable year on year increase observed at Dublin (+1.7 min vs. 2017). Notable year on year improvements were observed at Manchester (MAN) and Amsterdam (AMS).

ANS-related inefficiencies on the departure flow at the top 30 aiports in 2018

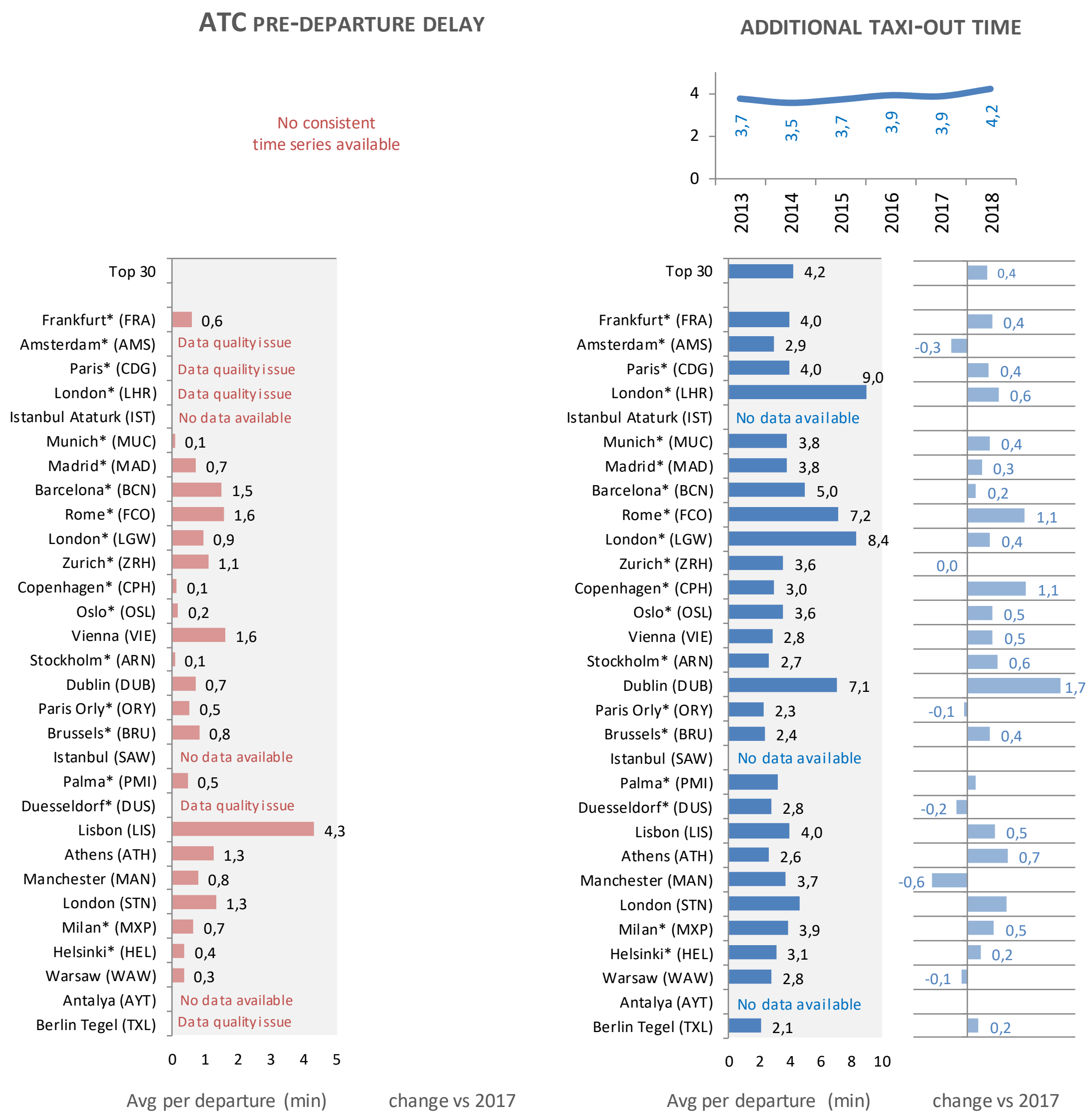
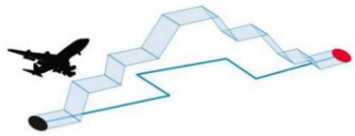


Figure 4-10: ANS-related inefficiencies on the departure flow at the top 30 airports in 2018

As can be seen on the left side of Figure 4-10, data for the computation of local ATC pre-departure delay is still either not available or does not reach the minimum quality threshold for a considerable number of the top 30 airports. The new EUROCONTROL specification for the collection of operational data at airports are expected to further help improving the data quality and coverage [19].

Similar to the efficiency changes on the arrival flow, Lisbon (LIS) and Barcelona (BCN) showed also a significant increase in local ATC departure delay in 2018, followed by Athens (ATH) and Vienna (VIE).

4.4.3 Vertical flight efficiency during climb and descent



Vertical flight efficiency during climb and descent is calculated by using a methodology developed by the PRC [20].

The methodology has been used for a number of case studies which were discussed with experts during the PRC's Vertical Flight Efficiency Workshop in November 2018. The contents and presentations are available for download on the event webpage [17]. Free tailored analyses for many European airports are available from the online reporting tool accessible through the ANS performance data portal.

Environmental impact

Reducing intermediate level-offs and diversions during climb and descent can save substantial amounts of fuel and CO_2 and also reduce noise levels in the vicinity of airports. The lower the level segment, the higher the additional fuel consumption.

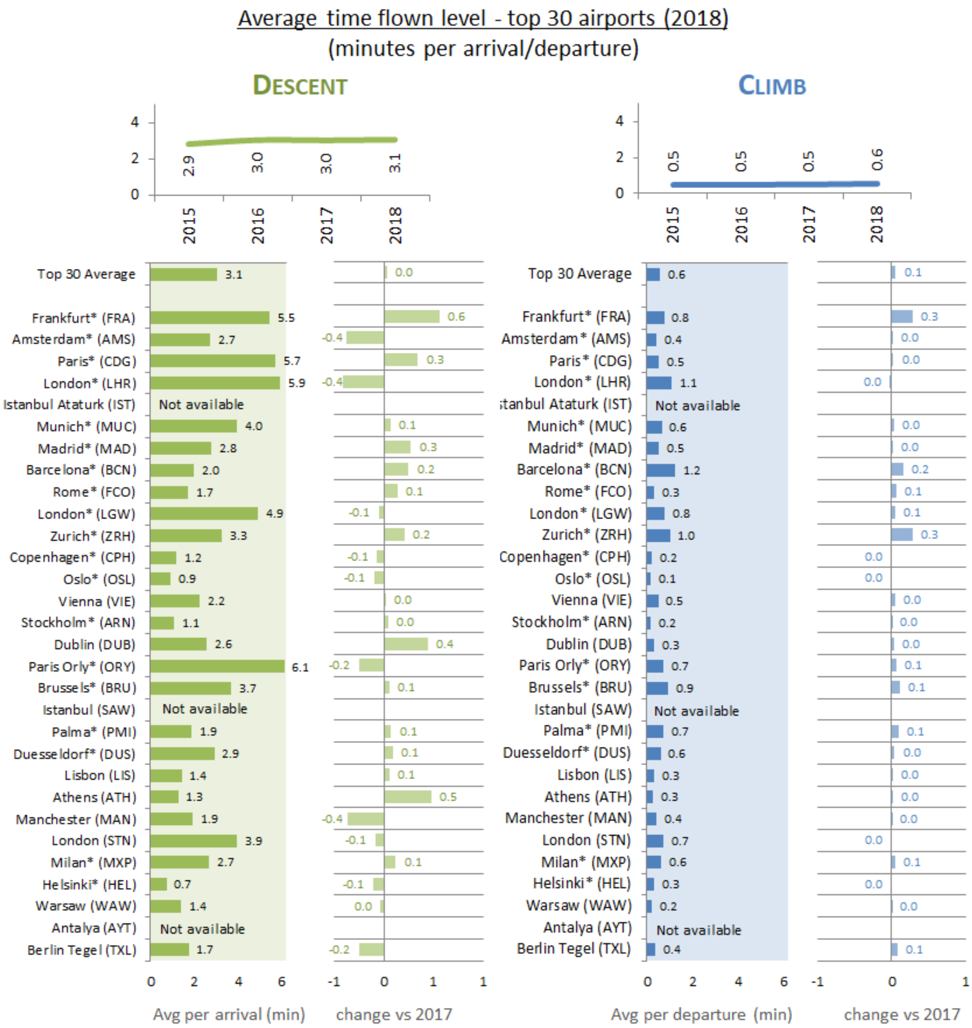
>5 min

level flight time at Frankfurt, London LHR and the two Paris airports during descent in 2018

Figure 4-11 shows the average time flown level per flight within a 200NM radius around the airport. Generally, climb-outs (right side) were less subject to level-offs than descents (left side).

On average, the time flown level during descent is around five times higher than the time flown level during climb. At system level average time flown level stays relatively constant over time with 3.1 minutes per arrival compared to 0.6 minutes per climb out.

Flights arriving at Frankfurt (FRA), Paris Charles de Gaulle (CDG), London Heathrow (LHR) and Paris Orly (ORY) showed the highest amounts of time flown level with more than 5 minutes of level flight on average in 2018.



Source: EUROCONTROL PRU

Figure 4-11: Average time flown level in descent/climb at the top 30 airports

Year on year, vertical flight efficiency during descent deteriorated at Frankfurt (FRA), Athens (ATH), and Dublin (DUB) in 2018. Notable efficiency improvements were observed at Amsterdam (AMS), London Heathrow (LHR) and Manchester (MAN).

Vertical flight efficiency during climb stayed quite stable in 2018 with slight increases at Frankfurt (FRA), Barcelona (BCN) and Zurich (ZRH).

Figure 4-12 shows the median altitudes at which continuous descent operations (CDO) started and at which continuous climb operations (CCO) ended versus the average time flown level per flight. The circles (climb) and triangles (descent) indicate the type of operation. Airports with good vertical flight efficiency results are located in the top left corner while efficiency deteriorates towards the bottom right corner of Figure 4-12.

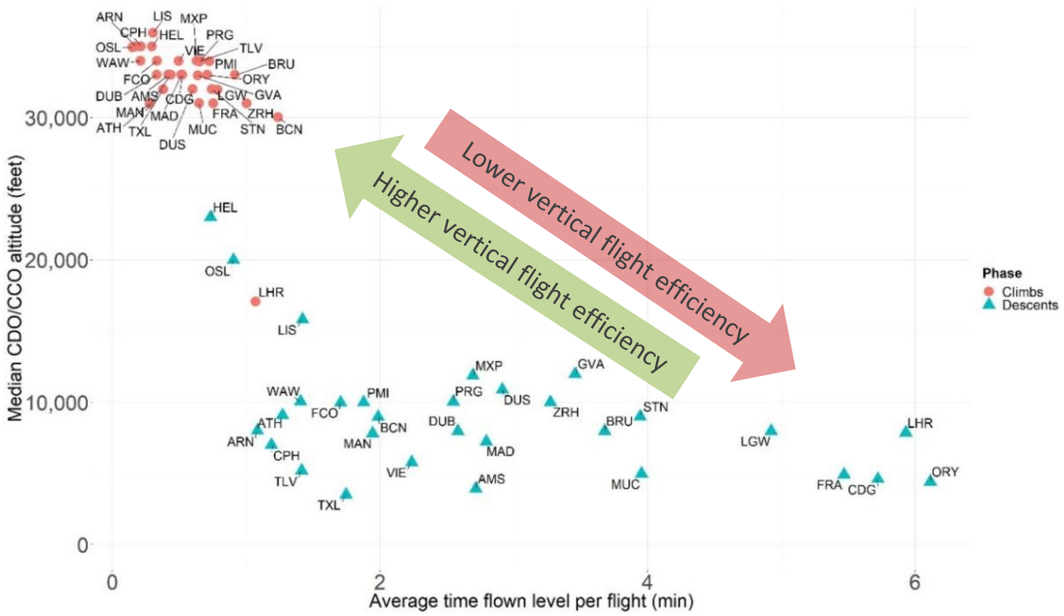


Figure 4-12: Median CDO/CCO altitude vs. Average time flown level per flight (2018)

As expected, the analysis of climb-outs shows that all airports but London Heathrow (LHR) are located in the top left corner confirming that vertical flight efficiency during the climb phase is good.

