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…”

All PRC publications are available from the website: www.eurocontrol.int/air-navigation-services-performance-review

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

Copyright notice and Disclaimer

© European Organisation for the Safety of Air Navigation (EUROCONTROL)
This document is published by the Performance Review Commission in the interest of the exchange of information.

It may be copied in whole or in part providing that the copyright notice and disclaimer are included. The information contained in this document may not be modified without prior written permission from the Performance Review Commission.

The views expressed herein do not necessarily reflect the official views or policy of EUROCONTROL, which makes no warranty, either implied or express, for the information contained in this document, neither does it assume any legal liability or responsibility for the accuracy, completeness or usefulness of this information.

Printed by EUROCONTROL, 96, rue de la Fusée, B-1130 Brussels, Belgium.
The PRU’s e-mail address is pru-support@eurocontrol.int.
FOREWORD

At the time of writing the Performance Review Report 2019, European air traffic had just finished its fifth year of continued growth and the review focus was on possible solutions for addressing the persisting en-route capacity crisis and how to reduce the environmental impact of aviation in view of the significant growth predicted for the industry over the coming years.

Although there were signs of weakening traffic towards the end of 2019 because of an economic slowdown in Europe, nobody was prepared for the unprecedented crisis emerging from the outbreak of the new SARS-CoV-2 virus in Wuhan, China in late December 2019.

As a result of COVID-19, the number of flights operating daily in the EUROCONTROL area declined in March-May by up to -90% compared to the same period in 2019 with dramatic consequences for the entire industry. Even though there are fragile signs of slowly growing traffic levels in June 2020, the road back to normality will be long and painful; the Performance Review Commission (PRC) welcomes and supports the measures taken by EUROCONTROL and the Member States to help the industry survive the COVID-19 crisis until traffic levels recover.

Given the challenges facing aviation because of COVID-19, the PRC decided not to make recommendations based on the past performance in 2019 but instead to use its analytical expertise and resources to support the aviation industry with up to date and relevant data and information on the impact of the COVID-19 crisis.

In coordination with the EUROCONTROL Agency, the PRC has developed several online tools to monitor, for example, the revenues from en-route charges or the number of grounded aircraft. The PRC will continue to make relevant information available on the redesigned Aviation Intelligence Performance Portal @ www.ansperformance.eu.

The goal is to provide a single, user-friendly entry point for all air traffic management related performance areas (operations, economics, etc.) in support of the entire European aviation industry. For instance, the economic data from the newly released ATM Cost-Effectiveness (ACE) Benchmarking Report, which will be relevant as a reference on the way to recovery, is available online from the ACE dashboard. Next year, the ACE report will focus on the impact of the COVID-19 crisis on ANSPs cost-effectiveness performance.

Despite the PRC's increased focus on online publications and an entirely changed situation in 2020, there are some takeaways from the review of the 2018/19 capacity crisis in PRR 2019, which will remain relevant and serve as a reference when traffic builds up again.

The COVID-19 crisis once again underlines the need for close cooperation and coordination and the importance of a proactive, harmonised network wide approach.

PRR2019 also illustrates the importance of balanced performance objectives and the need for improved scalability of the ATM system to adjust to changes in operations. Furthermore, the challenge to reduce aviation’s impact on the environment through improved efficiency will remain after the crisis.
These are turbulent times for the aviation industry but the road back to normality is also an opportunity to make our ATM system better, to deliver improved performance when traffic returns.

Although recovery will be challenging, the aviation industry has shown its strength and resilience before. It will, without a doubt, resume its important role in reconnecting families and business after the COVID-19 crisis.

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.

Marc Baumgartner
Chairman
Performance Review Commission

The PRC can be contacted via: pru-support@eurocontrol.int
This report of the Performance Review Commission analyses the performance of the European Air Traffic Management System in 2019 under the Key Performance Areas of Safety, Capacity, Environment and Cost-efficiency.

Keywords

<table>
<thead>
<tr>
<th>Air Traffic Management</th>
<th>Performance Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Indicators</td>
<td>ATM ANS</td>
</tr>
</tbody>
</table>

CONTACT: Performance Review Unit, EUROCONTROL, 96 Rue de la Fusée, B-1130 Brussels, Belgium. Tel: +32 2 729 3956, E-Mail: pru-support@eurocontrol.int, Web: http://www.eurocontrol.int/ansperformance

INTERNAL REFERENCE NAME: PRR 2019
Executive Summary

Traffic Growth (Flights) by Area Control Centre (2019)

Share of En-Route ATFM Delayed Flights by Area Control Centre (2019)

Horizontal En-Route Flight Efficiency - Actual Trajectory (2019)
ATM Performance in 2019 - Synopsis

Key Performance Indicator | Data & commentary
--- | ---
IFR flights | ECAC area | Variation

<table>
<thead>
<tr>
<th>Year</th>
<th>Flights (Millions)</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>11.1 M</td>
<td>+ 0.8% ↑</td>
</tr>
</tbody>
</table>

Air traffic in the ECAC area continued to grow for the sixth consecutive year in 2019, but with contrasted (and even negative) growth rates at State level. On average IFR flights increased by 0.8% over 2018 which was below the low scenario forecast (1.2%) by STATFOR in the February 2019 forecast.

Because of the COVID-19 outbreak and the resulting unpredictable challenges for the aviation industry in 2020 and beyond no new traffic forecast was available for this report.

Accidents with direct ANS contribution | Eurocontrol area | Variation
--- | --- | ---
2019 (preliminary) | 0 | - 1 ↓

There were no reported accidents with direct ATM or indirect ATM contribution in 2019 (P). There were 62 333 ATM-related incidents, reported through the EUROCONTROL AST mechanism, out of which 44 613 were operational and 17 720 were technical.

In 2019 (based on preliminary data), Separation Minima Infringements (SMI) and Unauthorised Penetration of Airspace (UPA) rates, in the EUROCONTROL area, were approximately 13.39 and 34.65 per 100 000 flight hours respectively. The rate of Runway Incursions (RIs) in 2019 was 0.86 RIs per 10 000 movements.

En-route ATFM delayed flights | Eurocontrol area | Variation
--- | --- | ---
2019 | 9.9% | + 0.3% ↑

Although the average delay per flight decreased from 1.74 to 1.57 minutes per flight in 2019, the number of en-route ATFM delayed flights increased further to 9.9% of all flights (+0.3 percentage points vs. 2018). Total en-route ATFM delays decreased by 9.0% compared to 2018, mainly driven by less delays attributed to adverse weather ATC disruptions/strike.

En-route flight efficiency (actual) | Eurocontrol area | Variation
--- | --- | ---
2019 | 97.2% | -0.1% pt.

The average horizontal en-route flight efficiency at EUROCONTROL level deteriorated slightly in 2019. The significant gap between the efficiency of the filed flight plans (blue line: 95.6%) and the actual flown trajectories (red line: 97.2%) remained also in 2019.

The shortest constrained routes (95.9%) are only slightly more efficient than the filed ones which means that the inefficiencies are mainly due to the constraints imposed by the route network.

En-route ANS costs per TSU (€2018) | Eurocontrol area | Variation
--- | --- | ---
2018 | 47.8 | -4.1% ↓

In 2018, en-route ANS costs increased by +1.8%. However, since the en-route service units also grew by +6.2%, the en-route costs per service unit decreased by -4.1% compared to 2017.
This report assesses the performance of Air Navigation Services (ANS) in the EUROCONTROL area for the calendar year 2019 for all key performance areas, except for cost-efficiency, which analyses performance in 2018 as this is the latest year for which actual financial data are available.

**Air traffic in the EUROCONTROL area** continued the positive trend observed over the past five years in 2019. Air traffic grew by 0.8% compared to 2018, yet at a notably lower growth rate compared to previous years. Compared to 2013 when the positive trend started, the ANS system controlled an additional 1.5 million flights (+15.4%) in 2019.

As in previous years, average aircraft size (+1.7% vs. 2018) and distance (+1.7% vs. 2018) continued to grow at a higher rate than flights in 2019 which consequently resulted also in a higher en-route service unit growth in 2019 (+2.8% vs. 2018).

Similarly, passenger numbers continued to grow at a higher rate (+3.2% vs. 2018) than flights in 2019, yet also with a notable slowdown in the rate of growth.

There was however a clear slowdown in traffic growth particularly in the second half of 2019, influenced by the slowing economic growth in Europe; the collapse of Flybmi, Germania and Thomas Cook, and the grounding of the B737 MAX fleet.

A total of 32 of the 42 Air Navigation Service Providers (ANSPs) included in the analysis reported a traffic increase in 2019. In absolute terms, ENAV (Italy), CroatiaControl, ENAIRE (Spain), HCAA(Greece), SMATSA (Serbia/Montenegro), and Austro Control showed the highest year on year growth in 2019. Sakaeronavigatsia (Georgia), LFV (Sweden), Maastricht Upper Area Control Centre (MUAC), Skeyes (Belgium), and ANS CR (Czech Republic) showed the highest decrease in absolute terms in 2019.

The traffic growth was to some extent affected by the traffic flow measures implemented by the Network Manager in summer 2019 (eNM/19) to mitigate the effects of the capacity shortfall in the core area. The eNM/19 measures aimed at offloading traffic from congested Area Control Centres (ACCs) such as Karlsruhe and Maastricht which resulted in more traffic in other ACCs.

The slowdown in traffic growth, less adverse weather, and the preventive measures taken by all stakeholders to avoid the high delay levels observed in summer 2018 helped to improve overall service quality in 2019. After a continuous deterioration over the past years, arrival punctuality improved again from 75.7% in 2018 to 77.8% in 2019. At the same time, average departure delay in the EUROCONTROL area decreased in 2019 by 1.6 minutes per flight to 12.8 minutes.

The COVID-19 outbreak at the beginning of 2020 has sparked an unprecedented crisis in Europe and elsewhere. While the full impact of the COVID-19 outbreak on the aviation industry remains to be seen, preliminary indications in early 2020 suggest an unparalleled reduction in traffic volumes at pan-European system level.

**Environment** is an important political, economic and societal issue and the entire aviation industry has a responsibility to minimise its impact on the environment. The environmental impact of aviation on climate results from greenhouse gas (GHG) emissions and contrails, generated by aircraft engine exhaust.

Based on the figures of the European Environment Agency (EEA) aviation accounted for approximately 3.8% of total EU28 GHG emissions in 2017 (the latest year for which information is available). Although this share appears to be comparatively small, aviation is one of the fastest growing sources of GHG emissions in Europe. The relative share of aviation is expected to further increase as aviation activity

---

1 Used for charging purposes based on aircraft weight factor and distance factor.
based on fossil fuels is forecast to continue to grow while other industrial sectors (including road transport) increasingly decarbonise over time.

The challenge in reducing aviation emissions is well known. To reduce GHG emissions from aviation the plans are essentially based on four pillars: (1) Aircraft technology (airframes and engines), (2) Sustainable aviation fuels, (3) Economic measures, and (4) Improved infrastructure and operations (operational efficiency).

The Air Traffic Management (ATM)-related impact on climate is closely linked to operational performance (fuel efficiency) which is largely driven by inefficiencies in the flight trajectory and associated fuel burn (and emissions). ATM deploys a number of projects and initiatives aimed at improving operational efficiency, including performance based navigation (PBN), free route airspace (FRA), collaborative decision making (CDM), and continuous climb and descent operations (CCO/CDO). Additional efficiency gains are expected to come from the further digitalisation and automation of the industry which will enable the better use of data-driven technologies like Artificial Intelligence (AI).

The current best estimate is that ATM can influence approximately 6% of the total gate-to-gate fuel burn (“benefit pool”). In this context, it is important to highlight that the estimated inefficiencies are based on a comparison of actual flight trajectories to theoretical reference trajectories which, due to operational restrictions, interdependencies, etc., cannot in practice be reached at system level.

If the “ANS related benefit pool” that can be actioned by ANS is related to the total GHG emissions in Europe the share that can be influenced by ANS corresponds to 0.2% of the total GHG emissions. Although this share is comparatively limited, the absolute numbers are significant and there is still ample scope for further improvement. It goes without saying that the strong focus on improving flight efficiency needs to be maintained.

The total economic assessment reviews performance over time but also by combining cost-efficiency with service quality. The lower traffic levels following the economic crisis starting in 2008 reduced the pressure on capacity to some extent and provided a suitable environment to change the economic models for ANSPs in preparation of the start of the Single European Sky performance scheme (SES-PS) in 2012.

Total en-route ANS costs remained almost flat between 2008 and 2018, mainly due to cost containment measures implemented following the crisis in 2008 and the binding SES-PS cost-efficiency targets as of 2012.

At the same time, flights increased by +7.4% while en-route service units grew at a notably higher rate (+32.6% vs. 2008) due to a continuous increase in average flight length and aircraft mass. Air Traffic Controller (ATCO) productivity increased significantly over time and ANS unit costs decreased by -25% between 2008 and 2018. At the same time, ANSPs reduced ATCO recruitment most likely as a reaction on the traffic downturn in 2008 or as part of the cost containment measures.

With traffic continuing to grow again in 2013, ATFM en-route delays increased gradually at first and then soared in 2018, which suggests substantial shortcomings in proactive capacity planning and deployment. Despite an increase in ATCO recruitment between 2014 and 2018, which appears to be a reaction on the increasing traffic and delay levels since 2013, the number of trainees in 2018 was still 25% below the 2008 level.

The total economic review of en-route ANS performance combines the direct ANS provision costs and the estimated costs of en-route ATFM delay to airspace users. The analysis illustrates that the substantial increase in en-route ATFM delay and associated costs in 2018 and 2019 clearly outweigh the notable cost efficiency gains over the past years. This underlines the importance of finding a balanced approach in performance management, which considers all key performance areas equally
instead of focusing entirely on one area. It is important to ensure that cost-efficiency measures consider effective capacity planning and deployment to avoid exponential increases in delays and related costs to airspace users.

In a dynamic interconnected system such as the ATM network, the ability to adapt to changing conditions (flexibility/scalability) and to mitigate effects of unexpected events (resilience) becomes more and more important. This will also help to better adjust the ATM network to economic and political turbulences, possible demand changes following the environmental debate, and not least the effect of the COVID-19 outbreak in December 2019 on aviation.

In 2019 (based on preliminary data), SMIs and UPA rates, in the EUROCONTROL area, were approximately 13.39 and 34.65 SMIs or UPAs respectively per 100 000 flight hours. The rate of RIs in the EUROCONTROL area 2019 was 0.86 RIs per 10 000 movements. There is almost no change compared to 2018.

To the PRC’s knowledge, the Annual Summary Template (AST) reporting mechanism discontinued as of April 2020. The PRC’s continued assessment of the KPAs from the Safety perspective has therefore to be reinvented due to the fact that the PRC at the moment has no access to reliable ATM-related safety data for its work post-2020.

The new methodology of calculating safety risk, which has been presented for the first time last year, has been further developed. The concept of a Composite Risk Index (CRI) as a cumulative risk value calculated aggregating all reported, assessed and severity classified safety-related incidents, has the potential to become a proxy of exposure to risk within certain airspace for top management information and decision making. The updated version of the CRI allows an assessment of the performance of the safety system considering four components: (1) the airspace environment (considering complexity of airspace and traffic demand), (2) the quality of reporting system within reporting entity (reporting practices and reporting culture), (3) measured risks within the system (based on reported safety occurrence data), and (4) human perception of risk. The technical report describing in detail updated CRI methodology will be published later in 2020.

The review of operational en-route ANS performance in the EUROCONTROL area in 2019 evaluates ANS-related flight efficiency constraints on airspace users’ trajectories. It addresses several performance areas including ATFM delay, capacity, horizontal flight efficiency and vertical flight efficiency.

**En-route capacity:** Following the disproportional increase in 2018 and the subsequent major disruptions for passengers, en-route ATFM delays fell by 9.0% in 2019 to reach 17.2 million minutes; the second highest level since 2010.

The average en-route delay decreased from 1.74 to 1.57 minutes per flight in 2019: flights were delayed more frequently, albeit with shorter average delays than in 2018. The number of flights that were delayed by en-route ATFM regulations increased to 9.9% of all flights (+0.3 percentage points vs. 2018). Even though approximately one flight in six was subject to en-route ATFM regulations, only one flight in twenty-five was delayed for more than 15 minutes. However, just those 4% of flights account for 70% of all en-route ATFM delays.

According to the ANSPs, ATC Capacity (43.9%) attributed delays remain the main portion of en-route ATFM delays, followed by ATC Staffing (24.3%), Weather attributed delays (21.2%), and ATC disruptions/industrial actions (7.2%).

The observed performance improvement in 2019 was mainly driven by less delays attributed to adverse weather (-24.1% vs 2018) and ATC disruptions/strike (-13.5% vs 2018). Delays attributed to ATC staffing decreased slightly over 2018 (-3.8%) while ATC Capacity attributed en-route ATFM delays increased further compared to 2018 (+6.6%).

Previous PRRs highlighted the inconsistent manner in which ANSPs attribute ATFM delays either
according to the delay cause or according to the geographical location to where the delay is being assigned. The analysis showed that the share of ATC staffing related delay would increase from 24% to approximately 77% of all en-route ATFM delays which suggests that ATC staffing is much more of a problem, and therefore a possible solution to capacity constraints, than is currently being acknowledged by ANSPs.

In 2019, DFS (Germany) generated 25.9% of all en-route ATFM delays in the EUROCONTROL area, followed by DSNA (France) (22.9%), Austro Control (10.1%) and HungaroControl (8.3%).

The most delay generating ACCs in 2019 were Karlsruhe (17.7%), Marseille (11.7%), Vienna, Budapest, Langen and Barcelona (4.4% respectively). Karlsruhe UAC, Marseille, Vienna and Budapest together generated half of all en-route ATFM delays in 2019.

In order to mitigate the effects of the serious capacity shortfall in the core area observed in summer 2018, the Network Manager, in cooperation with a number of ANSPs, implemented again flow measures (re-routing or level-capping) in summer 2019 (eNM/19) to offload traffic from constrained ACCs.

The collaborative, network-centric approach avoided even higher en-route ATFM delays in 2019 but at the cost of lower flight efficiency and additional CO2 emissions for a considerable number of flights. It is likely that the Network Manager will continue to have a role in coordinating similar mitigation exercises in the future, considering the existing capacity shortfalls in some locations and the current capacity plans of the ANSPs.

A review of the evolution of the declared capacity for the most constraining sectors during the period 2012-2019 highlights that several ANSPs have not been implementing capacity where it is most needed, indeed some sectors declare less capacity in 2019 than they were providing in 2012. In addition, the high number of collapsed sectors among the most constraining sectors reinforces the point that ATC staffing needs to be properly addressed.

En-route flight efficiency has a horizontal (distance) and vertical (altitude) component, both with a high relevance for fuel efficiency and the environment.

Average horizontal en-route flight efficiency at EUROCONTROL level remained relatively constant over the past five years with a slight deterioration in 2019. The efficiency of actual trajectories decreased by 0.1 percentage points to 97.2% in 2019.

The significant gap between the efficiency of the filed flight plans (95.6%) and the actual flown trajectories (97.2%) remained in 2019. In 2019, the actual trajectory is on average 1.6% more efficient than the filed flight plan and still 1.3% more efficient than the shortest constrained route. Or, expressed differently, if airspace users had flown the filed flight plans they would have flown an additional 156 million kilometres in 2019.

The efficiency of the shortest constrained routes (95.9%) is only slightly more efficient than the filed ones. This means that the inefficiencies are mainly due to the constraints imposed by the route network.

En-route flight efficiency is comparatively low in the core area where traffic density is highest and where Free Route Airspace (FRA) is not yet implemented. The envisaged FRA implementation by 2022 and optimised cross border implementation is expected to be one of the main contributors towards improving flight efficiency, as airspace users will have more choices to optimise their flight plans.

Although FRA implementation will help to file more efficient trajectories to avoid segregated areas, it will not improve the information flows necessary to optimise the use of segregated airspace in Europe. As shown in previous analyses, there is further scope to improve the civil/military cooperation and coordination.

Another important factor affecting horizontal en-route flight efficiency is the lack of capacity. Horizontal flight efficiency is worse in summer due to imposed ATFM constraints, resulting from capacity shortfalls. Days with high en-route ATFM delays tend to have notably lower flight efficiency.
EXECUTIVE SUMMARY

The vertical component of en-route flight efficiency has been gaining more attention over the past years, not least because of the impact of measures implemented by the Network manager to mitigate delays at network level during summer 2018 (4ACC) and 2019 (eNM/19). Although difficult to quantify at network level in terms of additional fuel burn and CO₂ emissions, the analysis shows a considerably higher number of altitude constrained flights since spring 2018.

There are numerous initiatives aimed at improving flight efficiency underway but even with traffic growth slowing down, it appears to be challenging to meet the Master Plan ambitions within the given timeframes, considering the existing lack of capacity and the negative effect on flight efficiency in some parts of the core area.

The average traffic growth at the top 30 European airports in 2019 was of 1.7%, the lowest increase since 2013. The growth is distributed unevenly among the top 30 airports, with 9 airports showing less traffic than the previous year.

The opening of Istanbul Grand airport in April 2019 was the biggest airport development in Europe in years consequently replacing Istanbul Atatürk in the list of the top 30, which otherwise remains unchanged.

Generally, the level of inefficiencies for both arrival and departure flows slightly increased in 2019.

Overall, 6.1% of all arrivals at the top 30 airports in 2019 were delayed by arrival ATFM regulations, this represents 0.3 percentage points more than in 2018. Average arrival ATFM delay increased from 1.09 to 1.14 minutes per arrival in 2019, with airports showing heterogeneous trends. The most important deterioration in terms of arrival ATFM delay was observed at Athens associated to ATC capacity problems, followed by Amsterdam that became the airport with the highest arrival ATFM delay per flight of the top 30 airports and is the biggest contributor to European airport ATFM delays.

The average additional ASMA times at the top 30 airports also increased from 2.07 to 2.17 minutes per arrival in 2019 with London airports, Heathrow and Gatwick, still showing the highest additional ASMA times (7 and 4.6 minutes per arrival respectively).

The average additional taxi-out times increased from 4.21 to 4.22 minutes per departure in 2019, where some significant variations at airport level are directly related to special circumstances. ATC pre-departure delays, where measurable, showed as well noteworthy increases at some airports.

Most important performance deteriorations observed in the different indicators are associated to specific events, mainly works on the runway systems or implementation of new systems or procedures. Mitigation measures and careful planning are to be considered to avoid this detrimental impact on performance.

Lisbon was the only airport that implemented A-CDM in 2019, but other projects like Advanced Towers allow airports to share departure information with the Network Manager (currently almost 45% of departures share DPIs with NM) which helps improve slot adherence and network predictability.

Vertical flight efficiency during climb and descent at the top 30 airports has in general increased very slightly. The biggest increase of average time flown level during descent in 2019 with compared to 2018 was observed for flights arriving at Munich (MUC) and Milan (MXP), each having an increase of almost 1 minute per flight. Flights arriving at Frankfurt (FRA), Paris Charles de Gaulle (CDG), London (LHR), London Gatwick (LGW) and Paris Orly (ORY) showed the highest inefficiencies with more than 5 minutes of level flight on average in 2019.
In 2018, 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 €47.8\(\text{2018}\), which is -4.1% lower than in 2017. This performance improvement, recorded for the sixth year in a row, results from the fact that the growth in TSUs (+6.2%) more than compensated the increase in en-route ANS costs (+1.8%).

At the same time, in November 2019 the Member States provided forecast cost and TSU figures covering the period 2019-2024. Undoubtedly, the COVID-19 crisis in 2020 will have a massive impact on future traffic growth. Therefore, it is likely that there will be a need to revise the TSUs plans made by States in November 2019. A thorough analysis of the impact of this crisis on the ANS industry will be provided in future PRR reports when updated States/ANSPs forward-looking plans in terms of costs and traffic will be available.

In 2018, the European terminal ANS unit costs amounted to €174.3\(\text{2018}\) per terminal service unit (TNSU), which was -3.3% lower than in 2017. This performance improvement results from the significant growth in TNSUs (+4.7%), which compensated the increase in terminal ANS costs (+1.3%).

Detailed benchmarking analysis of pan-European ANSPs indicates that, in 2018, gate-to-gate ATM/CNS provision costs increased by +2.0% over the preceding year and amounted to some €8.4 Billion at system level. At the same time traffic, expressed in composite flight-hours, rose by +5.4%, which resulted in a reduction in gate-to-gate unit ATM/CNS provision costs (-3.3%).

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 en-route and airport ATFM delays. This analysis shows that, at pan-European system level, unit economic costs grew by +6.2% in 2018. As a result, the relative share of ATFM delay costs also increased and represented, on average, 24% of total economic costs for pan-European ANSPs, compared to some 16% in 2017.
This page was intentionally left blank
TABLE OF CONTENTS

EXECUTIVE SUMMARY ........................................................................................................................................... 1

1 INTRODUCTION AND CONTEXT .......................................................................................................................... 1
  1.1 ABOUT THIS REPORT ..................................................................................................................................... 1
  1.2 PRC/PRU TASKS .............................................................................................................................................. 2
  1.3 EUROPEAN AIR TRANSPORT KEY INDICES .............................................................................................. 5
  1.4 AIR TRANSPORT PUNCTUALITY .................................................................................................................. 10
  1.5 ENVIRONMENT .............................................................................................................................................. 11
  1.6 TOTAL ECONOMIC ASSESSMENT (EN-ROUTE) ............................................................................................ 19

2 SAFETY ................................................................................................................................................................. 23
  2.1 INTRODUCTION .............................................................................................................................................. 23
  2.2 SAFETY PERFORMANCE SNAP SHOT ............................................................................................................. 24
  2.3 RISK EXPOSURE – COMPOSITE RISK INDEX ............................................................................................... 26
  2.4 SAFETY DATA AFTER 2020 ........................................................................................................................... 27
  2.5 CHALLENGES TO SAFETY AFTER 2020 ....................................................................................................... 27
  2.6 CONCLUSIONS .............................................................................................................................................. 28

3 OPERATIONAL EN-ROUTE ANS PERFORMANCE ............................................................................................... 29
  3.1 INTRODUCTION .............................................................................................................................................. 29
  3.2 ANS-RELATED OPERATIONAL EN-ROUTE EFFICIENCY ............................................................................... 30
  3.3 CONCLUSIONS .............................................................................................................................................. 46

4 OPERATIONAL ANS PERFORMANCE @ AIRPORTS ............................................................................................ 49
  4.1 INTRODUCTION .............................................................................................................................................. 49
  4.2 TRAFFIC EVOLUTION @ THE TOP 30 EUROPEAN AIRPORTS ....................................................................... 51
  4.3 CAPACITY MANAGEMENT (AIRPORTS) ........................................................................................................... 53
  4.4 ANS-RELATED OPERATIONAL EFFICIENCY AT AND AROUND AIRPORTS ................................................... 57
  4.5 CONCLUSIONS .............................................................................................................................................. 65

5 ANS COST-EFFICIENCY (2018) ........................................................................................................................... 67
  5.1 INTRODUCTION .............................................................................................................................................. 67
  5.2 EN-ROUTE ANS COST-EFFICIENCY PERFORMANCE .................................................................................... 68
  5.3 TERMINAL ANS COST-EFFICIENCY PERFORMANCE ...................................................................................... 74
  5.4 ANSPs GATE-TO-GATE ECONOMIC PERFORMANCE .................................................................................. 77
  5.5 CONCLUSIONS .............................................................................................................................................. 81
LIST OF FIGURES