Vertical flight efficiency during descent at Helsinki (HEL) and Oslo (OSL) is clearly above average (close to the top left corner). Most other airports have a median CDO altitude below 10,000 feet which means that at least 50% of their flights start a continuous descent below this altitude. Paris Orly (ORY), London Heathrow (LHR), Paris Charles de Gaulle (CDG), Frankfurt (FRA) and London Gatwick (LGW) are the airports with the worst vertical flight efficiency results during the descent.

During the PRC workshop in November 2018, vertical flight efficiency (VFE) case studies for London Heathrow (LHR), Brussels (BRU) and Oslo (OSL) were presented and discussed with interested stakeholders. The following aspects were raised with a view to improving VFE at airports:

- Usually operational reasons are causing inefficiencies
- Local initiatives and tools (AMAN, Point Merge …) already exist to improve VFE
- ATC has to understand how aircraft want to fly. New tools and new aircraft can result in different flight profiles
- Improved and additional data could enhance the detection and assessment of level flight
- Information sharing between ATC and aircraft could be helpful
- Vectoring can make it more difficult to achieve CDO (unknown distance to touchdown)
- Airlines can face considerable (financial) penalties associated with constraints to vertical flight efficiency
- Impact of non-operational factors can be an enabler or impediment to improvement
- Perfect CDA is not defined - measuring everything that has actually happened in a consistent manner enables a stable reference which can be further investigated at local level

During the development of the case studies, it became also very clear that it is only possible to improve vertical flight efficiency considerably by having open discussions amongst all stakeholders. Knowing the needs of all stakeholders enables improving the situation for as many actors as possible.

4.5 Conclusions

Antalya (AYT) joined the top 30 airports in 2018, replacing Geneva (GVA). Controlled movements at the top 30 airports in the EUROCONTROL area (in terms of traffic) increased for the fifth consecutive year in 2018. Average daily movement increased by 3.6% compared to 2017 which is equivalent to 828 additional movements per day. Thirteen of the top 30 airports reported a traffic growth above 5% in 2018. Following the increase in declared capacity and associated traffic (+7.7% vs 2017), Frankfurt (FRA) replaced Amsterdam Schiphol (AMS) as the busiest airport in Europe.

The number of passengers at the top 30 airports in 2018 continued to increase at a higher rate than movements (+5.9% vs 2017). According to ACI Europe, the highest year-on-year passenger growth was observed at Antalya (+21.1%), followed by Warsaw (+12.8%), Milan Malpensa (+11.5%), Athens (+11.2%) and Vienna (+10.8%).

Notwithstanding the continued traffic growth, the level of inefficiencies on the arrival flow were reduced in 2018. Overall, 6.0% of the arrivals at the top 30 airports were delayed by airport ATFM regulations in 2018 which is 0.4% percentage points less than in 2017. Different from the negative trend observed en-route, average airport ATFM delays at the top 30 European airports decreased from 1.24 to 1.13 minutes per arrival in 2018, mainly driven by the significant reduction in arrival ATFM delays at Sabiha Gökçen Airport (SAW).

Average additional ASMA time (airborne holdings) at the top 30 airports in 2018 also decreased from 2.18 to 2.07 minutes per arrival. Although London Heathrow (LHR) remained the airport with by far the highest additional ASMA time (7.7 minutes per arrival), the overall reduction was mainly due to significant improvements at Heathrow (LHR) (reduction of almost 1 minute in 2018) following the implementation of the “enhanced Time Based Separation” (eTBS) in March 2018 and improvements at Copenhagen (CPH) airport.

The effects of congestion are observed across the top 30 airports in 2018 on the departure management with a general increase of the additional taxi-out times and ATC pre-departure delays.

The continued A-CDM implementation in Europe also proved to be an enabler for improved situation awareness and performance which further increases the predictability and safety of the European network. Notwithstanding a higher number of ATFM regulated flights in 2018, overall ATFM slot adherence at the top 30 airports improved further, also due to a significant improvement at Amsterdam Schiphol (AMS) airport after becoming the 28th full A-CDM airport in May 2018.

Vertical flight efficiency during climb and descent at the top 30 airports remained in 2018 at the same level as in 2017. On average, inefficiencies (expressed in average time flown level per flight) were more than 5 times higher in descent than in climb with notable differences by airport. Whereas vertical flight efficiency during descent at Helsinki (HEL) and Oslo (OSL) is clearly above average, the flights arriving at Frankfurt (FRA), Paris Charles de Gaulle (CDG), London Heathrow (LHR) and Paris Orly (ORY) showed the highest amounts of time flown level with more than 5 minutes of level flight on average in 2018.

Although the focus is presently on the en-route capacity crisis, the continued growth in demand combined with the lack of capacity at several European airports is likely to result in a substantial degradation of performance in the future, as observed at Lisbon (LIS) airport in 2018. According to the Challenges of Growth Report, this will be the situation for more and more airports in the top 30 in the future. While ANS has no direct influence on infrastructural measures such as new runways, it can help improve airport performance and capacity resilience through operational enablers (A-CDM, eTBS, CDO, RECAT-EU, etc.).

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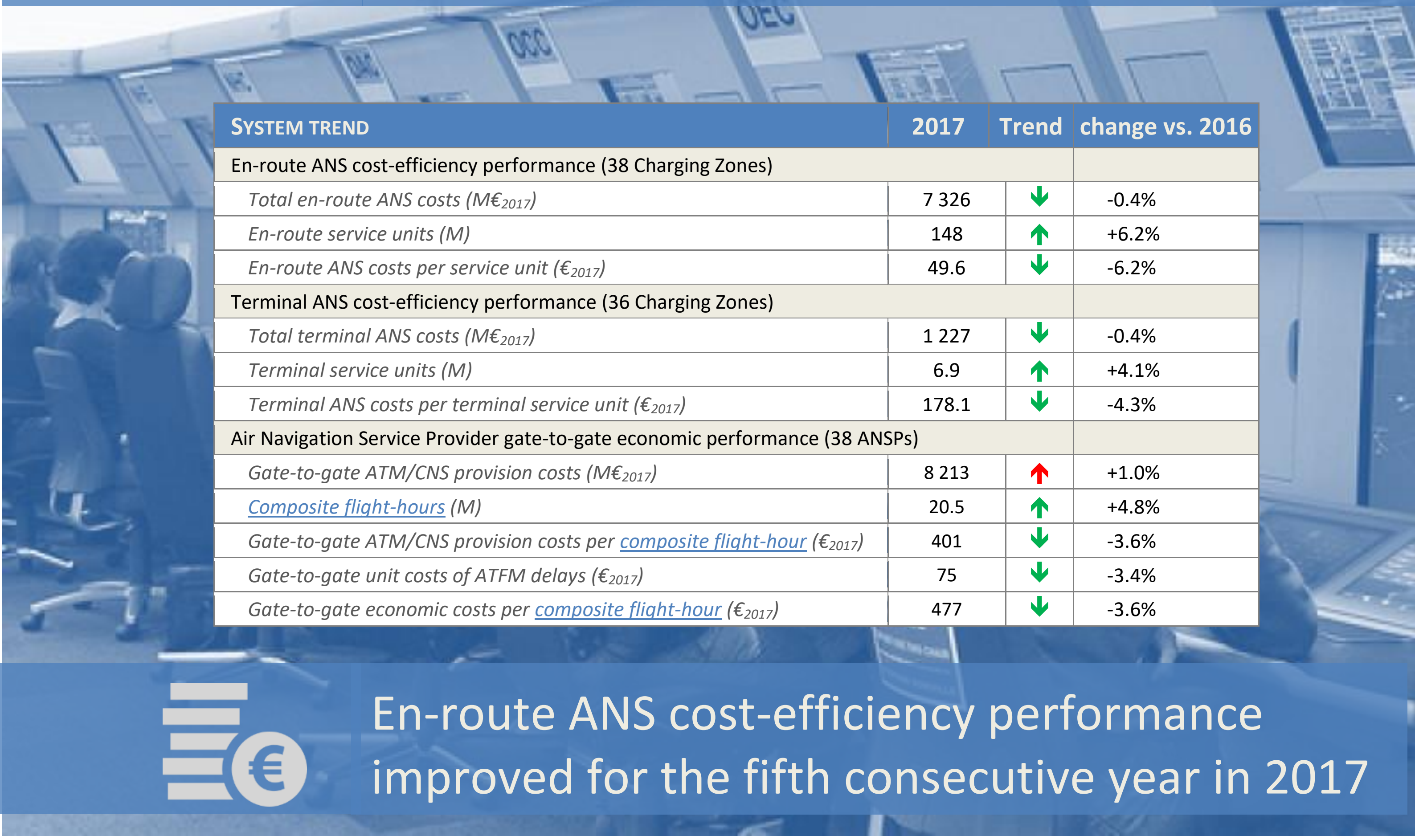
5 ANS Cost-efficiency (2017)



SYSTEM TREND	2017	Trend	change vs. 2016
En-route ANS cost-efficiency performance (38 Charging Zones)			
Total en-route ANS costs (M€$_{2017}$)	7 326	↓	-0.4%
En-route service units (M)	148	↑	+6.2%
En-route ANS costs per service unit (€$_{2017}$)	49.6	↓	-6.2%
Terminal ANS cost-efficiency performance (36 Charging Zones)			
Total terminal ANS costs (M€$_{2017}$)	1 227	↓	-0.4%
Terminal service units (M)	6.9	↑	+4.1%
Terminal ANS costs per terminal service unit (€$_{2017}$)	178.1	↓	-4.3%
Air Navigation Service Provider gate-to-gate economic performance (38 ANSPs)			
Gate-to-gate ATM/CNS provision costs (M€$_{2017}$)	8 213	↑	+1.0%
Composite flight-hours (M)	20.5	↑	+4.8%
Gate-to-gate ATM/CNS provision costs per composite flight-hour (€$_{2017}$)	401	↓	-3.6%
Gate-to-gate unit costs of ATFM delays (€$_{2017}$)	75	↓	-3.4%
Gate-to-gate economic costs per composite flight-hour (€$_{2017}$)	477	↓	-3.6%

En-route ANS cost-efficiency performance improved for the fifth consecutive year in 2017

5.1 Introduction

This chapter analyses ANS cost-efficiency performance in 2017 (i.e. the latest year for which actual financial data are available) and presents a performance outlook, where possible.

It provides a Pan-European view, covering 39 States[18] operating 38 en-route charging zones[19] 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 2017 has already been scrutinised in accordance with the SES Regulations and the results have been reflected in the Performance Review Body (PRB) 2017 monitoring report[20]. The PRC's annual PRR does not seek to duplicate this analysis nor assess performance against SES targets. Indeed, the focus in this PRR is on the changes in terms of cost-effectiveness performance from one year to another and not on the comparison of actual against planned performance as in the PRB reports. In addition, this chapter takes into account the SES data

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18 This is different from the 41 EUROCONTROL Member States in 2017 since: (1) Ukraine is a EUROCONTROL Member State which is not yet integrated into the Multilateral Agreement relating to Route Charges, and (2) Monaco en-route costs are included in the French cost-base.

19 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).

20 2017 Annual Monitoring Report is available online on EU SES Performance website

and aggregates it with the information provided by the non-SES States to present a Pan-European view. This year, this chapter also includes a long-term analysis of the changes in terms of en-route costs, service units and unit costs over the 2003-2017 period at Pan-European system level. This chapter also provides an outlook for the 2018-2019 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-efficiency within the SES area.

Finally, section 5.4 provides a factual benchmarking analysis of ANSPs' 2017 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.

Since the focus of this chapter is the analysis of cost-efficiency for the year 2017, the financial indicators presented in sections 5.2, 5.3 and 5.4 are expressed in Euro 2017.

Treatment of financial values for time series analysis in PRR

Presentation and comparison of historical series of financial data from different countries poses problems, especially when different currencies are involved, and inflation rates differ. There is a danger that time-series comparisons can be distorted by variations in exchange rates.

For this reason, the financial elements of performance are assessed, for each year, in national currency. They are then converted to national currency in 2017 prices using national inflation rates. Finally, for comparison purposes in 2017, all national currencies are converted to Euros using the 2017 exchange rate. Hence, the financial figures in this report are not directly comparable to the ones published in the PRR 2017 (i.e. expressed in EUR 2016).

This treatment is applied consistently throughout Chapter 5 for en-route, terminal and gate-to-gate ANS.

5.2 En-route ANS cost-efficiency performance

The analysis of en-route ANS cost-efficiency in this section refers to the 38 en-route charging zones which were part of EUROCONTROL's Route Charges System in 2017 (with the exception of Portugal Santa Maria).

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 [21] aiming at incentivising economic performance and driving cost-efficiency improvements.

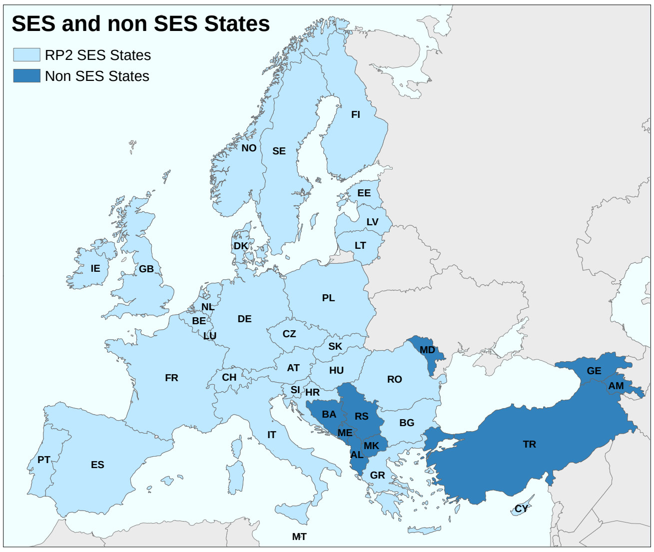


Figure 5-1: SES and non-SES States

The "non-SES States" refer to nine States which are not bound by SES regulations but which were part of the EUROCONTROL Multilateral Route Charges System in 2017 (i.e. Albania, Armenia, Bosnia-Herzegovina, Georgia, Moldova, North Macedonia, Serbia, Montenegro and Turkey). For these nine States, the "full cost-recovery method" applied in 2017.

5.2.1 Long-term trends in en-route cost-efficiency performance at Pan-European system level

The analysis presented in this sub-section focuses on the 30 en-route charging zones[21], for which consistent data on en-route costs[22] and en-route total service units (TSUs) is available over the period from 2003 to 2017.

-33%

reduction of en-route ANS unit costs between 2003 and 2017

Figure 5-2 below shows the long-term trends in terms of en-route costs, en-route service units and en-route costs per TSU between 2003 and 2017. Over the whole period, en-route TSUs grew much faster (+3.5% p.a.) than en-route costs (+0.6% p.a.). As a result, the en-route costs per TSU decreased by -2.8% p.a. between 2003 and 2017 (or -33.1% over the entire period).

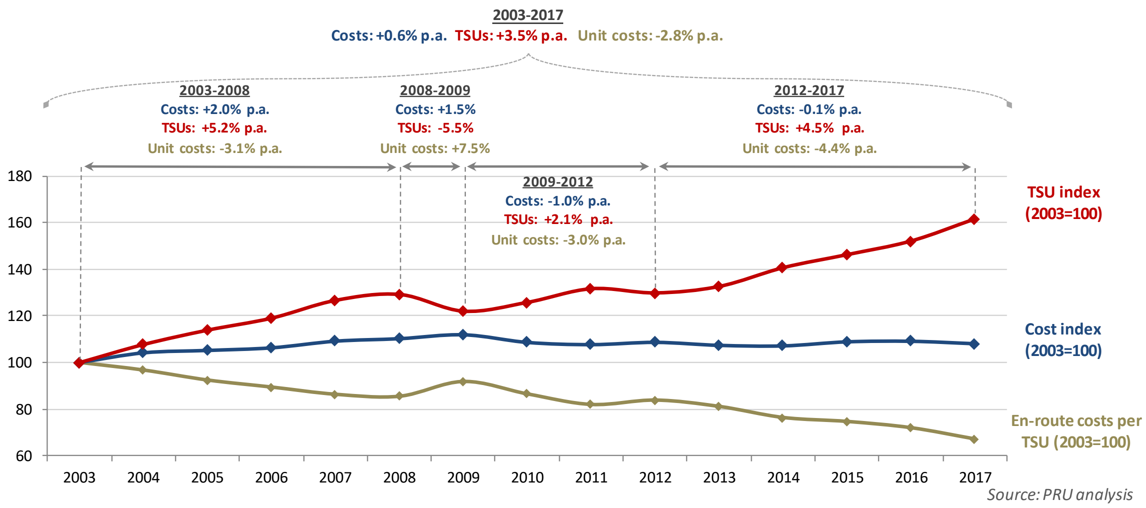


Figure 5-2: Long-term trends in en-route ANS cost-efficiency (€2017)

Figure 5-2 also shows that these average changes mask different trends and cycles over the 15-year period. Between 2003 and 2008, the robust growth in TSUs (+5.2% p.a.) outpaced the growth of en-route costs (+2.0% p.a.). This period, characterised by sustained traffic growth, resulted in continuously reducing en-route unit costs (-3.1% p.a.).

In 2009, the adverse effects of the economic recession impacted the aviation industry resulting in a -5.5% drop in TSUs, compared to 2008. In the meantime, the en-route cost-base continued to grow (+1.5%) reflecting the rigidity of the ATM industry to adjust costs downwards in the short-term. As a result, the en-route unit costs increased by +7.5% in 2009, effectively cancelling out a significant part of the en-route cost-efficiency improvements achieved since 2003.

From 2010 onwards, in response to the traffic downturn, several States implemented cost containment measures, which contributed to the -3.0% p.a. decrease in en-route unit costs observed over the 2009-2012 period. This performance improvement reflects decreasing cost-bases (-1.0% p.a.) in a context of TSU growth (+2.1% p.a.). This indicates that, as a whole, the ATM system was reactive and showed flexibility to adjust to external shocks.

Figure 5-2 shows that substantial performance improvements were achieved over the 2012-2017 period since en-route costs remained fairly constant (-0.1% p.a.) while TSUs rose by +4.5% p.a. leading to a significant reduction of en-route unit costs (-4.4% p.a.). This should be seen in the light of (a) the cost-containment measures initiated in 2009-2010 which continued to generate savings years after their implementation, and (b) for the States operating under SES regulations, the

[21] Consistent time-series is not available for Armenia, Bosnia-Herzegovina, Estonia, Georgia, Latvia, Lithuania, Poland and Serbia and Montenegro en-route charging zones. These States are therefore excluded from the long-term analysis presented in this chapter.

[22] Due to data availability, the en-route cost data presented in the long-term analysis also includes costs for exempted VFR flights. This presentation differs from that in the remainder of this chapter, which focuses on en-route costs excluding the costs for exempted VFR flights.

implementation of the Performance Scheme and the incentive mechanism embedded in the charging scheme which contributed to maintain a downward pressure on costs during the regulatory Reference Periods.

The analysis provided in the sub-section below focuses on the 2012-2017 period and highlights the observed differences in en-route cost-efficiency performance between the SES and non-SES States.

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

The analysis presented in this sub-section focuses on the 37 en-route Charging Zones that consistently provided en-route costs data over the 2012-2017 period[23]. For this reason, the figures reported in Figure 5-3 differ from the data presented in Figure 5-2 which relate to the 30 Charging Zones that provided data on en-route costs and TSUs since 2003.

Figure 5-3 shows that in 2017, at Pan-European level, TSUs continued growing (+6.2%) in the context of slightly reducing en-route ANS costs (-0.4%). As a result, en-route unit costs decreased by -6.2% compared to 2016. This is the fifth consecutive year of reducing en-route unit costs at Pan-European system level (-19.2% overall compared to 2012).

	2012 (37 CZs)	2013 (37 CZs)	2014 (38 CZs)	2015 (38 CZs)	2016 (38 CZs)	2017 (38 CZs)	2017 vs 2016 (38 CZs)	2012-17 CAGR (37 CZs)
Total en-route ANS costs (M€2017)	**7 283**	**7 188**	**7 226**	**7 333**	**7 357**	**7 326**	**-0.4%**	**0.1%**
SES States (EU-28+2)	6 867	6 762	6 747	6 828	6 805	6 746	-0.9%	-0.4%
Other 9 States in the Route Charges System	416	426	479	506	552	580	5.1%	6.2%
Total en-route service units (M TSUs)	**118**	**121**	**129**	**134**	**139**	**148**	**6.2%**	**4.4%**
SES States (EU-28+2)	105	107	112	115	120	127	5.6%	3.8%
Other 9 States in the Route Charges System	13	14	17	19	19	21	10.2%	8.8%
En-route real unit cost per TSU (€2017)	**61.5**	**59.5**	**56.2**	**54.8**	**52.9**	**49.6**	**-6.2%**	**-4.2%**
SES States (EU-28+2)	65.3	63.3	60.5	59.4	56.6	53.2	-6.1%	-4.0%
Other 9 States in the Route Charges System	31.5	30.5	28.0	26.9	29.0	27.7	-4.6%	-2.5%

Figure 5-3: Real en-route unit costs per TSU for EUROCONTROL Area (€$_{2017}$)

Between 2012 and 2017, en-route unit costs reduced by -4.2% p.a., on average. This is a result of continuous TSU growth over the entire period (+4.4% p.a.), while the en-route costs remained fairly constant (+0.1% p.a.).