Figure 1-1: EUROCONTROL States (2019) ........................................................................................................... 4
Figure 1-2: European air traffic indices (2008-2019) .............................................................................................. 5
Figure 1-3: Year on year change versus 2018 ........................................................................................................ 6
Figure 1-4: Traffic evolution by ANSP (2019/2018) ............................................................................................... 6
Figure 1-5: Traffic growth by ACC (2019) .............................................................................................................. 7
Figure 1-6: Daily traffic levels in the EUROCONTROL area (2019) ....................................................................... 7
Figure 1-7: Evolution of daily traffic levels (EUROCONTROL area) ................................................................. 7
Figure 1-8: Traffic variability by ACC (2019) ........................................................................................................... 8
Figure 1-9: Traffic complexity by ACC (2019) ....................................................................................................... 8
Figure 1-10: Traffic complexity by ANSP (2019) .................................................................................................... 8
Figure 1-11: Evolution of arrival punctuality ......................................................................................................... 10
Figure 1-12: ANS contribution towards departure total departure delays...................................................... 10
Figure 1-13: Radiative forcing components .......................................................................................................... 11
Figure 1-14: Evolution of GHG emissions between 1990 and 2017 by sector (EU28) ............................................ 12
Figure 1-15: Environmental IATA and ICAO goals .............................................................................................. 12
Figure 1-16: Alternative propulsion systems ....................................................................................................... 13
Figure 1-17: Distribution of flights and estimated CO₂ emissions by distance category (2019) ................. 13
Figure 1-18: Basket of measures aimed at meeting aviation’s environmental goals ........................................ 15
Figure 1-19: Gate-to-gate efficiency by phase of flight ....................................................................................... 16
Figure 1-20: Estimated ANS-related gate-to-gate benefit pool (CO₂ emissions)................................................. 16
Figure 1-21: Estimated share of GHG emissions that can be influenced by trajectory optimisation .... 17
Figure 1-22: Estimated ANS-related benefit pool by flight phase (CO₂ emissions) ........................................ 17
Figure 1-23: Population exposed to noise above 55dB in Europe (in millions) [14] ........................................ 18
Figure 1-24: Long term evaluation of en-route ANS performance (2008-2019) .............................................. 19
Figure 1-25: Network wide evolution of staff related key figures (2013-2018) ................................................. 20
Figure 1-26: Evolution of ATCOs and trainees in the EUROCONTROL area (2008-2018) .................... 20
Figure 1-27: En-route ANS provision costs and estimated costs of en-route ATFM delays (€ 2018) .. 21
Figure 2-1: Accidents with ATM contribution (2015-2019P) ............................................................................. 24
Figure 2-2: Total air traffic accidents (2015-2019P) ............................................................................................ 24
Figure 2-3: Total reported incidents (2014-2019P) .......................................................................................... 25
Figure 2-4: Incidents reported via AST in EUROCONTROL area (2019 preliminary data) .......................... 25
Figure 2-5: Occurrence rates EUROCONTROL area (2019) ........................................................................... 25
Figure 2-6: Composite Risk Index components and their parameters .......................................................... 26
Figure 3-1: Evolution of ATFM delays .............................................................................................................. 30
Figure 3-2: En-route ATFM delays in the EUROCONTROL area ................................................................. 30
Figure 3-3: En-route ATFM delays by attributed delay category (Overview) .................................................. 31
Figure 3-4: En-route ATFM delay by attributed delay category ........................................................................ 31
Figure 3-5: Monthly evolution of en-route ATFM delay by attributed cause .................................................... 31
Figure 3-6: Temporal distribution of ATFM delays (2019) ............................................................................... 32
Figure 3-7: Share of total en-route ATFM delay in 2019 ................................................................................. 32
Figure 3-8: Days with average en-route ATFM delay >1 min per flight .......................................................... 33
Figure 3-9: Share of en-route ATFM delayed flights by ACC ............................................................................. 33
Figure 3-10: Peak throughput and en-route ATFM delayed flights at the most constraining ACCs
Figure 3-11: En-route ATFM delay per flight by most constraining ACC
Figure 3-12: ATFM delay attributed by ANSP and revised attribution (2019)
Figure 3-13: Evolution of declared capacity (2012-2019) in bottleneck locations (Germany)
Figure 3-14: Evolution of declared capacity (2012-2019) in bottleneck locations (France)
Figure 3-15: Evolution of declared capacity (2012-2019) in bottleneck locations (Other)
Figure 3-16: eNM initiative shifting of traffic flows to offload congested ACCs
Figure 3-17: Horizontal en-route flight efficiency (EUROCONTROL area)
Figure 3-18: Daily horizontal en-route flight efficiency and ATFM en-route delays (2019)
Figure 3-19: Horizontal en-route flight efficiency by airport pair (2019)
Figure 3-20: Map of horizontal en-route flight efficiency by State (2019)
Figure 3-21: Implementation status of Free Route Airspace (FRA) – End 2019
Figure 3-22: Horizontal en-route flight efficiency by State (2019)
Figure 3-23: Illustration of routes impacted by military training areas
Figure 3-24: Edinburgh to London city airport (plan and actual)
Figure 3-25: Horizontal en-route flight efficiency by State (actual trajectories – 2019)
Figure 3-26: Evolution of total en-route vertical flight inefficiency during summer
Figure 3-27: Evolution of vertically RAD constrained airport pairs
Figure 3-28: Top 20 airport pairs with respect to total VFI
Figure 4-1: ANS-related operational performance at airports (overview)
Figure 4-2: Airport initiatives implementation status (2019)
Figure 4-3: Traffic variation at the top 30 European airports (2019/2018)
Figure 4-4: Top 30 airports and airport systems (2019)
Figure 4-5: Arrival throughput at the top 30 airports (2019)
Figure 4-6: Total throughput at the top 30 airports (2019)
Figure 4-7: Evolution of hourly movements at the top 30 airports (2009-2019)
Figure 4-8: Max. hourly movements for different runway configurations – T30 airports (2019)
Figure 4-9: Share of total en-route ATFM delay in 2019
Figure 4-10: Repartition arrival ATFM delay 2019
Figure 4-11: ANS-related inefficiencies on the arrival flow at the top 30 airports in 2019
Figure 4-12: Combined inefficiencies on the arrival flow at the top 30 airports in 2018-2019
Figure 4-13: ATFM slot adherence at the top 30 airports in 2019
Figure 4-14: ANS-related inefficiencies on the departure flow at the top 30 airports in 2019
Figure 4-15: Combined inefficiencies on the departure flow at the top 30 airports in 2018-2019
Figure 4-16: Average time flown level in descent/climb at the top 30 airports
Figure 4-17: Median CDO/CCO altitude vs. Average time flown level per flight (2019)
Figure 5-1: SES and non-SES States
Figure 5-2: Real en-route ANS cost per TSU for EUROCONTROL Area (€2018)
Figure 5-3: Long-term trends in en-route ANS cost-efficiency (€2018)
Figure 5-4: Trends in en-route costs, TSUs and unit costs for SES States
Figure 5-5: Trends in en-route costs, TSUs and unit costs for SES States
Figure 5-6: Breakdown of en-route costs by type
Figure 5-7: Changes in en-route cost categories - 2018 vs 2013 - SES & non-SES States (€2018)
Figure 5-8: 2018 Real en-route ANS costs per TSU by charging zone (€2018)
Figure 5-9: Geographical scope of terminal ANS cost-efficiency analysis ..............................................74
Figure 5-10: Real terminal ANS cost per TNSU at European System level (€2018) ........................................75
Figure 5-11: Breakdown of changes in terminal cost categories between 2017-2018 (€2018) ..................75
Figure 5-12: 2018 Real terminal ANS costs per TNSU by charging zone (€2018) .......................................76
Figure 5-13: Breakdown of gate-to-gate ATM/CNS provision costs 2018 (€2018) .................................77
Figure 5-14: Economic gate-to-gate cost-effectiveness indicator, 2018 ....................................................78
Figure 5-15: Changes in economic cost-effectiveness, 2013-2018 (€2018) ..............................................79
Figure 5-16: Long-term trends in traffic, ATM/CNS provision costs and ATFM delays ...........................80
Figure 5-17: ANSPs contribution to ATFM delays increase at pan-European system level in 2018 ......80
Figure 5-18: Breakdown of changes in cost-effectiveness, 2017-2018 (€2018) .........................................81

LIST OF TABLES

Table 2-1: Occurrence rates (SMI, RI, UPA) in the EUROCONTROL area (2019P) .................................25
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 2019) 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 2019, based on analysis, consultation and information provided by relevant parties. PRR 2019 also describes other activities undertaken by the PRC in 2019 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. The consultation phase was from 16 April - 13 May 2020.
1.2 PRC/PRU Tasks

The EUROCONTROL States and the European Union have a long-standing relationship and history of cooperation in ATM and in the implementation of the SES and other related policies.

Of central importance is the contribution that the EUROCONTROL Performance Review System and the Performance Scheme of the SES jointly make towards improving the overall performance of air navigation services and network functions.

The Performance Review Body (PRB) is an independent group of experts established under EU legislation. It assists the Commission in the implementation of the Performance Scheme of the SES.

The PRC, supported by the PRU, was designated as the PRB until 31 December 2016. Although this designation has ended, the ongoing co-operation and close links continue and are fostered.

The PRC and the PRB ensure that their tasks complement each other, and avoid overlaps.

1.2.1 Performance Analysis

The PRC, supported by the PRU, collects and analyses performance-related data and makes recommendations to the EUROCONTROL States. In particular, it:

- conducts research to improve long-term performance measurement and to test new indicators;
- benchmarks operational stakeholders;
- provides in-depth analysis and independent ad-hoc studies on PRC initiative and at the request of interested parties;
- ensures widespread circulation of best practices for ATM performance.

The PRC publishes an annual Performance Review Report (PRR) and an annual ATM Cost-Effectiveness (ACE) Benchmarking report. The ACE report presents yearly factual data and analysis on cost-effectiveness and productivity for Air Navigation Service Providers (ANSPs) in Europe.

In addition, the PRC also researches and analyses specific topics. Over the years, the PRC and PRU have expanded this activity, building on their extensive knowledge database and technical expertise.

The PRC’s most recent publications can be found on its webpages:

https://www.eurocontrol.int/air-navigation-services-performance-review

1.2.2 Dashboards

The PRC, in consultation with stakeholders, has adapted its outputs to make them more relevant and timely. It has created web-based Performance dashboards for its key PRR and ACE data, as well as key metrics for ANSP revenues such as en-route and terminal service units.

The web-based dashboards contain up-to-date performance data, in a user-friendly format:

- The ANS performance data portal provides monthly updates of performance information covering all 41 States. Customised reports can also be requested online, e.g. vertical flight efficiency.
- The ACE dashboard gives easy access to data, indicators and interactive graphics on European ANS cost-effectiveness.
- The Service Units Dashboard allows monitoring and interacting with en-route service units billed by the CRCO or forecasted by STATFOR and States.
- The PRU also supports the official Single European Sky SES Performance Dashboard.
1.2.3 Performance Benchmarking for non-EUROCONTROL States

The PRU works closely with a number of non-EUROCONTROL States (e.g. Brazil, China, Japan and Singapore) at their request, to develop performance benchmarking.

1.2.4 Support to the European Commission

The PRU provides support to the European Commission (EC) under a service contract, signed in 2017, which runs for four years. Activities include support to monitoring, target setting and assessment of performance plans.

The PRU also supports the EC, its Agencies and Advisory Bodies under a longer-term co-operation agreement. Activities include:

- assessment of technical compliance of unit rates and reporting on costs exempt from cost sharing;
- work on US-EU performance comparisons and ad hoc analyses at the EC’s request in support of performance and charging schemes;
- promotion of global and regional performance measurement within ICAO and other world regions;
- secondment of performance experts to the EC.

Areas of common interest can be added to this co-operation.

visit us @ https://ansperformance.eu
1.2.5 Geographical scope

Unless otherwise indicated, this report relates to the calendar year 2019 and refers to ANS performance in the airspace controlled by the 41 Member States of EUROCONTROL (see Figure 1-1), here referred to as “EUROCONTROL area”.

In 2016, EUROCONTROL signed an agreement with Israel and Morocco with a view to fully integrate both States into its working structures.

Where available, data for those two States have been included in the PRR 2019 analysis.

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

1.2.6 Report structure

The report is structured in five chapters:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Introduction and context</th>
</tr>
</thead>
<tbody>
<tr>
<td>• To provide you with the “bigger picture”, Chapter 1 informs you about the latest traffic and punctuality trends in the EUROCONTROL area.</td>
<td></td>
</tr>
<tr>
<td>• The second part takes a look at the environmental responsibility of aviation and the role of ANS</td>
<td></td>
</tr>
<tr>
<td>• The chapter closes with a review of performance trends observed over the past years in order develop a wider economic evaluation of performance and to identify future challenges.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Chapter 2 revies ANS safety performance in terms of accidents, ATM-related incidents and the rate of the key risk occurrences in the EUROCONTROL area.</td>
<td></td>
</tr>
<tr>
<td>• It also gives introduction of a methodology that could be used to measure the performance of the European ATM system, using the principle of the Composite Risk Index (CRI).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>En-route ANS performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• In this chapter you will find a detailed analysis of en-route ATFM delays including a breakdown by most constraining en-route locations and attributed delay causes in 2019.</td>
<td></td>
</tr>
<tr>
<td>• In the second part looks at the horizontal and the vertical dimension of en-route flight efficiency in 2019.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>ANS performance @ airports</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Airport capacity is one of the key challenges for future growth. Chapter 4 reviews ANS related performance at the top 30 airports in 2019 for the arrival (terminal holdings, airport ATFM delays) and the departure (taxi-out and pre departure delays) flows.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>ANS Cost-efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The final chapter evaluates ANS cost efficiency performance for 2018 (which is the latest year for which actual financial data is available).</td>
<td></td>
</tr>
<tr>
<td>• The analyses are provided for en-route and terminal services and by Air Navigation Service Provider.</td>
<td></td>
</tr>
</tbody>
</table>
1.3 European air transport key indices

The evolution of the European air traffic indices\(^2\) in Figure 1-2 shows that the positive trend observed since 2013 also continued in 2019, yet at a notably lower rate. The impact of the COVID-19 outbreak on the aviation industry remains to be seen but indications in early 2020 suggest an unprecedented reduction in traffic as a reaction on the drop in demand.

Controlled flights in the ECAC area\(^3\) increased by +0.8% in 2019 which was below the low growth scenario (+1.2%) in the STATFOR 7-year forecast published in February 2019 [2].

The lower growth rate in 2019 was influenced by the slowing economic growth in Europe; the collapse of Flybmi, Germania and Thomas Cook, and the grounding of the B737 MAX fleet.