Figure 5-4 shows that en-route unit costs significantly reduced for SES States (-4.0% p.a.) over the 2012-2017 period. This was achieved by slightly reducing costs (-0.4% p.a.) in the context of TSU growth (+3.8% p.a.).

This average en-route unit costs decrease is significantly affected by the notable reduction observed for the year 2017 (-6.1%), which results from a +5.6% increase in TSUs, while costs slightly decreased (-0.9%).

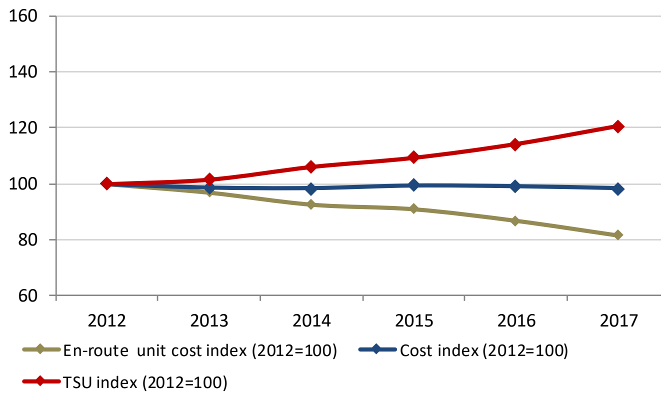


Figure 5-4: Trends in en-route costs, TSUs and unit costs for SES States

Detailed analysis shows that the TSU growth observed in 2017 is mainly driven by four CZs, including United Kingdom (+8.2%), Spain Continental (+7.0%), Germany (+6.0%) and France (+4.9%). It is

[23] Details on the changes in scope and the impact of adjustments implemented on the historical cost efficiency data, in particular for the Croatian and Hungarian en-route charging zones, are provided on pg. 52-53 of PRR 2016 [24]. In addition, it should be noted that Georgia, which started to provide actual en-route costs data as of 2014, is not included in the trend analysis for the years 2012-2017 presented in this section. On the other hand, Georgia data is reflected in analysis of changes between 2016 and 2017.

noteworthy that three of these CZs managed to absorb the TSU growth while also reducing their en-route cost-bases (Germany (-11.5%), United Kingdom (-3.5%) and Spain Continental (-2.5%)).

When interpreting this result, it is important to note that Germany reported negative components in its 2016 and 2017 en-route cost-bases (some -50 M€$_{2017}$ for each year), mostly reflecting a contribution of the German State in DFS equity. It should also be noted, that as of 2017, part of the administrative and regulatory costs including EUROCONTROL contribution to Part I of the budget (some 43 M€$_{2017}$) is now financed by the Ministry of Transport and therefore are no longer included in the en-route cost-base for Germany. While these two elements allow to significantly reduce the unit rate charged to airspace users, they affect the trend analysis of cost-efficiency performance for Germany and the Pan-European system. Should these two items be taken into account in this analysis, the 2017 en-route costs for SES States would be +0.2% higher than in 2012 (instead of -1.8% lower).

Figure 5-5 indicates that en-route unit costs also decreased for non-SES States (-2.5% p.a.) over the 2012-2017 period. This is primarily the result of a substantial TSU growth (+8.8% p.a.), while costs rose by +6.2% p.a. over the period.

In 2017, en-route unit costs for non-SES States reduced by -4.6% compared to previous year, primarily resulting from a significant growth in TSUs (+10.2%).

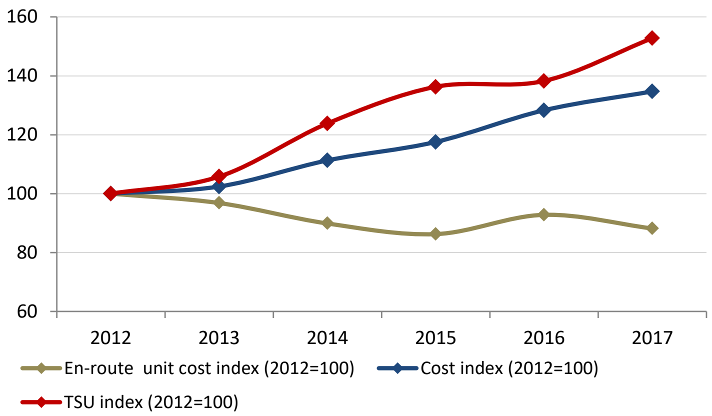


Figure 5-5: Trends in en-route costs, TSUs and unit costs for non-SES States

It should also be noted that in 2017, TSUs grew for all the non-SES States. This was particularly the case for Armenia (+60.1%) and Moldova (+15.3%), which returned to growth for the first time following a prolonged period of traffic downturn.

Detailed changes in en-route unit costs at a State level are analysed in the sub-section below.

5.2.3 Breakdown of en-route costs by type

As shown in Figure 5-6, en-route costs in 2017 can be broken down into the following main components:

- Staff costs – the largest category representing some 59% of the en-route cost-base;
- The second largest category, other operating costs account for 23% of the total;
- Capital-related costs which represent 18% of total en-route costs can be further broken down into depreciation (12%) and cost of capital (6%);
- Finally, exceptional costs recorded in 2017 are negative and represent less than 0.1% of total costs.

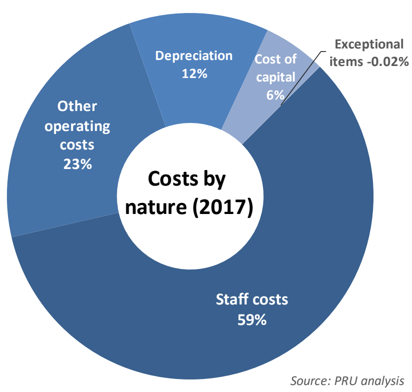


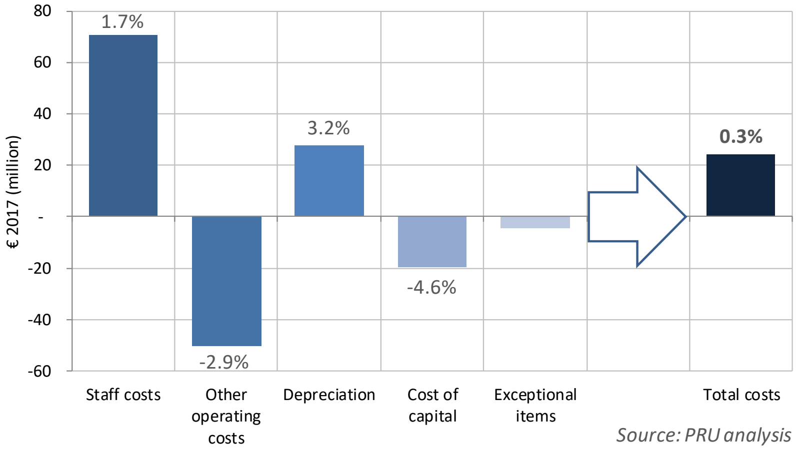
Figure 5-6: Breakdown of en-route costs by type

Figure 5-7 shows how the costs associated to these different categories changed over the 2012-2017 period. Over the 2012-2017 period, the en-route costs slightly rose (+0.3%, or +24.2 $M€_{2017}$) since higher staff costs (+1.7%, or +70.5 $M€_{2017}$) and depreciation costs (+3.2%, or +27.5 $M€_{2017}$) were almost compensated by lower other operating costs (-2.9%, or -50.1 $M€_{2017}$) and the cost of capital (-4.6%, or -19.3 $M€_{2017}$).

As shown in Figure 5-6 above, staff costs is the largest component of en-route ANS costs (59%).

These costs can be significantly affected by the level of contributions made by ANSPs into the States and the occupational pension schemes offered to their employees.

For this reason, the PRC commissioned a study [22] providing a factual description of the pension schemes to which ANSPs contribute, looking at the trends in the level of contributions and identifying possible risks over the coming years.



Source: PRU analysis

Figure 5-7: Breakdown of changes in en-route cost categories between 2012 and 2017 ($€_{2017}$)

The study showed that the pension costs incurred by ANSPs rose by almost +25% between 2010 and 2016, despite a decrease in the number of staff, and represented some 12.5% of total ANSP costs in 2016. Pension costs per employee also tend to be relatively high for ANSPs contributing to defined benefit schemes, and the study found that some of these ANSPs have already taken measures to reduce their exposure to defined benefit risks, for example by transitioning to defined contribution schemes. Depending on the situation of individual ANSPs, increasing pension liabilities could become a significant issue in the future which should be monitored locally. The pension study report is available on the PRC website.

5.2.4 Actual en-route unit costs at charging zone level

Figure 5-8 shows the level of en-route unit costs[24] for each individual charging zone in 2017. En-route unit costs ranged from 97.4 $€_{2017}$ for Switzerland to 22.3 $€_{2017}$ for Malta, a factor of more than four between these two charging zones. It is important to recognise the effect of currency exchange rate fluctuations, in particular for CZs which are outside the Euro zone. Substantial changes of the national currency against the Euro may significantly affect the level of en-route unit costs when expressed in Euros[25].

[24] The actual unit costs reflected in Figure 5-8 only refer to the ratio of actual en-route costs and TSUs recorded for 2017 and should not be confused with chargeable unit rate since the under and over recoveries stemming from previous years are not considered in this graph.

[25] This is for example the case of Switzerland which experienced a significant appreciation of Swiss Franc vis-à-vis the Euro in 2015. The Swiss en-route unit costs would amount to some 89.1 € in 2017 (instead of 97.4 €), assuming that the Swiss Franc had remained at its 2014 level. Further details on the variations in exchange rates can be found in Annex 7 of the ACE 2017 Report [29].

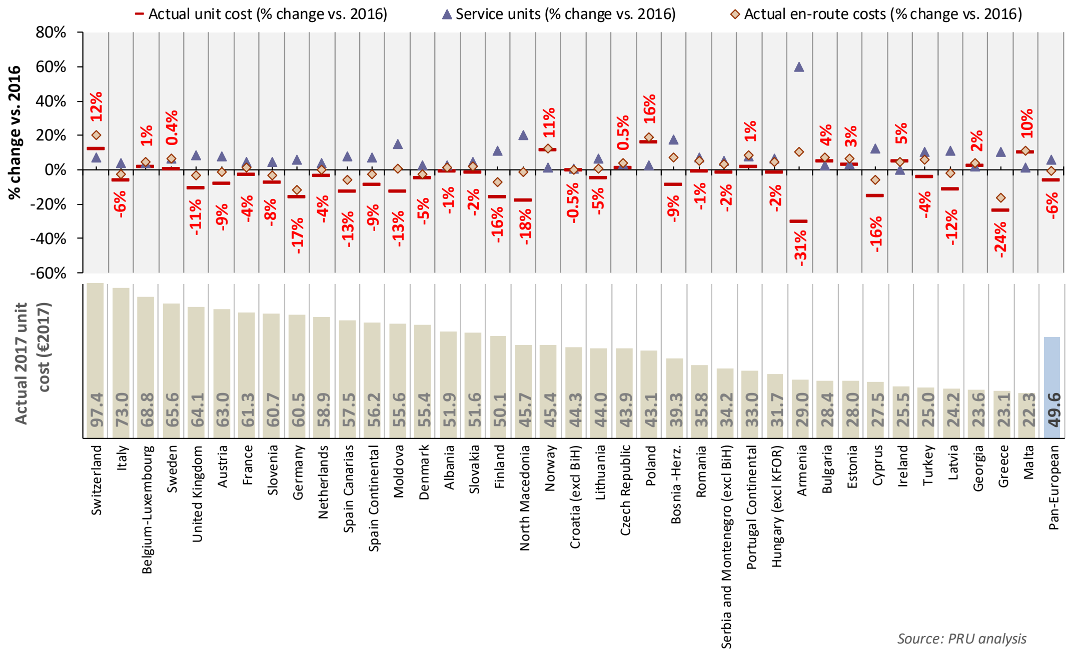


Figure 5-8: 2017 Real en-route ANS costs per TSU by charging zone (€2017)

Figure 5-8 also presents the changes in en-route unit costs, TSUs and costs compared to 2016. In 2017, en-route unit costs increased for 12 en-route CZs out of the 38 included in the analysis. For four charging zones, en-route unit costs rose by more than +5% in 2017. This includes Poland (+15.7%), Switzerland (+12.0%), Norway (+11.3%) and Malta (+10.0%). For these States, the increase in unit costs is mainly due to a significant increase of en-route costs in 2017 which is understood to result from:

- For Poland: +29.4 M€$_{2017}$ (+18.8%) mainly driven by an increase in staff costs (+18.9%), mostly due to increases for the Polish ANSP – PANSA reflecting the revision of Baltic FAB RP2 Performance Plan in the en-route cost efficiency area. Furthermore, it is understood that the implementation of PANSA investment plan, as included in the revised RP2 Performance Plan, led to an increase in the net book value of fixed assets and higher depreciation costs (+17.6%). Similarly, the increase in asset base combined with the use of a higher rate of return on equity resulted in an increase in cost of capital (+55.7%) in 2017.
- For Switzerland: +26.4 M€$_{2017}$ (+19.3%) primarily resulting from higher staff costs (+28.5%) which reflect a one-off payment relating to the occupational pension scheme made by Skyguide following a change in actuarial assumptions.
- For Norway: +12.9 M€$_{2017}$ (+12.7%) is driven by an increase in staff costs (+21.6%) which is mainly associated with the transfer of pension obligations from the Norwegian State to the ANSP (Avinor).
- For Malta: +2.1 M€$_{2017}$ (+11.3%) is due to an increase in staff costs (+12.0%), mainly resulting from unplanned overtime payments to operational staff in order to cope with additional traffic, and an increase in other operating costs (+20.8%).

On the other hand, Figure 5-8 indicates that for 6 CZs, en-route unit costs decreased by more than -15% in 2017, with substantial unit costs reductions observed for Armenia (-30.8%), Greece (-23.9%), North Macedonia (-18.1%), Germany (-16.6%), Finland (-16.3%) and Cyprus (-15.8%). For most of these CZs, the unit costs reduction reflects the combination of lower en-route costs and higher TSUs.

This is different for Armenia, for which the substantial TSU growth (+60.1%) more than compensated for the +10.8% increase in en-route costs and marked the end of the continuous reduction in TSUs observed over the past five years. Similarly, for Moldova the TSUs also increased (+15.3%) for the first time since 2013 resulting in a -12.7% decrease of en-route unit costs. It is noteworthy that the downturn in TSUs experienced by these States in the previous years was a result of changes in traffic flows following the establishment of restricted/prohibited areas in the Ukrainian airspace. On the other hand, the TSU increase in 2017 for these States mostly reflects an increase of the flights between the Russian Federation and the Pan-European area (Turkey in particular).

In the case of Greece, it is understood that the sizeable reduction in the en-route cost base (-16.1%) observed in 2017 mainly reflects the changes in accounting procedures applicable to its ANSP. As part of these changes, some costs that previously would have been reported in 2017 are expected to be reflected in the 2019 cost-base. At the same time, the cost reduction for Germany (-11.5%) should be seen in the light of the changes made to the German en-route cost-base in 2017 including the contribution from the State (see p. 58 above).

5.2.5 Pan-European en-route cost-efficiency outlook for 2018-2019

The objective of this sub-section is to provide information on planned changes in en-route unit costs at Pan-European system level for the period 2018-2019. It is based on data reported by EUROCONTROL Member States in the en-route reporting tables submitted in November 2018 in the context of the Enlarged Committee for Route Charges[26].

Overall, at Pan-European level, en-route unit costs are expected to increase by +0.7% per year, on average, between 2017 and 2019. This reflects the fact that over this period en-route costs are planned to increase faster (+1.3% p.a.) than TSUs (+0.6% p.a.).

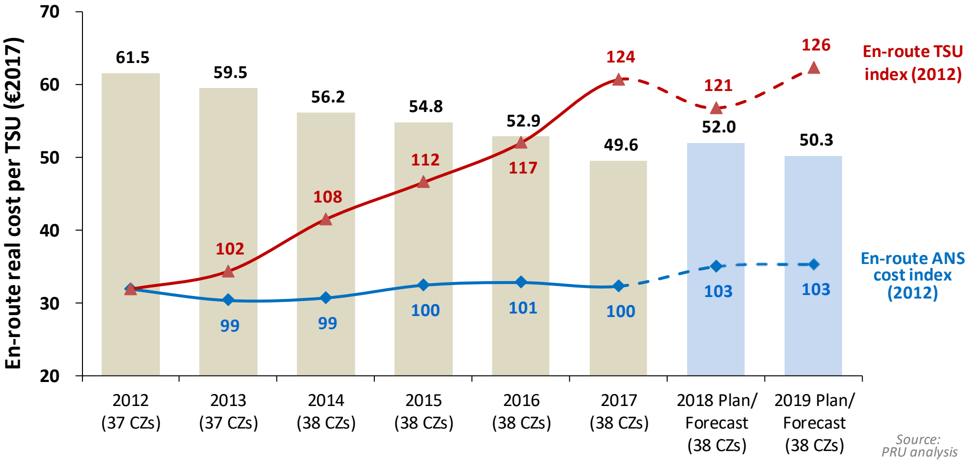


Figure 5-9: Pan-European en-route cost-efficiency outlook 2017-2019 (€$_{2017}$)

Figure 5-9 shows that in 2019, average en-route unit cost at Pan-European level[27] are expected to amount to 50.3 €$_{2017}$, some -18.1% lower than in 2012. If these plans materialise, this remarkable cost-efficiency performance improvement will be achieved by maintaining the cost-base mostly stable (+0.4% p.a.) in the context of a +3.3% annual TSU increase over the period.

It is important to note that the apparent decrease of en-route TSUs shown in Figure 5-9 above for the year 2018 (-2.6%) is mainly due to the fact that, for States bound by SES regulations, the planned data reported for the years 2018-2019 reflect the determined TSU figures provided in the RP2 Performance Plans which are not updated on a yearly basis. Actual data [4] shows that 2018 TSUs are +6.2% higher than in 2017 indicating that, all else being equal, the Pan-European system actual en-route unit costs for the years 2018 and 2019 are likely to be substantially lower than the figures shown in Figure 5-9 (52.0 €$_{2017}$ and 50.3 €$_{2017}$).

26 It is noted that the European Commission has approved the revisions of RP2 en-route cost-efficiency targets for the years 2018-2019 requested by Portugal and Romania [30]. For these States, the information used in Figure 5-9 reflects the adopted en-route cost-efficiency revisions as provided in the November 2018 Reporting Tables.

27 Note that Georgia, which started to provide data in 2014, is included from the year 2014 onwards in Figure 5-9 above.

5.3 Terminal ANS cost-efficiency performance

The analysis of terminal ANS cost-efficiency in this section refers to the SES States (see Figure 5-10) which are required to provide terminal ANS costs and unit rates information in accordance with EU legislation [21]. As detailed in section 5.1, the financial figures are expressed in Euro 2017 throughout this analysis. 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 38 Terminal Charging Zones (TCZs), generally one per State, but two for Italy, UK, Poland[28] and France, and five for Belgium.

2017 is the third year for which the "determined costs" method is applied for terminal ANS.

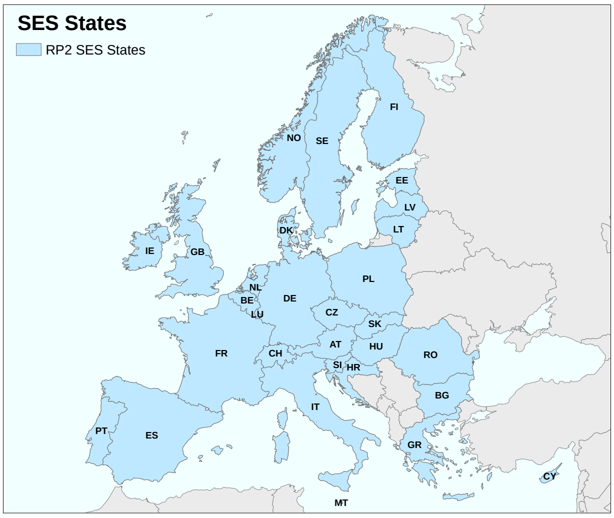


Figure 5-10: Geographical scope of terminal ANS cost-efficiency analysis

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 [23], 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.

This analysis includes 36 TCZs comprising 165 airports. It should be noted that the two UK TCZs have been excluded from this analysis since:

a) 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,
b) 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 four States (i.e. Cyprus, Greece, Belgium and Spain) the unit costs presented in this analysis do not consider other revenues which are used to subsidise all or part of terminal ANS costs charged to the users of terminal airspace.

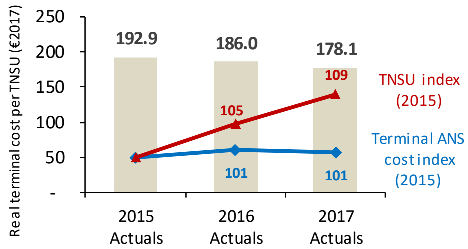
5.3.1 Trends in actual terminal ANS cost-efficiency performance at European system

Figure 5-12 below provides a summary of actual terminal ANS performance at European system level for the period 2015-2017. As explained in PRR 2016 [24], no consistent dataset is available at system level prior to 2015 due to a) introduction of a common formula to compute TNSUs (described above), and b) a number of changes in reporting scope introduced with at start of second reference period. As a result, the data recorded prior to 2015 for both terminal ANS costs and terminal ANS service units is not directly comparable at charging zone and European system level.

28 In 2017, Poland split its terminal charging zone into two zones – TCZ 1 comprising only Warsaw Chopin airport and TCZ 2 comprising 14 airports. Similarly, France also split its TCZ into two – TCZ 1 (2 airports) and TCZ 2 (58 airports). It should be noted that the year-on-year comparison for these four new TCZs contained in this report is notional, since these zones did not exist prior to 2017.

Figure 5-12 shows the changes in terminal ANS costs, TNSUs and unit costs between 2015 and 2017 at European system level. It is expected that with the availability of additional actual terminal ANS data in the future, this figure will be developed to show a five years trend analysis.