Although airlines managed to find alternative aircraft, the grounding of the B737 MAX is estimated to amount to nearly 0.2 percentage points lost from Europe wide growth in 2019 [3].

---

\(^2\) Note that the individual indices can refer to slightly different geographical areas.

\(^3\) 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.
Since 2013, flights in the ECAC area have grown by 15.4% which corresponds to 1.5 million additional flight in 2019 compared to 2013.

As in previous years, average aircraft size (+1.7% vs. 2018) and distance (+1.7% vs. 2018) continued to grow at a higher rate than flights in 2019. This resulted in a higher en-route service unit\(^4\) growth in 2019 (+2.8% vs. 2018).

Similarly, passenger numbers continued to grow at a higher rate (+3.2% vs. 2018) than flights in 2019, yet also with a notable slowdown in the rate of growth.

Figure 1-3 provides a year on year comparison in terms of flight type, traffic segment, distance and flight hours compared to 2018. The main driver of growth in 2019 was scheduled traffic to and from Europe while intra-European traffic growth confirms the slowdown of traffic growth in Europe in 2019.

![Figure 1-3: Year on year change versus 2018](image)

Figure 1-4 shows the number of average daily flights by Air Navigation Service Provider (ANSP) in 2019 at the bottom and the change compared to 2018 in absolute (grey bars) and relative (red lines) terms at the top. The figure is sorted according to the absolute change versus 2018.

![Figure 1-4: Traffic evolution by ANSP (2019/2018)](image)

In absolute terms, ENAV (Italy), CroatiaControl, ENAIRE (Spain), HCAA (Greece), SMATSA (Serbia/Montenegro), and Austro Control showed the highest year on year growth in 2019.

Sakaeronavigatsia (Georgia), LFV (Sweden), Maastricht Upper Area Control Centre (MUAC), Skeyes (Belgium), and ANS CR (Czech Republic) showed the highest decrease in absolute terms in 2019.

---

\(^4\) Used for charging purposes based on aircraft weight factor and distance factor.
Figure 1-5 zooms in at Area Control Centre (ACC) level. The map shows that traffic decreased notably in Scandinavia due to less domestic and tourist travel as a result of a slowdown in economic growth.

ACCs in the Balkan region and eastern Italy again had high traffic growth in 2019 due to continued tourist flows to Greece and Turkey and traffic shifting from more Northern routes to avoid regulated airspace.

In order to mitigate the capacity crunch observed in summer 2018, the Network Manager implemented Enhanced NM/ANSPs Network Measures for Summer 2019 (eNM/S19) to offload traffic from congested ACCs. The initiative involved a number of ACCs which – as a result – had more or less traffic.

For instance, there was a reduction of traffic in the upper airspace in the core area (Maastricht and Karlsruhe UAC) but an increase of traffic for Langen and Munich ACCs in lower airspace.

More information on the eNM/S19 initiative is provided in Chapter 3 Section 3.2.7.

Traffic characteristics

Figure 1-6 shows the daily number of flights in the EUROCONTROL area in 2019.

The significant difference between summer and winter season but also between weekday and weekend is clearly visible.

Figure 1-7 shows the evolution of the average daily flights in the EUROCONTROL area between 2008 and 2019.

The box plots show that the peak traffic load and all quartiles increased notably between 2015 and 2018, but with only a slight increase in 2019.

The peak day in 2019 (and the highest level on record) was on Friday 28 June 2019 when the system handled 37,228 controlled flights. The peak day in 2019 was 22.5% higher than an average day.
Figure 1-8 shows the level of seasonal variation between peak and average week by ACC in 2019. In some ACCs, traffic in the peak week is more than 50% higher than in the average week. Typically this is the case for ACCs with a high share of holiday traffic peaking in summer.

Although the relationship between “traffic complexity” and ANS performance is in general not straightforward, traffic complexity is a factor for consideration when analysing performance.

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

The map in Figure 1-9 shows the annual complexity scores by ACC in 2019. As can be expected, the highest complexity levels are observed in the core area where traffic is most dense.

Figure 1-10 shows the complexity score in 2019 by ANSP, broken down into adjusted traffic density (y-axis) and structural complexity (x-axis).

As can be expected the picture is contrasted with Skyguide showing the highest level, followed by Maastricht, DFS, NATS (continental), Skeyes and Slovenia Control.

Please note that the figures shown in this section represent annual averages which may differ substantially depending on the time period analysed (e.g. daily, peak period, etc.).

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.
Traffic forecast

With the 2019–20 coronavirus pandemic sweeping its way across the globe, the entire aviation industry is facing an unprecedented challenge.

Unlike previous outbreaks (SARS, MERS) which were more regional in scope, the COVID-19 outbreak is global and nobody can answer the most pressing question, namely how long will the crisis last, how bad it will be, and how to get back to normality?

While those questions remain unanswered at the time of writing, the only option is to monitor closely the dynamic situation to take coordinated action and to prepare as much as possible for the long road back to normality.

The new STATOR forecast was due to be published at the end of February 2020 but in view of the COVID-19 outbreak in 2020 and the uncertainties attached the forecast has been postponed.

The PRC will monitor the situation and produce dedicated analyses as soon as more information becomes available.
1.4 Air transport punctuality

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.

After a continuous deterioration over the past years, arrival punctuality improved again from 75.7% in 2018 to 77.8% in 2019.

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.

Figure 1-12 provides a causal breakdown of the delays reported by airlines to better understand the drivers of departure delays5 and the contribution of ANS towards operational performance.

Average departure delay in the EUROCONTROL area decreased in 2019 by 1.6 minutes per flight to 12.8 minutes.

As in 2018, air traffic flow measures (mainly en-route related) contributed to the observed level in overall arrival punctuality in 2019. The relative share of ANS related departure delay increased slightly from 19.4% in 2018 to 20.6% in 2019.

Reactionary delay from previous flight legs accumulate throughout the day, and in 2019 were by far the largest delay category (44.4% in 2019), followed by local turn around delays (32.6%).

The network sensitivity to primary delays6 decreased in 2019 from 0.87 to 0.80 leading to the observed decrease in the relative share of reactionary 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)7.

---

5 Departure delays can be further classified as “primary” delay (directly attributable) and “reactionary” delay (carried over from previous flight legs). Different from ATFM delays, which are based on the last filed flight plans, the departure delays are based on published airline schedules. Therefore the delays are not directly comparable.

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

7 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). The data is collected from airlines and the coverage is 70% of the commercial flights in the ECAC region for 2019.
1.5 Environment

Environmental 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.

Whilst the focus of the PRR is on ATM performance, it is helpful to first set out the overall context with regard to aviation and the environment as a whole, before discussing ATM and environmental performance.

1.5.1 Aviation impact on climate

What is the problem?

The environmental impact of aviation on climate results from greenhouse gas (GHG) emissions (CO\textsubscript{2}, NO\textsubscript{x}, etc.) and contrails, generated by aircraft engine exhaust.

Figure 1-13 provides an overview of the radiative forcing\textsuperscript{9} of different contributors to climate change, as detailed in the 5\textsuperscript{th} IPCC report \[4\].

Whereas CO\textsubscript{2} emissions are directly proportional to the fuel burn, NO\textsubscript{x} emissions are more difficult to quantify as they depend on engine settings and prevailing atmospheric conditions. Moreover, the radiative forcing effect of non-CO\textsubscript{2} emissions depends on altitude, location, and time of the emission.

The remainder of this section focuses on GHG emissions of which CO\textsubscript{2} is considered to be the most important one.

Based on the figures of the European Environment Agency (EEA) aviation accounted for approximately 3.8\% of total EU28 GHG emissions (4.5\% of CO\textsubscript{2} emissions) in 2017 (the latest year for which information is available) \[5\]. Although this share appears to be comparatively small, aviation is one of the fastest growing sources of GHG emissions in Europe.

Whereas anthropogenic GHG emissions in Europe decreased by 20.6\% between 1990 and 2017 (mainly due to reductions in electricity and heat production), total GHG emissions from the transport sector (incl. aviation) grew by +28\% vs 1990, resulting in an increase of its relative share of total EU28 GHG from 16.7\% in 1990 to 27\% in 2017.

At the same time, total GHG emissions from aviation increased by 110\% compared to 1990 levels to reach 174 million tonnes in the EU28 area in 2017 (+91 million tonnes per annum compared to 1990 levels). As a result, the relative share of aviation grew from 1.4\% in 1990 to 3.8\% of total GHG in 2017.

\textsuperscript{8} GHG are the gases against which emission reduction targets were agreed under the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Global warming factors are applied to each gas in order to present the emissions in terms of CO\textsubscript{2} equivalent. For example: 1 kg of N\textsubscript{2}O is equivalent to 298 kg of CO\textsubscript{2} in terms of global warming effect. An important natural GHG that is not covered by the protocol is water vapour.

\textsuperscript{9} Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism.
The distribution by mode on the right side of Figure 1-14 shows that aviation was accountable for 13.9% of the GHG emissions from transport in 2017. By far the most important source of transport GHG emissions was road transport, which accounted for 71.7% of all emissions from transport.

The relative share of aviation is expected to further increase as aviation activity based on fossil fuels is forecast to continue to grow while other industrial sectors (including road transport) increasingly decarbonise over time.

What are the expectations?

Recognising the need to address aviation’s impact on climate, the International Air Transport Association (IATA), adopted three global goals for civil aviation in 2009 to address its impact on climate:

1. Short-term (2009-2020): average fuel efficiency improvement of 1.5% per annum;
2. mid-term: carbon neutral growth from 2020; and,
3. long term: Reduce CO₂ emissions from aviation by 50% by 2050 compared with 2005 levels.

In 2010, the International Civil Aviation Organization (ICAO) adopted a comprehensive agreement to reduce the impact of international aviation emissions on climate change with the following goals:

1. annual average fuel efficiency improvement rate of 2% up to 2050; and,
2. Carbon neutral growth of international aviation from 2020 onwards.

To achieve these goals, ICAO adopted in 2016 a global carbon offsetting scheme (CORSIA10) for CO₂ emissions above 2020 levels to address emissions from international aviation.

Additionally, ICAO agreed in 2017 on a CO₂ efficiency standard for new aircraft which limits the CO₂ emissions form aircraft to their size and weight (applicable to new aircraft as of 2020 and to in production aircraft as of 2028).

---

10 Carbon Offsetting and Reduction Scheme for International Aviation.
According to the Air Transport Action Group (ATAG), commercial aviation fuel efficiency improved by 21.4% between 2009 and 2019 which corresponds to an average annual improvement of 2% [6].

In Europe, much focus has been on environment. Emissions from aviation were included in the EU trading system (EU ETS) already in 2012 and the new European Green Deal for the European Union [7] lays out a much more ambitious plan to address climate change. One of the overarching goals is to achieve climate neutrality by 2050. To achieve this, a 90% reduction in transport emissions is needed by 2050.

How to get there?

The challenge in reducing aviation emissions is well known. Essentially there are four pillars to reduce GHG emissions from aviation: (1) Aircraft technology (airframes and engines), (2) Sustainable aviation fuels, (3) Economic measures, and (4) Improved infrastructure and operations (operational efficiency).

**Aircraft technology:** With the relative share of fuel cost in airline operational costs increasing, there has historically been a strong focus on increasing fuel efficiency. Hence the pressure to reduce fuel burn is not new but gained additional momentum through the environmental focus.

The Clean Sky Joint Undertaking is, for instance, a public-private partnership between the European Commission and the European aeronautics industry which was formed in 2008 to deliver significantly quieter and more environmentally friendly aircraft.

The latest generation of aircraft burn about 15-20% less fuel than the previous generation. Overall, fuel burn per 100 passenger kilometres fell by 24% between 2005 and 2017. The latest generation of jet aircraft has a fuel consumption of around 3 litres per 100 passenger kilometre [8].

The increasing environmental focus has added to this pressure and aircraft manufacturers find it increasingly difficult to deliver efficiency gains from design and engine improvements. Moreover, aircraft generally have a lifespan of 20-30 years which means that efficiency gains through fleet replacements will take time to filter through the entire aircraft fleet.

Electric or hybrid aircraft are an option to help decarbonising aviation but only make sense if the process is based on renewable sources. This technology is considered to be an option for short haul flights up to 1000-1500 km after which the necessary batteries will become too heavy.

Whereas the potential to substitute flights with electric or hybrid aircraft is high (70% of the departures in 2019 were below 1500 km), the impact on reducing GHG emissions is in the best case scenario limited to one quarter of the total GHG emissions from aviation (see Figure 1-17).
Hence, sustainable aviation fuels (SAF) appear to be a real option to help decarbonising aviation, especially on medium to long haul flights which cannot be substituted by electric or hybrid powered aircraft.

Biofuels\textsuperscript{11} and electrofuels\textsuperscript{12} provide the necessary energy density and can be used to power the existing aircraft fleet with only minor modifications to engines and existing infrastructure.

However, the production processes are energy intensive and blending of or switching to SAF only helps decarbonising aviation if the production is fully based on renewable sources.

As a result, SAF uptake in the aviation sector is still very limited today due to the price gap between SAF and traditional kerosene. The gap is expected to narrow with commercialisation and higher demand from the industry.

Economic measures: Essentially economic measures aim to introduce a price for carbon emissions to incentivise innovative technologies to bring down CO\textsubscript{2} emissions from aviation but also to curb demand (price elasticity of air tickets). There is a vast portfolio of possible economic measures including, global or regional emission trading schemes, specific taxes on fuel\textsuperscript{13} or tickets\textsuperscript{14}, or the application or adjustment charges to incentivise the decarbonisation of aviation.

As international aviation is not part of the Kyoto Protocol, the EU decided to include emissions from aviation in the EU emissions trading system (EU ETS) in 2012, after earlier consideration of taxation.

The initial legislation covered all flights in and out of the European Economic Area (EEA), with a cap based on average emissions in 2004-2006. Following resistance from the industry and non EU States, the EU decided to support the development of a global scheme by ICAO for reducing aviation emissions and to limit the EU ETS obligations to flights within the EEA. The EU has decided to maintain the geographic scope of the EU ETS limited to intra-EEA flights from 2017 onwards and to review the scheme to reflect progress on the development of a global scheme through ICAO [9].

In 2016, the ICAO 39\textsuperscript{th} Assembly approved CORSIA as the global market-based measure to limit and offset emissions from international aviation. Domestic CO\textsubscript{2} emissions from aviation will be addressed under the Paris Agreement which enters into force in 2020.

The CORSIA emissions baseline is the average of 2019-2020 emissions from international air traffic. Although the EU ETS baseline can be considered as more constraining as it was set when emissions were lower, CORSIA does have the advantage of being applied worldwide.

CORSIA requires monitoring of fuel consumption on international flights starting on 1\textsuperscript{st} January 2019. By 2027, CORSIA will be mandatory for all international flights between States not exempted from the scheme. To compensate for CO\textsubscript{2} emissions growth above 2020 levels in international aviation airlines will have to buy emission units from green projects to compensate excess CO\textsubscript{2} levels.

While the EU ETS and CORSIA encourage airlines to reduce emissions, contrary to the EU ETS, which is a “cap and trade” scheme, CORSIA is an “offsetting” scheme implying that emissions can grow as long as they are compensated by offsets which may reduce CO\textsubscript{2} emissions elsewhere rather than directly in the sector, but does count towards net reductions for aviation.

Even though the schemes are expected to generate large amounts of climate financing through the offsetting process (CORSIA is estimated to generate some $40 billion by 2035), it is not foreseen that the money will be used to directly support the costly transition to SAF which would directly reduce aviation’s net CO\textsubscript{2} emissions.

Figure 1-18 provides an overview of the expected contribution from the respective areas to achieve aviation’s environmental goals [8].

\textsuperscript{11} Fuels of biological origin (biomass: crops but also from waste and residues).
\textsuperscript{12} Fuels of non-biological origin (hydrogen from water is usually combined with CO\textsubscript{2}).
\textsuperscript{13} International aviation is generally exempt from excise duty on jet fuel.
\textsuperscript{14} In Europe there is a large variety of country specific environmental taxes on tickets.
Whereas more fuel efficient aircraft and operational improvements will further reduce CO₂ emissions per passenger kilometre, it is obvious that those improvements alone will not be sufficient to offset the increase in CO₂ emissions from increased aviation activity. Sustainable aviation fuels clearly is a major factor in the industry meeting its goals as the widespread adoption by airlines has the potential to substantially reduce aviation’s net emissions once the key hurdles of price and supply can be overcome.

**What can ATM do to help?**

**Optimised flights & operations:**

The ATM-related impact on climate is closely linked to operational performance (fuel efficiency) which is largely driven by inefficiencies in the flight trajectory and associated fuel burn (and emissions). For every tonne of fuel reduced, an equivalent amount of 3.15t of CO₂ is avoided.

Hence, the focus 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 CO₂ savings.

ATM deploys a number of projects and initiatives aimed at improving operational efficiency, including performance based navigation (PBN), free route airspace (FRA), collaborative decision making (CDM), and continuous climb and descent operations (CCO/CDO).

Additional efficiency gains are expected to come from the further digitalisation and automation of the industry (especially as drones proliferate) which will enable the better use of data-driven technologies like Artificial Intelligence (AI). Although there is already a significant collection of data sets in European aviation today it is not efficiently used and shared.

There is a need to further speed up digitalisation and the development of a common infrastructure for data sharing including agreed standards which is a crucial enabler for efficiency gains and the way stakeholders in the ATM system interact with each other at operational level. This is increasingly being done through system wide information management (SWIM) protocols and business to business (B2B) interfaces, including a better use of ADS-B data.

Although it is understood that there are safety and confidentiality issues that need to be solved, the better sharing of trajectory and airspace data and the increase in predictability, resulting both from the use of AI and the use of additional source of data clearly has the potential to bring further benefits for all involved parties in terms of planning (utilisation of resources) and decision making.
Figure 1-19 provides an overview of the gate-to-gate efficiency by phase of flight including an indication of the supporting ATM related projects/enablers. In view of the aforementioned close links between ANS related operational efficiency and to avoid duplication the environmental perspective is directly addressed in the respective chapters of the report.

Figure 1-19: Gate-to-gate efficiency by phase of flight

To get a high level estimate of the possible contribution of ATM towards reducing CO₂ emissions, Figure 1-20 provides a breakdown of estimated gate-to-gate excess CO₂ 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 theoretical reference trajectories\(^{15}\). It is important to highlight 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 current best estimate\(^{16}\) suggests that ATM can influence approximately 6% of the total gate-to-gate fuel burn (emissions) in the ECAC area\(^{17}\) through the optimisation of trajectories.

![Graph showing gate-to-gate efficiency by phase of flight]

Source: EUROCONTROL/MA

Figure 1-20: Estimated ANS-related gate-to-gate benefit pool (CO₂ emissions)

It is important to point out that the percentage is the ECAC average. The average masks notable

---

\(^{15}\) 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. 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.

\(^{16}\) The calculation is the current best estimate and is being continuously refined and improved to reflect new or additional data as it becomes available.

\(^{17}\) Only the share of the trajectories in the ECAC area are considered.

PRR 2019 - Chapter 1: Introduction 16
differences in performance at city pair or airline level across the network. On short haul flights operating on airport pairs with complex terminal manoeuvring areas (TMA), the inefficiency can be in some cases above 25%. Therefore, inefficiencies for individual flights, airport pairs or airlines can be notably different from this system-wide average.

If the “ANS related benefit pool” that can be actioned by ANS is related to the total GHG emissions in Europe the share that can be influenced by ANS corresponds to 0.2% of the total GHG emissions (6% of 3.8% = 0.2% of total GHG emissions).

As visualised in Figure 1-18, by far the main contribution to decouple CO₂ emissions growth from air traffic growth is expected to come from the use of sustainable aviation fuels, aircraft technology (airframes, engines) and to a lesser extent from economic measures.

Although the ANS contribution towards reducing CO₂ emissions is with around 6% of the total emissions from aviation comparatively limited in relation to total European CO₂ emissions (0.2% of total GHG emissions), the absolute numbers are significant and there is still ample scope for further ANS improvement (see Figure 1-22).

Horizontal en-route flight efficiency is the largest single component and also the only component subject to target setting in the Single European Sky, followed by inefficiencies during the arrival phase.

Considering the ATM effort required and the fact that a certain level of inefficiency will not be recoverable due to necessary operational constraints (separation minima, etc.) and interdependencies (capacity vs. flight efficiency) the ambition of the 2020 European ATM Master Plan [10] to reduce the share of excess gate-to-gate CO₂ emissions to 2.3% by 2035 appears to be challenging.

It goes without saying that the strong focus on improving flight efficiency needs to be maintained. However, considering the forecast traffic growth over the next 20 years the task for ATM will be challenging and the margins for improvement are likely to narrow as the ongoing improvement initiatives such as Free Route Airspace (FRA) are fully deployed.
1.5.2 Noise and ANS performance

Although perceived noise reduced by 75% since the first jets [8], 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 [11].

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 (Doc 9829) 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 [12].

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 interdependencies and trade-offs for instance between capacity and noise, or when different flight paths reduce noise exposure but result in less efficient trajectories and hence increased emissions.

Accordingly a collaborative approach is of paramount importance and ANS has an important active supporting role in this process. The noise management at airports is usually, but not always, under the responsibility of the airport operators which coordinate and cooperate with all parties concerned to reduce the population’s exposure to noise while optimising the use of scarce airport capacity.

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 including ANS. 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.

Noise restrictions are then usually imposed by Governments or local authorities and the level of compliance is monitored at local level.

Apart from the active support in noise management decisions, the areas where ANS can contribute to the reduction of aircraft noise are mainly related to operational procedures. Continuous climb (CCO) and descent operations (CDO), noise preferential routes and runways are all in the ANS portfolio and help to avoid unnecessary exposure to aircraft noise. CCO/CDO is addressed in more detail in Section 4.4.3 in Chapter 4.

Although the main contributions for reducing noise usually come from measures with long lead times outside the control of ANS (land use planning, reduction of noise at source), there is clearly an active role for ANS to help reducing the noise exposure of the population.

---

18 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.
1.6 **Total economic assessment (en-route)**

Under the full cost recovery regime, the focus was largely on the provision of sufficient capacity to accommodate anticipated traffic demand.

With the advent of the Single European Sky (SES) performance scheme, and the application of binding targets, ANSPs are mandated to provide sufficient capacity to meet the Network delay target whilst providing value for money for the airspace users.

The lower traffic levels following the economic crisis starting in 2008 reduced the pressure on capacity to some extent and provided a suitable environment to change the economic models for ANSPs in preparation of the start of the performance scheme in 2012.

However, with traffic continuing to grow again in 2013, also ATFM en-route delays increased first gradually and then soared in 2018 which suggests substantial shortcomings in proactive capacity planning and deployment.

While traffic in the EUROCONTROL area increased by 14.4% between 2013 and 2018, en-route ATFM delays increased by 279% to reach 19 million minutes in 2018. An increasing share of the en-route ATFM delay was attributed to Air Traffic Control (ATC) capacity and staffing issues which provides a clear indication that capacity is either not available, or not deployed, when and where needed.

Previous PRC research suggests that the ATC staffing issue is bigger than currently visible in the delay statistics due to delay cause attribution issues (see also Chapter 3 for more information).

The previously described trends are clearly visible in Figure 1-24 which provides an overview of the evolution between 2008 and 2019. While the data on en-route ANS cost for 2019 is not yet available, the actual 2019 traffic and en-route ATFM delay figures are included. The ANS costs in this section were derived from Chapter 5, where a more detailed analysis of ANS cost-efficiency is available.

**Figure 1-24: Long term evaluation of en-route ANS performance (2008-2019)**

Although average en-route delay per flight decreased in 2019, compared to 2018, the decrease is mainly in delays attributed to adverse weather and ATC disruptions (strikes).

Despite the reduction in average en-route ATFM delay, the number of flights delayed by en-route ATFM regulations continued to increase to 1.1 million in 2019, which corresponds to 9.9% of all flights and the outlook for the coming years is not promising. A comprehensive analysis of the operational en-route performance in 2019 is provided in Chapter 3.
Total en-route ANS costs (black line) remained almost flat between 2008 and 2018 mainly 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.

At the same time, flights increased by +7.4% (blue line) while en-route service units grew at a notably higher rate (+32.6%) due to a continuous increase in average flight length and aircraft mass. As a result, ANS unit costs decreased by -25% between 2008 and 2018.

So what has happened?

With the advent of the Single European Sky (SES) performance scheme in 2012 and the application of binding targets many Air Navigation Service Providers (ANSPs) shifted their focus towards cost-efficiency, especially as the lower traffic levels resulting from the economic crisis provided a suitable environment to adopt these measures.

The data in the ATM Cost-Effectiveness (ACE) benchmarking reports [13] shows that between 2013 and 2018 (provisional data), controlled flight hours at EUROCONTROL level (37 ANSPs) increased by +19.5% while ATCO hours on duty grew by only +2.2%.

Hence, overall cost efficiency and ATCO productivity (+15.3% vs 2013) improved notably during that time.

At the same time, ANSPs reduced ATCO recruitment over the past years, most likely as a reaction to the traffic downturn or as part of cost containment measures.

Figure 1-26 shows a continuous decrease in ATCO trainees levelling off in 2014/2015 with a slow change of the trend in the following two years.

Despite the increase between 2014 and 2018, which appears to be a reaction on the increasing traffic and delay levels since 2013, the number of trainees in 2018 was still 25% below the 2008 level.

The rising delay levels since 2013 suggests that the ATC capacity plans (including staffing) were not sufficient to cope with the traffic growth leading to substantial capacity shortages in some areas.

What’s the problem?

The European aviation system is a dynamic interconnected network with continuously changing capacity and demand levels. Air Traffic Management (ATM) has to safely, and effectively, accommodate airspace users’ demand in a cost-efficient manner.

In addition to the increasing pressure to reduce costs, the challenges ANSPs are facing with regard to capacity planning and deployment include (1) traffic demand evolution, (2) the comparatively long lead times to recruit and train new air traffic controllers (ATCOs), and (3) potentially substantial investments to upgrade or implement new systems.

Traffic demand, in time and space, is largely determined by airspace users’ choices but increasingly influenced by constraints, due to a lack of capacity.
Accommodating this demand requires capacity, which is determined by factors including airspace design, ATM infrastructure, ATM system capabilities, and the availability of qualified staff.

Depending on demand levels, the airspace configuration can be changed during the day. Sectors may be split when demand and hence controller workload increases or collapsed when workload decreases. The ability of an ANSP to build and deploy capacity depends on the planning horizon available.

**Strategic planning** defines system capabilities, available airspace configurations and the number of available ATCOs. Decisions are usually based on annual traffic forecasts for the next 5 years.

Inadequate strategic planning can lead to situations which are difficult to solve in the short term as ATCO recruitment and training requires a considerable lead time. For some extreme cases, the Network Operations Plan (NOP) [14] estimates capacity gaps of up to 25% in 2019, mainly due to the lack of ATCOs to open sectors during peak hours.

Although it is likely that it will take some time to close the existing capacity gaps, ATC staffing is clearly an issue which needs to be urgently addressed and managed (see also Section 3.2.5 in Chapter 3) – even more so considering the demographic profile in some ANSPs and the reduced or postponed level of ATCO recruitment over the past years.

It underlines the importance of dynamic and proactive capacity planning processes with sufficient flexibility to adjust the capacity plans as necessary and also the need to monitor that the capacity will be deployed as foreseen (i.e. availability of sufficient ATCOs to deploy full capacity when required).

**Tactical planning** is more concerned with the deployment of existing resources as determined by previous strategic decisions on the day of operations. The ability to deploy maximum capacity when needed depends on the number of available ATCOs, qualifications (licensing, rating) and prevailing staffing policies.

The introduction of dynamic shift management and a flexible roster with an appropriate planning process can simultaneously improve capacity and cost-efficiency. The ANSP challenge is to ensure adequate numbers of qualified ATCOs to meet requirements – meet current demand (including sickness, retention, and competency); prepare for future demand (including staff replacement and implementation of projects, e.g. SESAR).

Insufficient capacity will have a significant impact on airspace users and passengers in terms of delays and associated costs.