	2015 Actuals	2016 Actuals	2017 Actuals	2017 vs 2016	2015-17 CAGR
Total terminal ANS costs (M€2017)	1 219	1 232	1 227	-0.4%	0.3%
Total terminal service units ('000 TNSUs)	6 319	6 622	6 891	4.1%	4.4%
Real terminal unit cost per TNSU (€2017)	192.9	186.0	178.1	-4.3%	-3.9%

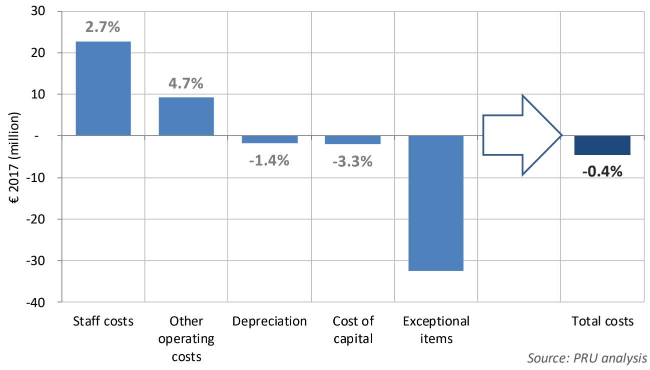


Source: PRU analysis

Figure 5-12: Real terminal ANS cost per TNSU at European System level (€$_{2017}$)

Figure 5-11 below shows how the main components of terminal ANS costs changed between 2016 and 2017.

In 2017, the slight decrease in terminal ANS costs (-0.4%, or -4.5 M€$_{2017}$) is mainly due to a significant decrease in exceptional item costs (-32.4 M€$_{2017}$), which compensated for the higher staff costs (+2.7%, or +22.7 M€$_{2017}$) and other operating costs (+4.7%, or +9.2 M€$_{2017}$).



Source: PRU analysis

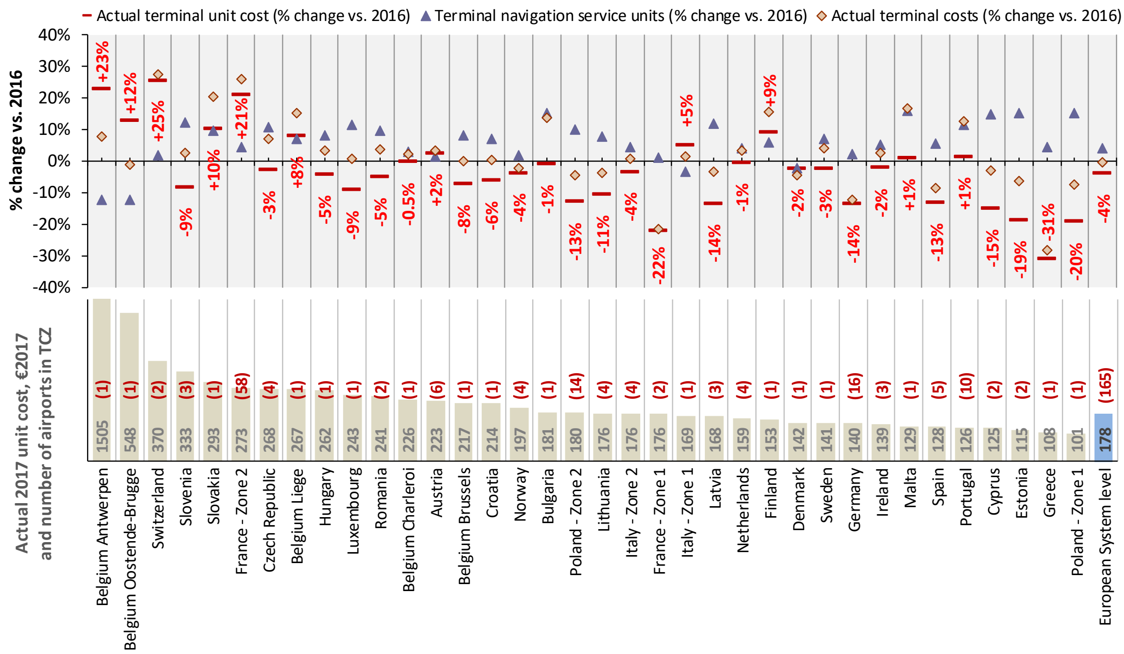
Figure 5-11: Breakdown of changes in terminal cost categories (2016-2017, (€$_{2017}$))

As detailed on p. 58 of this report, the decrease in exceptional costs observed at European system level is mainly driven by the fact that Germany reported a negative component in its terminal cost-base for 2016 and 2017 (-12 M€$_{2017}$ and -45 M€$_{2017}$ respectively). Excluding these amounts arising from the German State intervention, the European system actual terminal ANS costs would be +2.3% higher than in 2016 (instead of -0.4% lower).

5.3.2 Terminal ANS 2017 cost-efficiency performance at terminal charging zone level

Figure 5-13 presents a composite view of the changes in terminal ANS unit costs for the 36 TCZs included in this analysis. Upper part of the figure shows the changes in terminal costs, TNSUs and terminal unit costs between 2016 and 2017, while the lower part provides information on the level of terminal ANS unit costs in 2017. For the sake of completeness, the bottom chart of Figure 5-13 also shows the number of airports included in each of the charging zone (see number in brackets).

Figure 5-13 indicates that in 2017, the average terminal ANS costs per TNSU amounted to 178.1 €$_{2017}$ at system level. Figure 5-13 also shows that the terminal unit costs ranged from 1 505 €$_{2017}$ for Belgium Antwerpen TCZ, to 101 €$_{2017}$ for Poland TCZ 1, a factor of almost 15.



Source: PRU analysis

Figure 5-13: 2017 Real terminal ANS costs per TNSU by charging zone (€2017)

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 TNSUs numbers across TCZs and the scope of ANS provided.

For instance, Figure 5-13 shows that the two Belgian TCZs (Belgium Antwerpen and Oostende-Brugge) with the highest unit terminal costs in 2017 only include one airport each and represent 0.7% of the total terminal ANS costs at European system level. Similarly, while the French TCZ 2 reflects the information relating to 58 airports (including regional airports), only the five main airports are included in the two Italian TCZs.

The upper half of Figure 5-13 indicates that terminal unit costs increased for 11 TCZs. For four of these TCZs, terminal unit costs increased by more than +10% in 2017. This includes Switzerland (+25.5%), Belgium Oostende-Brugge (+12.5%), France TCZ 2 (+20.8%) and Belgium Antwerpen (+22.5%). Detailed analysis indicates that these increases mainly reflect substantially higher terminal ANS costs in 2017, with the notable exception of Belgium Oostende-Brugge, for which the costs reduction was not sufficient to compensate for the decrease in TNSUs.

On the other hand, Figure 5-13 indicates that five TCZs managed to reduce unit costs by more than -15% in 2017: Greece (-31.1%), France TCZ 1 (-22.3%), Poland TCZ 1 (-19.5%), Estonia (-18.9%) and Cyprus (-15.3%). The performance improvements observed in 2017 for these TCZs stem from a combination of much lower terminal ANS costs and an increase in TNSUs.

5.3.3 Terminal ANS cost-efficiency performance: outlook for 2018-2019

The objective of this sub-section is to provide information on planned terminal unit costs at system level for the period 2018-2019. It is based on data reported in the terminal reporting tables submitted to the EC in November 2018[29].

Figure 5-14 shows the planned changes in real terminal ANS costs and TNSUs between 2017 and 2019 for all TCZs included in this analysis.

Figure 5-14 indicates that reductions are expected for both terminal ANS costs (-1.5% p.a.) and TNSUs (-0.8% p.a.) over the 2017-2019 period.

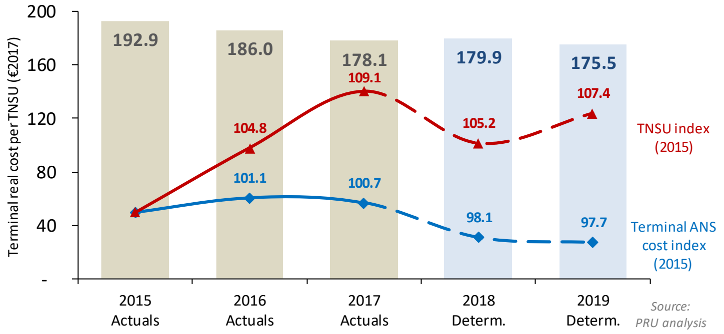


Figure 5-14: Real terminal ANS costs per TNSU, costs (€2017) and TNSUs

As a result, terminal ANS unit costs are planned to reduce from 178.1 €$_{2017}$ in 2017 to 175.5 €$_{2017}$ in 2019 (or -0.7% p.a.).

It is important to note that the apparent decrease of TNSUs presented in Figure 5-14 above for the year 2018 (-3.6%) is mainly due to the fact that the planned data reported for the years 2018-2019 reflect the determined TNSU figures provided in the RP2 Performance Plans which are not updated on a yearly basis. Actual TSNU estimates for 2018 [4] show that TNSUs were +4.7% higher than in 2017 indicating that, all else being equal, the European system actual terminal ANS unit costs for the years 2018 and 2019 are likely to be lower than the values shown in Figure 5-14 (179.9 €$_{2017}$ and 175.5 €$_{2017}$)

[29] It is noted that Portugal and Romania have revised their adopted RP2 terminal determined unit costs for years 2018-2019. For these States, the information used in Figure 5-14 reflects the latest terminal cost-efficiency revisions.

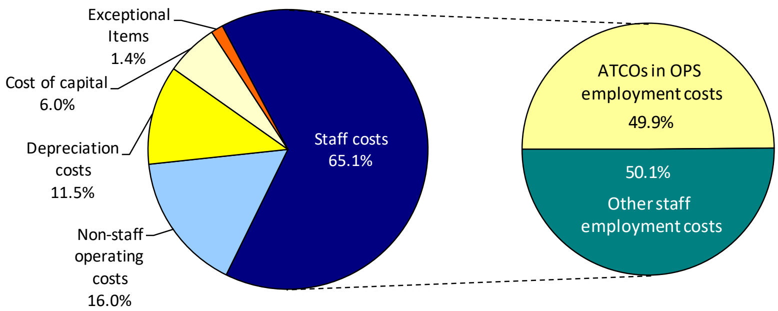
5.4 ANSPs gate-to-gate economic performance

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 1st January 2017 part of the SES, and hence subject to relevant SES regulations and obligations. Detailed analysis is given in the ACE 2017 Benchmarking Report [25].

The ACE 2017 data analysis presents information on performance indicators relating to the benchmarking of cost-effectiveness and productivity performance for the year 2017, and shows how these indicators changed over time (2012-2017). 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 (2017) 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 5-15 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.



Total ATM/CNS provision costs: € 8 213 M

	En-route		Terminal		Gate-to-gate	
	€ M	%	€ M	%	€ M	%
Staff costs	4 098	64.2%	1 244	68.2%	5 343	65.1%
ATCOs in OPS employment costs	2 054	n/appl	610	n/appl	2 664	n/appl
Other staff employment costs	2 044	n/appl	634	n/appl	2 678	n/appl
Non-staff operating costs	1 011	15.8%	305	16.7%	1 316	16.0%
Depreciation costs	785	12.3%	158	8.6%	943	11.5%
Cost of capital	407	6.4%	89	4.9%	496	6.0%
Exceptional Items	85	1.3%	29	1.6%	114	1.4%
Total ATM/CNS provision costs	6 387	100.0%	1 825	100.0%	8 213	100.0%

Figure 5-15: Breakdown of gate-to-gate ATM/CNS provision costs 2017 (€$_{2017}$)

Figure 5-15 indicates that in 2017, at Pan-European system level, gate-to-gate ATM/CNS provision costs amount to some €8.2 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 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.