Figure 1-27 aims at providing a more complete economic picture of the en-route ANS performance by combining the ANS costs and the estimated costs of en-route ATFM delay to airspace users.

The analysis clearly shows the substantial increase in en-route ATFM delay and associated costs in 2018 and 2019 which outweigh the unit cost improvements over the past years (see also Figure 1-24).

It is estimated that en-route ATFM delay costs to airspace users were equivalent to 25% of the total en-route ANS provision costs in 2018. This underlines the importance of finding a balanced approach in performance management which considers all key performance areas equally instead of focusing entirely on one area.
As also detailed in Chapter 5, the en-route ANS cost figures up to 2018 reflect actuals whereas the costs for 2019 are based on the latest available planned/forecasted figures, which might change.

The estimated delay costs\(^{19}\) to airspace users are based on a study from the University of Westminster [15]. 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.

It is acknowledged that the analysis only considers costs of en-route ATFM delays. A holistic approach will also need to consider costs related to operational inefficiencies in the gate-to-gate phase. The PRC is working to establish a more complete picture in future editions of this report.

**What to focus on?**

In a dynamic interconnected system such as the ATM network, the ability to adapt to changing conditions (flexibility/scalability) and to mitigate effects of unexpected events (resilience) becomes more and more important. This will also help to better adjust the ATM network to economic and political turbulences, possible demand changes following the environmental debate, and not least the effect of the COVID-19 outbreak in December 2019 on aviation.

In a performance based environment it is important to ensure that cost-efficiency measures consider effective capacity planning and deployment to avoid exponential increases in delays and related costs to airspace users.

The planning and deployment of adequate capacity levels may entail a cost to be borne by the ANSP but failing to deploy sufficient staffing levels results in disproportionally higher costs to airspace users and passengers which are in most cases sufficiently high to justify adding extra ATCOs.

In the short to medium term, an increase in tactical flexibility at local ANSP level (dynamic shift management, review and optimisation of current rostering practices, etc.) could help to simultaneously improve capacity and cost-efficiency and avoid delay during peak periods.

Although en-route ATFM delay levels remain unacceptably high in 2019, close collaboration between the Network Manager, ANSPs and airspace users adds flexibility and helps to find a balanced network wide solution to mitigate the effects of the serious capacity shortfall in some areas today and in the foreseeable future. The coordinated effort of the eNM/19 measures is clearly a good step in the right direction (see also Chapter 3 for more information on operational en-route performance).

As there are limits to how many times a sector can be split to increase capacity, there is also a need to rethink the way the system is presently operated, particularly with a view to the still existing considerable level of fragmentation.

In simple terms what is needed is an increased predictability of the traffic demand on the one side (digitalisation, etc.) and a better scalability and flexibility in the deployment of capacity and staff on the supply side.

A future enabler with considerable synergy effects and benefits for the entire ATM network will be the increased digitalisation with common standards to enhance data accuracy and sharing. Data sharing will increase predictability and enable the use of new technologies such as artificial intelligence to support decision making and planning while making the best use of available resources.

\(^{19}\) 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.
Chapter 2: Safety

2.1 Introduction

This chapter reviews the Air Navigation Services (ANS) safety performance of the EUROCONTROL Member States (the EUROCONTROL area) between 2010 (or 2015 where applicable) and 2019 (note that 2019 data is only preliminary).

The review of ANS safety performance 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), i.e. the data was cross checked and supplemented with the available information from the ICAO Accident/Incident Data Reporting (ADREP). The PRC has made use, with gratitude, of the AST data provided by EUROCONTROL DECMA/PCS/SCS Unit.

Lastly, this chapter concludes with the brief summary of the PRC future work on safety performance analysis.
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.

**Accidents**

Based on preliminary data, there were 112 air traffic accidents (increase of over 25% compared to 2018) in the EUROCONTROL area in 2019, of which 9 were fatal accidents (8%).

However, out of all air traffic accidents, there were no reported accidents with direct\(^{20}\) ATM contribution or indirect\(^{21}\) ATM contribution in 2019.

**Incidents**

Figure 2-4 shows the share of incidents reported via AST in 2019, based on preliminary data.

In 2019, there were 62,333 ATM-related incidents reported through the EUROCONTROL AST mechanism, out of which 72% were operational and 28% were technical. The key risk operational occurrences share was with 3.8% Separation Minima Infringements (SMIs), followed by Runway Incursions (RIs, 3.1%), and Unauthorised Penetration of Airspace (UPAs, 10.4%).

---

\(^{20}\) 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.

\(^{21}\) 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.
Figure 2-3 shows the evolution of the number of reported occurrences between 2015 and 2019(P), including a breakdown by operational and technical occurrences.

The increase in the number of reported occurrences as of 2017 is mainly due to the 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: SMI, RI, and airspace infringements (Als)/UPAs, Table 2-1 shows the EUROCONTROL area overall occurrence rates (as reported by 36 States) for these types of occurrences in 2019.

In 2019 (based on preliminary data), SMI and UPA rates, in the EUROCONTROL area, were approximately 13.39 SMI and 34.65 UPA per 100,000 flight hours. The rate of RIs in the EUROCONTROL area in 2019 was 0.86 RIs per 10,000 movements. There is almost no change compared to 2018.

Complementary to Table 2-1, Figure 2-5 shows the underlying distribution of occurrence rates of all 36 EUROCONTROL Member States for the three categories of occurrences SMI, RI and UPAs compared to the EUROCONTROL area overall rate. 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.
2.3 Risk exposure – Composite Risk Index

In PRR 2018, the PRC presented a methodology that could be used to measure the performance of the European ATM system as a whole and its individual entities, using the principle of the Composite Risk Index (CRI).

The initial calculation of the CRI was mainly based on reported safety occurrences. More specifically, the CRI was represented as a cumulative risk value calculated aggregating all reported, assessed and severity classified key safety-related incidents to form an index. This measure of risk exposure was based on probability and severity that considers the human perception of equivalent risk. The overall idea behind the CRI was that the performance of the safety system can be analysed in three important broad categories: (1) the quality of the reporting system with reporting entity, (2) measured risks within the system, and (3) the human perception of risk (https://ansperformance.eu/methodology/cri-pi/).

The PRC has highlighted that there could be possibilities to further improve the CRI by considering specific local operating conditions, airspace size, capacity and/or complexity. For this reason the PRC expanded the methodology which now includes four distinct components (Figure 2-6):

1. Safety data (with the following parameters: number and type of safety occurrences, severity classification, and human perception of risk),
2. Traffic / exposure data (consisting of the following parameters: flight hours and airport movements),
3. Complexity (namely adjusted density, structural index and Complexity index), and
4. Reporting practices (described through parameters of reporting rate and reporting culture).

![Figure 2-6: Composite Risk Index components and their parameters](image)

Different statistical methods and expert opinions were used to form Weights for various components and parameters, ranging from optimisation methods, Principal Component Analysis and Cluster Analysis. Overall, the updated CRI methodology should now allow a better representation of the local conditions as specific parameters, such as airspace environment and its local characteristics are better captured through the inclusion of complexity, reporting culture and traffic.

The detailed technical report will be published later in 2020. Besides a detailed explanation of the methodology it will include uncertainty and sensitivity analyses which should further improve the transparency of the method.
2.4 Safety data after 2020

The first EUROCONTROL Performance Review Report published in 1998 identified that ‘across the ECAC area, significant variations exist in the scope, depth, consistency and availability of ATM safety data’. Based on this outcome the EUROCONTROL Provisional Council mandated the Agency to develop a pan-European safety regulatory system in the ATM domain, basically signing the birth certificate of the ESARR2 – ‘Reporting and assessment of Safety Occurrences in ATM’ and the associated Annual Summary Template (AST) mechanism.

Over two decades, but especially during the initial years, the AST played a major role in the identification of Key Risk Areas and the development of safety improvement initiatives in the European ATM. The AST brought significant added value to many other activities: provision of the results of safety analysis to the EUROCONTROL Performance Review activities, feedback to the ICAO Regional Monitoring Agency on the altitude deviation in the RVSM airspace, or the provision of performance related data to the EU and EASA in the framework of the Performance Scheme Regulation during Reporting Period 1 and 2 (2012-2020). Last but not least the quality of the data provided to EUROCONTROL in the ATM domain was used as a reference for the improvement of the completeness and consistency of the ATM related data stored in the European Central Repository (ECR).

To the PRC’s knowledge, this will be the last year of the AST reporting mechanism, as it is discontinued from 2020 onwards. After having played such a significant role, and contributed to many activities, this work on safety occurrence collection and reporting will be continued by EASA in their endeavour to harmonize the activities conducted in all aviation domains.

The PRC’s continued assessment of the KPAs from the Safety perspective due to lack of reliable safety occurrence data, has to be reconsidered. The PRC has held discussions with the Agency to try to ensure continued access to a reliable source of ATM-related safety data for its work post-2020. To this date, however, there are unfortunately no arrangements in place to secure a suitable reporting mechanism post-2020.

At the time when the AST mechanism has reached the end of its existence in the European ATM arena, the PRC thanks with gratitude the EUROCONTROL DECMA/PCS/SCS Unit and its AST Team, that have provided the PRC, over more than two decades, with the necessary safety intelligence to complete its important role.

2.5 Challenges to Safety after 2020

The ATM system goal is to facilitate the flow of air traffic in a seamless, efficient and expeditious way, in as safe a manner as possible by controlling safety risks, although in practice developments are often dominated by changes made to improve capacity, efficiency and cost of the system.

ATM safety has improved over the past decades for many reasons, including better equipment, more efficient operations and additional safety defences and mitigation tools. However, any further improvement of current safety performance, and even maintaining the current levels, will be extremely demanding due to numerous technological and institutional changes in the future and rising levels of traffic. These changes raise several concerns and questions that would need to be addressed before they are officially accepted and implemented in any shape and form.

As safety in aviation and in ATM is a priority; the challenge for the European ATM stakeholders is to determine what (potential) threats to safety are of concern, how these can be measured and what analyses are needed to ensure acceptable safety levels with any new developments and changes in operational concepts. Therefore, it is important to identify challenges to future ATM safety, and besides identifying how to assure the safety of the systems, processes and procedures, to also define methods and tool which would allow monitoring of the safety performance of the new system.

The ATM community will have to look deeper into questions related to the future challenges to ATM safety. For that reason, the PRC proposes to engage with the ATM community in a discussion and work in order to (1) properly identify the key risks to ATM safety in the light of the changing ATM
environment and (2) to formulate a performance approach in a risk environment, which could help in assessing safety performance in the future. This is an extremely complex undertaking, however, a prerequisite for measurement of safety performance in the future ATM environment.

The Workshop, originally planned for 16th March 2020, had to be postponed because of the COVID-19 outbreak. The PRC is currently organising alternative ways on how to gather the input from ATM Bodies and Stakeholder and organise a dialogue on this matter.

2.6 Conclusions

In 2019 (based on preliminary data), Separation Minima Infringements (SMI) and Unauthorised Penetration of Airspace (UPA) rates, in the EUROCONTROL area, were approximately 13.39 and 34.65 per 100 000 flight hours respectively. The rate of Runway Incursions (RIs) in the EUROCONTROL area in 2019 was 0.86 RIs per 10 000 movements. There is almost no change compared to 2018.

As pointed out by the PRC in PRR 2015, with the safety reporting environment changing, 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 discontinued as of April 2020. The PRC’s continued assessment of the KPAs from the Safety perspective has to be therefore reinvented due to the fact that the PRC at the moment has no access to reliable ATM-related safety data for its work post-2020. The PRC would like to thank EUROCONTROL DECMA/PCS/SCS Unit for their continuous support over the past years and their important work in supplying the ATM community with safety related data with a highest quality and completeness.

The new methodology of calculating safety risk, which has been presented for the first time last year, has been further developed. 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. The updated version of the CRI allows an assessment of the performance of a safety system considering four components: (1) the airspace environment (considering complexity of airspace and traffic demand), (2) the quality of reporting system within reporting entity (reporting practices and reporting culture), (3) measured risks within the system (based on reported safety occurrence data), and (4) human perception of risk. The technical report describing the updated CRI methodology in detail will be published later in 2020.

Lastly, the PRC has started several initiatives for the measurement of safety performance in the future ATM environment. Due to their demanding nature and the fact that careful consideration has to be given to validation processes, it might take time before reporting can be included in future PRR reports. The PRC however will regularly report on their progress.
Chapter 3: Operational En-route ANS Performance

3. Operational en-route ANS Performance

### System Trends

<table>
<thead>
<tr>
<th>System</th>
<th>2019</th>
<th>Trend</th>
<th>Change vs. 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFR flights controlled</td>
<td>11.1M</td>
<td>↑</td>
<td>+0.8%</td>
</tr>
<tr>
<td>Capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>En-route ATFM delayed flights</td>
<td>9.9%</td>
<td>↑</td>
<td>+0.3 %pt.</td>
</tr>
<tr>
<td>Average en-route ATFM delay per flight (min.)</td>
<td>1.57</td>
<td>↓</td>
<td>-0.17 min</td>
</tr>
<tr>
<td>Total en-route ATFM delay (min.)</td>
<td>17.2M</td>
<td>↓</td>
<td>-9.0%</td>
</tr>
<tr>
<td>Environment/ Efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average horizontal en-route efficiency (flight plan)</td>
<td>95.6%</td>
<td></td>
<td>+/ -0.0%pt.</td>
</tr>
<tr>
<td>Average horizontal en-route efficiency (actual)</td>
<td>97.2%</td>
<td>↓</td>
<td>-0.1%pt.</td>
</tr>
</tbody>
</table>

En-route ATFM delays decreased by 9.0% in 2019 but more delayed flights

### 3.1 Introduction

This chapter reviews operational en-route ANS performance in the EUROCONTROL area in 2019.

En-route ATFM delays decreased by 9.0% in 2019: reaching 17.2 million minutes while traffic increased by 0.8% over the same period. 2018 & 2019 had the highest amount of en route delays since 2010.

The European ANS system operated with an average en-route delay above 1 minute per flight on 206 days in 2019 which is equivalent to 56% of the days.

Together with the 6.5 million minutes airport ATFM delay (+1.8% vs. 2018), the total ATFM delay reached 23.8 million minutes (-6.3% vs. 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.
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 ATFM delay, capacity, horizontal flight efficiency and vertical flight efficiency.