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. Further details on the methodology used to compute economic costs are available in the ACE 2017 Benchmarking Report [25] [30].

5.4.1 Economic cost-effectiveness performance (2012-2017)

Figure 5-16 below shows the comparison of ANSPs gate-to-gate economic cost per composite flight-hour ("unit economic costs" thereafter) in 2017. The economic cost-effectiveness indicator at Pan-European level amounts to €477 per composite flight-hour in 2017, and, on average, ATFM delays represent 16% of the total economic costs.

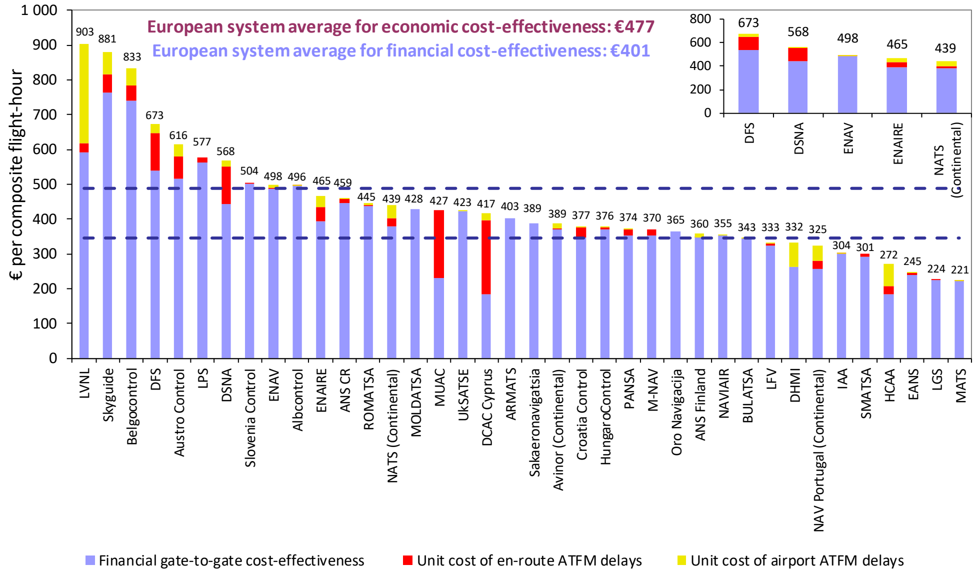
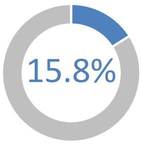


Figure 5-16: Economic gate-to-gate cost-effectiveness indicator, 2017

30 The ACE 2017 Benchmarking Report is available online at www.eurocontrol.int/prc/publications.

Figure 5-16 indicates that in 2017 unit economic costs ranged from €903 for LVNL to €221 for MATS, a factor of more than four. Figure 5-16 also indicates that DFS had the highest unit economic costs amongst the five largest ANSPs.



share of total ATFM delay costs in total economic costs 2017

Figure 5-17 displays the trend at Pan-European level of the unit economic costs between 2012 and 2017 for a consistent sample of 37 ANSPs for which data for a time-series analysis was available[31]. The upper part of the Figure 5-17 shows the changes in unit economic costs, while the lower part provides complementary information on the year-on-year changes in ATM/CNS provision costs, composite flight-hours and unit costs of ATFM delays.

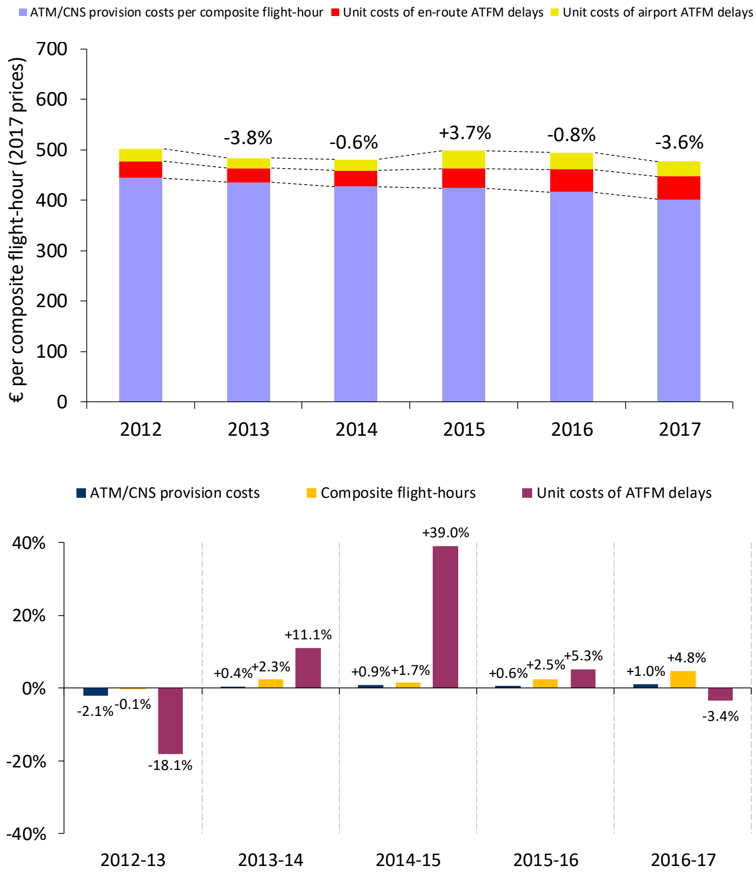


Figure 5-17: Changes in economic cost-effectiveness, 2012-2017 (€$_{2017}$)

Between 2012 and 2017, economic costs per composite flight-hour decreased by -1.1% p.a. in real terms. Over this period, ATM/CNS provision costs remained close to their 2012 level (+0.2% p.a.) while the number of composite flight-hours increased (+2.2% p.a.). At the same time, the unit costs of ATFM delays increased by +5.2% p.a., on average, over the period, primarily due to the significant increases recorded in 2014 (+11.1%), 2015 (+39.0%) and 2016 (+5.3%).

In 2017, composite flight-hours rose faster (+4.8%) than ATM/CNS provision costs (+1.0%). As a result, unit ATM/CNS provision costs reduced by -3.6% in 2017. In the meantime, the unit costs of ATFM delays decreased by -3.4% and therefore unit economic costs decreased by -3.6% compared to 2016. However, it is important to note that as of April 2016 the Network Manager (NM) introduced a new methodology to improve the accuracy of ATFM delays calculation[32]. This change resulted in substantially less ATFM delays compared to those computed using the old methodology. If 2016 and 2017 ATFM delays were computed according to the old methodology, then in 2017 the unit economic costs would be approximately -3% lower than in 2012 (instead of -5.2% as shown in Figure 5-17).

31 Sakaeronavigatsia which provided data for the first time as part of the ACE 2015 cycle is not included in this analysis.

32 Further details on the change in ATFM delay calculation methodology and its impact on the trend analysis of gate-to-gate economic costs are provided on p. 16 of ACE 2016 [29].

Figure 5-18 shows the long-term trends in terms of ATM/CNS provision costs, composite flight-hours, ATFM delays and unit economic costs[33].

The trend of decreasing ATFM delays, which began in 2011, stopped in 2014, when a new cycle characterised by higher delays started (+15.1% p.a. on average between 2013 and 2017).

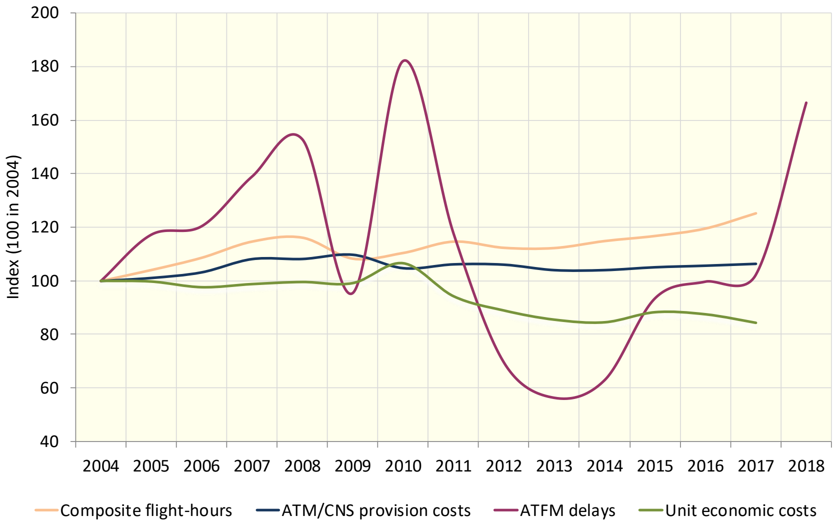


Figure 5-18: Long-term trends in traffic, ATM/CNS provision costs and ATFM delays

The most recent available data shows that the trend of increasing ATFM delays continued in 2018 with a +64.5% increase compared to 2017.

Figure 5-19 shows the contribution of each of the 38 ANSPs to the change in ATFM delays observed in 2017 at Pan-European system level.

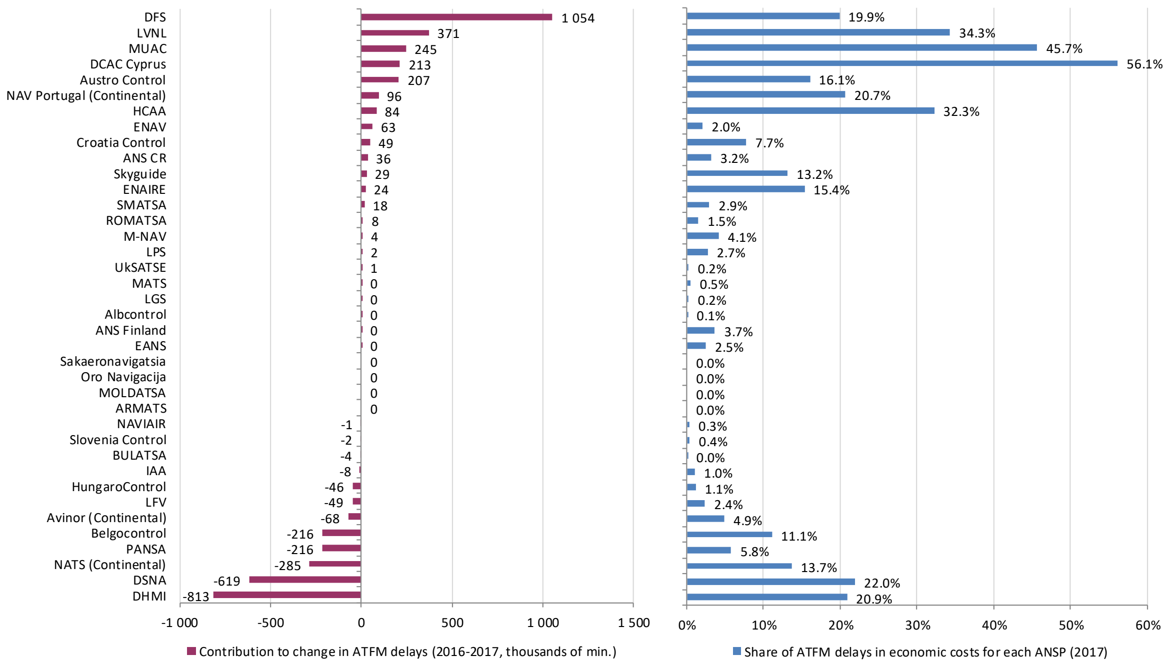


Figure 5-19: ANSPs contribution to ATFM delays increase at Pan-European system level in 2017

Figure 5-19 indicates that the increase in ATFM delays observed at system level in 2017 mainly reflects increases for a few ANSPs (DFS, LVNL, MUAC, DCAC Cyprus and Austro Control). The right-hand side of Figure 5-19 shows that, as a result, for most of these ANSPs the share of ATFM delays in

33 Consistent time-series data for the entire period is not available for ARMATS, PANSA and SMATSA, these ANSPs are therefore excluded from the long term analysis.

economic costs in 2017 is significantly higher than the European average (16%). This is particularly the case for LVNL (34.3%), MUAC (45.7%) and DCAC Cyprus (56.1%). The main factors explaining the increase in ATFM delays for the top five contributors in 2017 are:

- en-route weather and ATC capacity (including delays due to military activities and the application of protective measures during the ATC industrial actions in France) and staffing issues in Karlsruhe ACC for DFS;
- weather issues in Amsterdam/Schiphol airport for LVNL;
- en-route ATC capacity (including delays due to military activities) and staffing issues in Nicosia ACC for DCAC Cyprus;
- ATC capacity issues for MUAC (including delays due to military activities and the application of protective measures during the ATC industrial actions in France), as well as, adverse weather phenomena especially during the Summer period; and,
- en-route weather issues in Vienna ACC for Austro Control.