ANS-related constraints are not the only constraints on the airspace users’ trajectories. For example, ATFM delays will not be the only delays affecting a flight: turnaround delays due to ground services, reactionary delays and passenger-related delays can also impact the departure time. Therefore, it is not surprising that the average departure delays in section 1.4 are significantly higher than the figures reported in this chapter.

3.2.1 ATFM delay: 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).

**En-route ATFM delays:** Following the significant increase from 2017 to 2018, total en-route ATFM delays decreased slightly in 2019.

**Airport delays:** Airport ATFM delays have stayed at a similar level over the past 5 years.

[Airport ATFM delays are addressed in more detail in Chapter 4 of this report.]

### 17.2 M min
en-route ATFM delay

(↓ 9.0% vs. 2018)

### 9.9 %
en-route ATFM delayed flights

(↑ +0.3% pt. vs. 2018)

### 1.57 min
average en-route ATFM delay per flight

(↓ -0.17 vs. 2018)

### 15.8 min
ATFM delay per en-route delayed flight

(↓ -2.3 min vs. 2018)

Total en-route ATFM delays decreased by 9.0% compared with 2018, to 17.2 million minutes, while traffic increased by +0.8% over the same period.

Although the total en-route delays were less than 2018, they were significantly higher than the total annual delays from 2013 to 2017. Although the average en-route delay decreased from 1.74 to 1.57 minutes per flight in 2019, the number of flights that were delayed by en-route ATFM regulations increased to 9.9% of all flights (+0.3 percentage points vs. 2018).

At the same time, the average en-route ATFM delay per delayed flight decreased from 18.2 to 15.8 minutes per flight.

In summary: more flights were delayed, but for a shorter average delay period than in 2018.
3.2.2 Reasons given for the en-route ATFM delays

This section reviews ATFM delays from en-route ATFM regulations and the delay cause as attributed by the local Flow Management Position (FMP), when the regulation was implemented. An alternative perspective on en-route ATFM delay attribution is presented in section 3.2.5 below.

As was the case in previous years, delays attributed to ATC Capacity (43.9%) remain the main portion of en-route ATFM delays, followed by ATC Staffing (24.3%), Weather attributed delays (21.2%), and ATC disruptions/industrial actions (7.2%).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2%</td>
<td>2.4%</td>
<td>0.4%</td>
<td>1.6%</td>
<td>0.4%</td>
<td>9.9%</td>
</tr>
<tr>
<td>0.9%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>-0.3%</td>
<td>-0.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>13.3</td>
<td>16.2</td>
<td>27.3</td>
<td>20.9</td>
<td>15.0</td>
<td>15.8</td>
</tr>
<tr>
<td>-1.7</td>
<td>-1.2</td>
<td>-5.2</td>
<td>-2.5</td>
<td>-2.8</td>
<td>1.8</td>
</tr>
<tr>
<td>7.6 M</td>
<td>4.2 M</td>
<td>1.2 M</td>
<td>3.6 M</td>
<td>0.6 M</td>
<td>17.2 M</td>
</tr>
<tr>
<td>43.9%</td>
<td>24.3%</td>
<td>7.2%</td>
<td>21.2%</td>
<td>3.5%</td>
<td>100%</td>
</tr>
<tr>
<td>0.9 M</td>
<td>-0.2 M</td>
<td>-0.2 M</td>
<td>-12 M</td>
<td>-0.7 M</td>
<td></td>
</tr>
</tbody>
</table>

In 2019, 5.2% of all flights were delayed by en-route ATFM regulations attributed to ATC capacity, 2.4% of all flights by regulations attributed to ATC staffing, and 1.6% by regulations attributed to adverse weather.

The evolution of en-route ATFM delay categories as attributed by the ANSPs, year on year, is shown in Figure 3-4.

Total en-route delay decreased in 2019, compared to 2018, mainly in delays attributed to adverse weather (-24.1%) and ATC disruptions/strikes (-13.5%).

Delays attributed to ATC Staffing decreased slightly, by 3.8%, while delays attributed to ATC capacity increased by 6.6%. [Section 3.2.5 gives a significantly different perspective.]

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

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.
3.2.3 Delays experienced by airspace users.

Figure 3-6 below shows a graphical representation of the ATFM regulations in the EUROCONTROL area in 2019. Almost 4 in every 5 flights operate without need for ATFM regulation. 1 flight in 20 is subject to an airport ATFM regulation and 1 in 6 is subject to an en-route ATFM regulation.

Being subject to a regulation does not necessarily mean that the flight is delayed - 40% of regulated flights are regulated without being delayed. 78% of all en-route regulated flights receive ATFM delays of 15 minutes or less.

However, the 22% of en-route regulated flights (just under 4% of all traffic) that are delayed by more than 15 minutes, account for 70% of all ATFM delays.

3.2.4 Most constraining ANSPs and en-route locations in 2019

In 2019, DFS (Germany) generated 25.9% of all en-route ATFM delays in the EUROCONTROL area, followed by DSNA (France) (22.9%), Austro Control (10.1%) and HungaroControl (8.3%).

The most delay generating ACCs in 2019 were Karlsruhe (17.7%), Marseille (11.7%), Vienna, Budapest, Langen and Barcelona (4.4% respectively).

Karlsruhe UAC, Marseille, Vienna and Budapest together generated half of all en-route ATFM delays in 2019.

As in previous PRRs, Figure 3-8 below shows the ACCs in the EUROCONTROL area that, in 2019, had more than 30 days of an average en-route ATFM delay >1 minute per flight.

Figure 3-7: Share of total en-route ATFM delay in 2019

Source: EUROCONTROL/PRU
https://ansperformance.eu

Figure 3-6: Temporal distribution of ATFM delays (2019)
Within the EUROCONTROL area there were 206 days when the network en-route delay per flight was above 1 minute (+22 vs. 2018).

As in 2018, Karlsruhe UAC remains the main bottleneck with 254 days when the average en-route ATFM delay per flight >1 min.

Brest, Maastricht, Prague, Canarias, Zurich and Beograd are no longer on the list, having appeared in 2018.

Kosovo, Bremen and Bordeaux appear on the list for the first time with 139 days, 105 days and 31 days respectively.

Figure 3-9 shows the share of flights delayed by en-route ATFM regulations within each ACC in 2019.

At least one flight in every ten passing through either Karlsruhe UAC or Budapest ACC were delayed by en-route ATFM regulations in 2019.

Figure 3-10 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, when taken from the perspective of total ATFM delay.

In 2019, notable decreases in peak throughput can be observed in Karlsruhe UAC, Reims ACC and Budapest ACC.
Figure 3-11 provides an overview of en-route ATFM delay in each ACC and the evolution compared to 2018.

Budapest, Brussels, and Bremen ACCs had a notable increase in delay despite lower traffic levels in 2019.

Performance at Karlsruhe UAC improved compared to 2018 but with less traffic and a notable reduction of delay attributed to adverse weather.

The decrease in traffic at Karlsruhe UAC was a direct result of efforts to reduce demand in light of the significant reduction in available capacity at Karlsruhe UAC over recent years.

Such efforts include the eNM measures which are discussed in section 3.2.7 below.

3.2.5 Alternative perspective on en-route ATFM delay attribution

Delays attributed to ATC Staffing are a significant portion of en route ATFM delays in the network (24% of total delays). Simply put, capacity constraints due to ATC staffing are when there is a lack of suitably qualified ATC staff to provide the required capacity.

A shortage of ATC staff may result from corporate decisions on rostering, may be last-minute (e.g. sickness) or may possibly be due to training purposes where an ATCO-in-training is not yet able to safely handle the declared capacity of the elementary sector.

In the first two cases the ANSP operates a collapsed sector (two or more elementary sectors combined) which provides less capacity to airspace users than would be available if the sectors were open individually. In the final instance the ANSP would operate the elementary sector at a reduced capacity.

The PRC decided to review the ATFM delays attributed to ATC staffing throughout the network in general, and at the 10 ACCs listed in Figure 3-11 above, to identify the deployed sector configurations (i.e. collapsed sectors) where the ANSPs admit that additional capacity could have been deployed if qualified ATC staff were available.

The relative allocations of delays both network-wide and within the 10 ACCs is very consistent: ATC staffing is 24-25% of the total delays. ATC capacity accounts for 46-47% of delays and 22-23% of delays were attributed to adverse weather.

The PRC then reviewed the ATFM delays attributed to adverse weather and to ATC capacity in the same ACCs. The PRC observed that a significant portion of those delays occurred in the same sector configurations where the ANSPs have already flagged that the capacity constraints are due to the unavailability of qualified ATC staff (ATC staffing).

It would therefore appear that ATC staffing and deployment, an issue under the full control of the ANSP, is often an aggravating factor in capacity constraints that are totally attributed to ATC capacity and even to adverse weather.

The PRC recalls that some ANSPs consider capacity constraints due to adverse weather to be outside their responsibility. The PRC recalls the principles provided in the rationale of its recommendations from PRR 2017 and PRR 2016 where “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”, and “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.”

Identifying those instances where ATC staffing was responsible, in whole or in part, for the capacity constraints leading to the ATFM delays presents a very different picture of ATFM performance at the list of ACCs, and for the network, as shown in Figure 3-12.

![Figure 3-12: ATFM delay attributed by ANSP and revised attribution (2019)](image)

### 3.2.6 Evolution of declared capacity (2012-2019) in bottleneck locations

The PRC has previously highlighted the need to plan and implement additional capacity to mitigate or resolve capacity bottlenecks within the Network.

Every year the ANSPs publish capacity plans in the Network Operations Plan (NOP) following dialogue with the Network Manager in light of future traffic growth and, where relevant, required levels of capacity performance.

The PRC reviewed the en route ATFM regulations from 2012 to the end of 2019. The individual ATFM delays (all delay causes) attributed to each reference location over the 8 year period were aggregated and ranked in terms of the overall total, from highest to lowest. The top 20 reference locations with the greatest amount of ATFM delays over the 8 year period can be grouped as follows: Belgium (Brussels UIR -2 sectors [Maastricht UAC]); Germany (Langen FIR – 1 sector), (Rhein UIR – 6 sectors); Netherlands (Amsterdam FIR – 1 sector); Cyprus (Nicosia FIR – 2 sectors); Croatia (Zagreb FIR – 1 sector); Spain (FIR/UIR Barcelona – 2 sectors); France (UIR France- 5 sectors [Reims ACC-1; Paris ACC-1; Brest ACC-3])

The declared capacity of an ATC sector is the nominal amount of traffic that can be safely handled during normal activities. ANSPs provide the Network Manager with the declared capacities of individual sectors in a static format.

Declared capacities can be viewed as the level of capacity that airspace users can expect within an ATC sector. When an ANSP increases capacity in a sector (for example by redesigning airspace, reducing ATCO workload, or improving technical equipment (e.g. implementation of radar)) the declared capacity of the sector should increase accordingly.

The PRC reviewed the declared capacity for the top 20 reference locations (total ATFM delay) published annually over the 8 year period. The findings and PRC observations are as follow:

**Germany:** One elementary sector: Wurzburg 325-355, high traffic demand but only 2% growth in declared capacity over entire period.
Six collapsed sectors (2/3 sectors combined): with exception of EDGG1 sector, no increase in declared capacity after delays became a problem for any sector. Significant capacity gains can be realised from operating the separate sectors – indicating that staffing is significant contributory factor.

![Figure 3-13: Evolution of declared capacity (2012-2019) in bottleneck locations (Germany)](image1.png)

**France**: Two elementary sectors: Paris UJ sector, high traffic demand, low-medium sector throughput 9% reduction in sector capacity over period; Brest NU sector, high traffic demand, low-medium sector throughput 9% increase in sector capacity over period.

Three collapsed sectors (2/4 sectors combined): no increase in declared capacity over period, reduction of 3% in Brest MZU, despite implementation of ERATO project. Capacity gains can be realised from operating the separate sector – indicating that staffing is significant contributory factor.

![Figure 3-14: Evolution of declared capacity (2012-2019) in bottleneck locations (France)](image2.png)

**Belgium** (MUAC): Two collapsed sectors (Brussels East High & Olno), high throughput, high traffic demand, frequently impacted by activation of segregated airspace – both showed significant growth over period (+13% and +10% respectively).

**Netherlands**: EHAACBAS sector: not an operational sector. Used to regulate traffic landing at Schiphol whilst attributing delays to entire Amsterdam FIR, including part controlled by MUAC. Impossible to identify specific sector where capacity constraint required application of ATFM regulation.

**Spain**: Two collapsed sectors, medium throughput. No growth in declared capacity over period. Significant capacity gain can be realised by operating separate sectors, indicating that staffing is contributory factor.

**Croatia**: Collapsed sector - 3% growth in declared capacity over period but 2019 level is lower than 2014. Medium throughput.
**Cyprus:** Two collapsed sectors, low throughput. LCCS1 shows 4% growth in declared capacity over entire period but none since delays became a problem. LCCCES0 shows 11% reduction in declared capacity over period.

**Figure 3-15: Evolution of declared capacity (2012-2019) in bottleneck locations (Other)**

**PRC observations on evolution of declared capacity.**

The PRC is disappointed to observe that so many of the most constraining sectors over the period 2012 – 2019 are collapsed sectors, where additional capacity could have been deployed if qualified ATC staff had been available.

The PRC does not understand how five of the most constraining sectors have not had any increases in capacity over the last 8 years, and how three of those are declaring less capacity in 2019 than was already existing in 2012.

The PRC notes that Amsterdam ACC routinely allocates ATFM delays to airspace that lies partially outside its area of responsibility, EHAACBAS, making it impossible to identify where the actual capacity constraints exist.

The PRC finds it difficult to correlate the above situation with the capacity plans that are published annually by the ANSPs. The question that arises is: how can ANSPs claim to increase capacity if they do not increase the capacity of the sectors that are causing the capacity constraints?
3.2.7 eNM initiative – Network Manager perspective

The Enhanced NM/ANSPs Network Measures for summer 2019 (eNM/S19) were implemented at the end of April.