Figure 5-20 below shows how the unit ATM/CNS provision costs (see blue part of the bar in Figure 5-20) 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 5-20 also shows how these various components contributed to the overall change in cost-effectiveness between 2016 and 2017.

Figure 5-20 shows that in 2017, ATCO-hour productivity rose faster (+3.9%) than ATCO employment costs per ATCO-hour (+1.1%). As a result, ATCO employment costs per composite flight-hour substantially decreased (-2.7%). In the meantime, unit support costs fell by -4.0% since the number of composite flight-hours increased by +4.8% while support costs were +0.6% higher than in 2016. As a result, in 2017 unit ATM/CNS provision costs reduced by -3.6% at Pan-European system level.

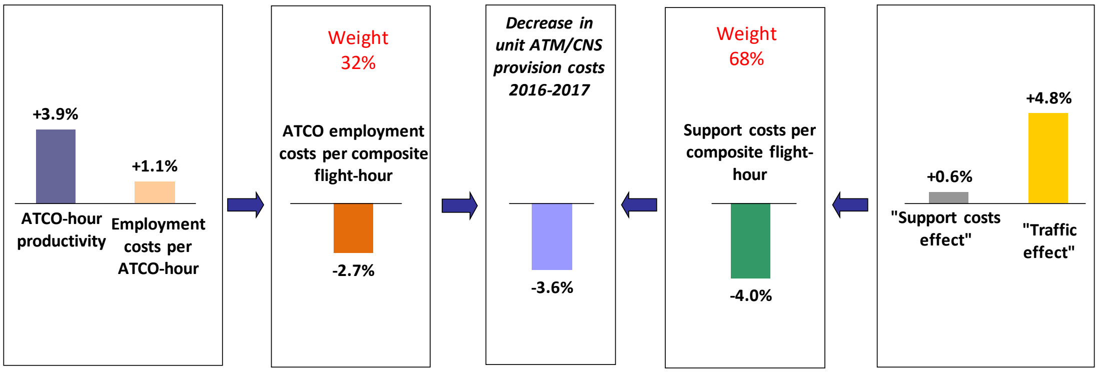


Figure 5-20: Breakdown of changes in cost-effectiveness, 2016-2017 (€$_{2017}$)

More details on the changes in unit ATM/CNS provision costs at ANSP and Pan-European system levels are available in the ACE 2017 Benchmarking Report.

In addition, time-series of ANSPs cost-effectiveness performance data for the period 2002-2017 are available online in the ATM cost-effectiveness dashboard.

5.5 Conclusions

PRR 2018 analyses performance in 2018 for all key performance areas, except for cost-efficiency, which focuses on performance in 2017 as it is the latest year for which actual financial data are available. PRR 2018 also presents an outlook on forecasted cost-efficiency trends for the period 2018-2019.

In 2017, the **en-route ANS cost-efficiency performance** of the Pan-European system improved for the fifth consecutive year, since real en-route unit cost per service unit (TSU) reduced by -6.2% to reach an amount of 49.6 $€_{2017}$. This performance improvement is driven by a combination of a slight decrease in en-route ANS costs (-0.4%) and a significant growth in TSUs (+6.2%).

The long term analysis of en-route cost-efficiency performance covering 30 en-route charging zones over a 15 year period from 2003 to 2017 shows that, at a Pan-European System level, the en-route costs remained relatively stable (+0.6% p.a.) while the TSUs grew by +3.5% p.a., on average, resulting in a -2.8% p.a. reduction in en-route unit costs over this period.

Over the 2012-2017 period, en-route unit costs reduced by -4.2% p.a., reflecting performance improvements achieved by both SES (-4.0% p.a.) and non-SES (-2.5% p.a.) States. The unit costs decrease observed for SES States over this period was achieved by reducing costs (-0.4% p.a.) in the context of robust TSUs growth (+3.8% p.a.). This is different for non-SES States, for which the improvement in en-route cost-efficiency was entirely driven by significant TSU growth (+8.8% p.a.), which more than compensated the increase in en-route ANS costs (+6.2% p.a.).

Real **terminal ANS costs** per terminal navigation service unit (TNSU) decreased by -4.3% compared to 2016 and amounted to 178.1 $€_{2017}$. The drivers for this improvement are similar to those observed for en-route ANS since terminal ANS costs decreased slightly (-0.4%) in the context of significant TNSU growth (+4.1%).

It should be noted that staff costs, which represent the largest share of en-route and terminal cost-bases, are significantly affected by the level of contributions made by the ANSPs into the employee pension schemes. As shown in the Pension study report commissioned by the PRC, the pension costs incurred by the ANSPs rose by some +25% between 2010 and 2016, despite a decrease in staff numbers. Pension costs per employee also tend to be relatively high for ANSPs contributing to defined benefit schemes. Some of them have already taken measures to limit their exposure to the increasing pension costs by, for example, transitioning from defined benefit to defined contribution schemes. Depending on the situation of individual ANSPs, increasing pension liabilities could become a significant issue in the future which should be monitored locally.

Detailed benchmarking analysis focusing on ANSPs cost-efficiency shows that in 2017 the **gate-to-gate unit costs** of the Pan-European system reduced by -3.6% since the increase in ATM/CNS provision costs (+1.0%) was more than compensated by the traffic growth (+4.8% in terms of composite flight-hours). In the meantime, the ATFM delays generated by the ANSPs rose for the fourth consecutive year in 2017 (+1.2%). The impact of this increase on the Pan-European system economic cost-effectiveness indicator in 2017 was mitigated by the substantial traffic growth (+4.8%). However, detailed analysis shows that the trend of increasing ATFM delays continued in 2018 since en-route ATFM delays were much higher than in 2017. All else being equal, this increase substantially affects the Pan-European system economic cost-effectiveness performance in 2018.

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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.

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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.

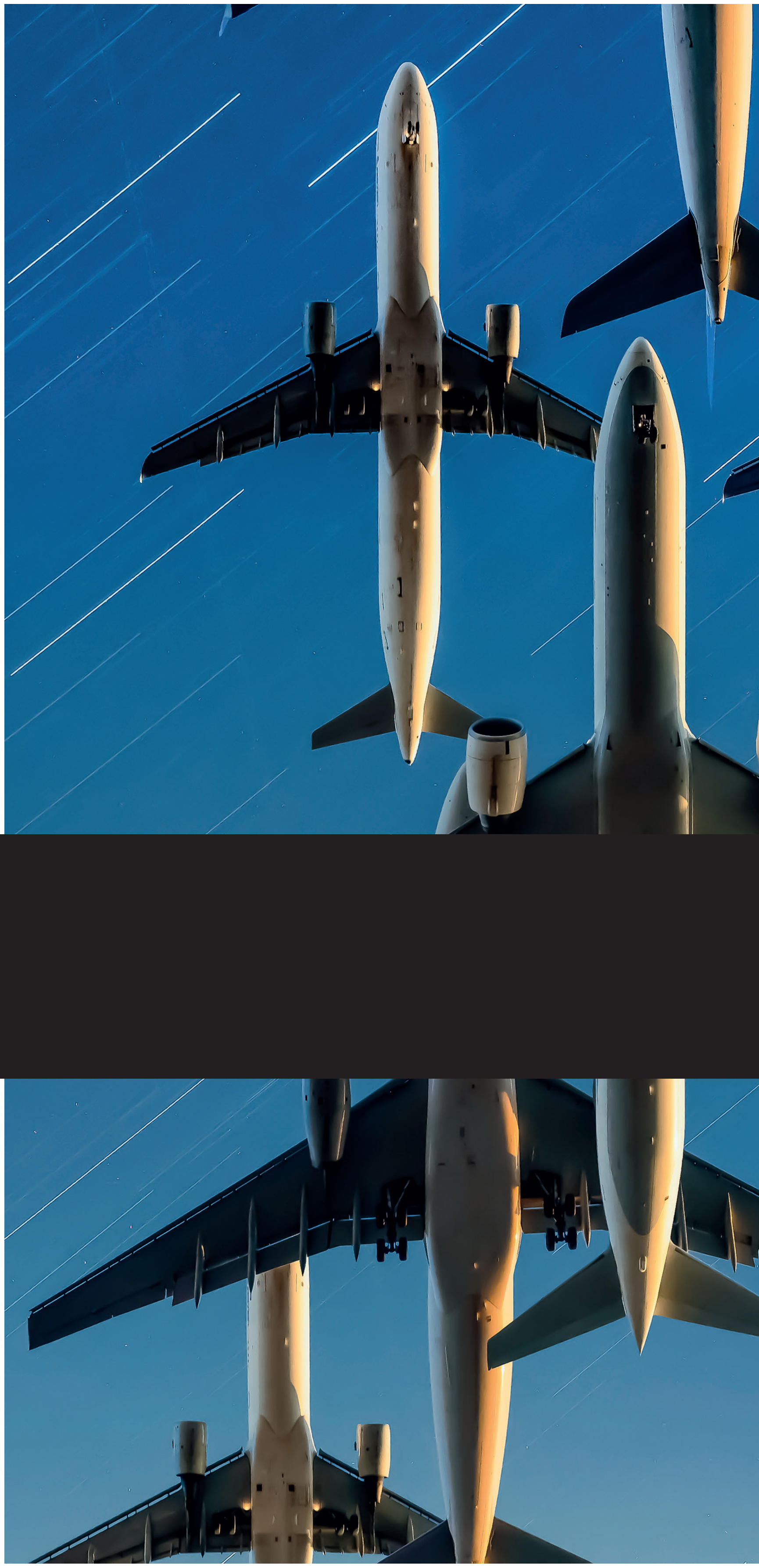
The Performance Review Unit (PRU) supports the PRC and operates administratively under, but independently of, the EUROCONTROL Agency. The PRU's e-mail address is pru-support@eurocontrol.int

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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