This set of ATFM measures was aimed at reducing summer delays by removing traffic from congested areas, either by re-routing or level-capping flights. The traffic re-routing objective of the initiative was well achieved and airlines were spared much of the disruption of the previous summer. The constrained ACCs benefited from a decrease in traffic complexity. Since implementation, traffic has been reduced in Karlsruhe (-3%), Maastricht (-1%) UACs and Bremen (-3%).

Without the eNM measures, NM estimated that en-route delay per flight in summer 2019 could have reached twice the level of 2018.

Re-routes and flight level caps on traffic meant that the eNM/S19 initiative had an impact on fuel burn on the city pairs affected by the RAD measures since the start of the summer.

An impact analysis of the eNM/S19 initiative was performed by the operations planning unit of NM. The city pairs subject to each category of RAD measures were identified. The fuel burn estimations were based on operational flight data.

According to NM estimates, the routes potentially impacted by horizontal re-routing measures (3% of the daily traffic in the network) resulted on an additional route length per flight of 1.62 NM and an average increase in fuel burn of 11 kg per flight.

As for level capping measures, there were two main types of restrictions: departures / arrivals subject to a level cap before they exit airspace where the level cap existed (typically only for 10-15NM); and city-pair restrictions where the change in level could be in the region of 4000 feet. The routes potentially affected by flight-level measures represented 4% of the traffic and had a higher average increase in fuel burn of 12 kg per flight throughout the summer. However, when looking at certain city-pairs affected by FL measures (e.g. some German domestic routes), the fuel increase was significantly higher but these represented only a fraction of the traffic affected by the measures.

The total environmental impact for the 6 months of the initiative was estimated by the NM to be over 16 thousand tonnes of additional CO₂. Some airspace users expresses their concerns that the estimated numbers computed by NM are too conservative with a higher fuel burn due to the implemented measures.

Although the initiative prevented an even higher increase in en-route ATFM delays in 2019, 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 congested in many areas and solutions some time from deployment, a collaborative, network centric, approach will be an important enabler to manage the forecast rising demand levels over the coming years.

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.
3.2.8 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.

As fuel is a big share in airlines’ operating costs, there has been a considerable focus on reducing fuel burn over the past years. Those economic considerations are now supplemented and reinforced by the additional environmental focus, which makes reducing fuel burn even more important.

ANS has clearly a role to play because of the constraints which are imposed due to capacity and safety considerations. These constraints limit the choices available to the airspace users.

3.2.8.1 Horizontal en-route flight efficiency

The horizontal en-route flight efficiency indicator is computed for three different trajectories: (1) the actual flown trajectory, (2) the planned trajectory according to the flight plan and (3) the shortest constrained route\textsuperscript{22} provided by the NM. It is expressed as a ratio of distances and is therefore an average per distance within a given airspace (distance achieved per distance flown).

The shortest constrained route (SCR) reflects the effect of the constraints imposed by ANSPs (route structure, airspace availability, etc.) on flight planning. It is not influenced by weather conditions or specific airline considerations, and it sets the limits within which the airlines can optimise.

The filed flight plan takes into consideration not only those constraints, but also other factors which are linked to airlines’ preferences (including cost considerations and trade-offs). The filed flight plan must always be at least as long as, if not longer than, the SCR.

Finally, the actual flown trajectory is based on the flight plan but is influenced by unforeseen or unplannable factors at the time of filing, including weather and tactical ATC routings. Some of these modifications might lead to a lengthening of the trajectory, while others will lead to a shortening of it.

The high level picture

Figure 3-17 shows that the average horizontal en-route flight efficiency at EUROCONTROL level\textsuperscript{23} remained relatively constant over the past five years with a slight deterioration in 2019.

As pointed out in previous PRRs, there is a significant gap between the efficiency of the filed flight plans (95.6%) and the actual flown trajectories (97.2%).

The shortest constrained routes (95.9%) are only slightly more efficient than the filed ones. This means that the flight planning processes of airspace users don’t add much inefficiencies to the ones created by the imposed constraints.

The flown trajectories are notably shorter than the ones airspace users file. They are also notably shorter than the ones they could have filed given the existing constraints in the network (shortest

\textsuperscript{22} 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.

\textsuperscript{23} The airspace analysed in this section refers to the NMOC area.
constrained route).

In 2019, the actual trajectory is on average 1.6% more efficient than the filed flight plan and still 1.3% than the shortest constrained route. Or expressed differently if airspace users would have flown the filed flight plans they would have flown an additional 156 million kilometres in 2019 (approx. 3897 trips around the world).

As already mentioned, the gap between the actual trajectory and the flight plan is affected by a number of factors. The SCR explains most of the flight plan inefficiencies, as the values of SCR and flight plan are very close so that airspace users add only marginally to the overall value. This marginal contribution has slightly decreased between 2018 and 2019.

The gap between flight plan and actual trajectory reflects a trade-off between conservative constraints in flight planning and flexibility in operations. Actual trajectories which are much shorter than the SCR imply that those same trajectories would be rejected as flight plans and indicate that flexibility more than compensates the effect of conservative constraints.

In order to better understand the EUROCONTROL wide high level annual average, Figure 3-18 provides a breakdown of the horizontal en-route flight efficiency (actual trajectories) by day and en-route ATFM delay in 2019. Each dot represents a day in 2019.

Horizontal flight efficiency is clearly worse in summer. The analysis suggests that the lack of capacity and the resulting ATFM constraints (see also eNM initiative on page 38) have a notable negative effect on flight efficiency. Days with high en-route ATFM delays tend to have notably lower flight efficiency.
timeframes considering the existing lack of capacity in some parts of the core area (see next section of this chapter).

Figure 3-19 provides a distribution of the horizontal en-route flight efficiency on airport pairs in 2019.

It shows that the vast majority of airport pairs have already a relatively good flight efficiency (measured in distance, not in flights).

Approximately 58% of the traffic was more efficient than the EUROCONTROL average in 2019.

Some 3% of the traffic had a flight efficiency of 90% or worse.

**Horizontal en-route flight efficiency by State**

Figure 3-20 provides a map showing level of horizontal en-route flight efficiency (actual trajectories) by state in 2019.

En-route flight efficiency is comparatively low in the core area where traffic density is highest and where Free Route Airspace (FRA) is not yet implemented (see Figure 3-21).

FRA is expected to be one of the main contributors towards improving horizontal en-route flight efficiency as it provides airspace users with more choices to optimise their flight plans.

According to the European ATM Master Plan [10] and supported by Commission implementing regulation (EU) No 716/2014 [16], Free Route Airspace on a H24 basis should be implemented above flight level 305 throughout the entire EUROCONTROL area by 2022.
In view of the high traffic volume, expected savings in terms of fuel burn and CO₂ emissions following the FRA implementation in the entire core area are high.

Nonetheless it is important to point out that the overall benefits that can be expected vary by airspace and depend, inter alia, on traffic volume and growth, complexity and other factors.

Figure 3-22 shows the level of flight efficiency in actual trajectories (x-axis) and filed flight plans (y-axis) by State in 2019. States in which FRA is fully or partly implemented are shown as a red dot.

The benefits are clearly visible. On average, States were FRA has been implemented show a 0.5% higher flight efficiency compared to the other states.

Moreover, it can be seen that the gap between the flight plan efficiency and the efficiency in actual flown trajectories (vertical distance between a dot and the diagonal arrow) is narrower than for the other States. Actual operations closer to plan improves the level of predictability for all players involved with a positive impact on capacity and resource utilisation. The gap is clearly more prominent in those States where FRA has not been fully implemented all day. Although the continued FRA implementation is expected to bring further benefits over the next years there are also other areas that need to be addressed.
Figure 3-23 shows a map of the 10 most penalising airport pairs in 2019 in terms of total additional flown distance (driven by the level of inefficiency and the number of flights on the airport pair).

The light green areas in Figure 3-23 indicate FRA airspace and the brown areas represent restricted/seggregated airspace. The analysis shows that flight efficiency is not only affected by the level of FRA implementation but also by the need to integrate military objectives and requirements in the ATM system.

To meet their national security and training requirements, while ensuring the safety of other airspace users, it is occasionally necessary to restrict or segregate airspace for exclusive use which may conflict with civilian objectives to improve flight efficiency as flights must then detour around these areas.

Through the implementation of the Flexible Use of Airspace (FUA) concept – which is included in EU legislation since 2005 [17] – civil and military requirements should be coordinated through a dynamic CDM process which culminates in the publication of the daily European Airspace Use Plan (AUP) on D-1 and Updated Airspace Use Plans (UUP) on the day of operations. The AUP and UUP activate Conditional Routes and allocate Temporary Segregated Areas and Cross-Border Areas for specific periods of time.

Previous PRC research on the level of civil military cooperation and coordination [18] suggested that there is still ample scope for optimisation in terms of processes and information flows. Although FRA implementation will help to file more efficient trajectories to avoid segregated areas, it will not improve the information flows necessary to optimise the use of segregated airspace in Europe. Previous analysis showed that horizontal flight efficiency is better on weekends when no military training activities take place and therefore more airspace is available to be used for civil traffic. The PRC hasn’t observed any improvement in the application of FUA, providing benefits for civil traffic.

Figure 3-24 shows flights between Edinburgh and London City airport which is Europe’s least efficient airport pair in terms of total additional distance (inefficiency and volume combined). The computed level of efficiency in 2019 was 78.3% and due to the high frequency the estimated total additional distance amounted to some 476,000 kilometres in 2019.

The example illustrates nicely how the various factors affect flight efficiency. The filed flight plans (blue lines) are affected by military airspace but also by the terminal interface (make a big detour to enter the London TMA from the south-east).

The actual flown trajectories (red lines) were then improved on a tactical basis in coordination with ATC resulting in the observed gap efficiency gap between filed flight plans and actual trajectories.

As the flight efficiency indicator is expressed as a ratio of distances, the results do not allow to get an understanding of the total additional distance flown (inefficiency and traffic combined) in the respective airspace which is proportional to the impact on system wide performance.
To provide an additional perspective and a more complete picture of the contribution of the individual states, the total additional distance flown (top) and the average additional distance per flight (bottom) in 2019 is shown in Figure 3-25.

Moreover the analysis provides a breakdown in a local component (additional distance within a given airspace) and an interface component (additional distance related to the whole flight). The local component is always shown in dark red at the bottom of each bar.

France and Spain combine a below average flight efficiency with long average flight segments and a high traffic volume which consequently results in substantial amounts of total additional kilometres.

The four states with the highest amount of additional distance flown in 2019 (France, Spain Continental, UK Continental, and Germany) accounted for more than half (53%) of total additional distance which corresponds to 143 million kilometres (approx. 3 576 trips around the world).

As illustrated in this section, the efficiency of actual flown trajectories is affected by a number of factors. Once FRA is fully implemented in the EUROCONTROL area (targeted data is 2022), further improvements will be needed to reach the ambitions laid out in the ATM Master Plan.

The additional improvements will need to come from cross-border FRA implementation, improvements in airspace availability, the avoidance of capacity shortfalls, less TMA entry/exit point penalisation, and airlines making different route choices themselves.

An overarching enabler to achieve performance improvements will be improved information flows (in terms of accuracy and timeliness) on trajectories and airspace availability in the planning and tactical phase. This will help improving the level of predictability for the benefit of all stakeholders involved with a positive impact on capacity and resource utilisation.

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.
3.2.8.2  Vertical en-route flight efficiency

The vertical component of flight efficiency gets more and more attention. Since years, the PRC has been using its methodologies to assess vertical flight efficiency [19]. More information on the methodology is available on the ANS performance data portal.

The vertical en-route flight inefficiency (VFI) follows a cyclical trend with higher inefficiency levels in summer.

Figure 3-26 shows the total VFI (in terms of total additional feet) for AIRAC cycles 06 to 09 (representing the summer periods) since 2015.

The amount of vertical en-route flight inefficiency during the summer of 2019 was again higher than previous years. Part of this increase is due to the higher number of movements.

Figure 3-27 shows the number of airport pairs and flights 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 altitude constrained flights since spring 2018. Since then, this number stayed quite stable, even though the number of RAD constraints decreased again in the beginning of 2019.

The analysis shows a notable increase in vertically RAD constrained airport pairs which appears to be the result of the measures implemented by the 4ACC initiative in 2018 and the eNM initiatives in 2019 (see also Section 3.2.7).

Figure 3-28 shows the top 20 airport pairs with respect to total VFI. The flight levels next to the arrows connecting the departure and arrival airports indicate the altitudes of the RAD constraints on these airport pairs. Fourteen (14) out of the 20 airport pairs were completely or partially below the Karlsruhe UAC and MUAC.

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.
The top 20 airport pairs with the highest amount of total vertical flight inefficiency during AIRAC cycle 1907 (June-July 2019) are shown in Figure 3-28.

![Top 20 airport pairs for total VFI (AIRAC 1907)](image)

**Figure 3-28: Top 20 airport pairs with respect to total VFI**

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

### 3.3 Conclusions

The headline figure for capacity: en-route delay was lower in 2019 than in 2018 (-9.0%), although still higher than every year since 2013. The proportion of flights that incurred ATFM delays increased to almost one in ten although the delay per delayed flight decreased from 18.2 minutes to 15.8 minutes. In summary, aircraft were delayed less but more frequently than in 2018.

Approximately one flight in six was subject to ATFM regulations and only one flight in twenty five was delayed for more than 15 minutes. However, those flights account for 70% of all ATFM delays, so there is room for lots of improvement.

As usual, the majority of ANSPs provide good capacity performance. Just four ANSPs were responsible for two thirds of en route ATFM delay in 2019: DFS (25.9%), DSNA (22.9%), Austro Control (10.1%) and HungaroControl (8.3%).

Individual ACCs had varied performance: some had higher delays with less traffic, others had lower delays with increased traffic. Not all ANSPs needed to add capacity, but there are still ACCs that cannot handle the existing traffic demand, never mind future growth.

As in 2018, the Network Manager coordinated, with participating ANSPs, a range of measures to re-route traffic (vertically or laterally) from congested areas, primarily MUAC Brussels sectors and Karlsruhe UAC – which has significantly reduced available capacity in recent years.

Until ANSPs actually address the capacity deficits within their airspace, it appears that the Network Manager will have an increasing role in coordinating such measures in the future. It must be noted however, that re-routing aircraft, either vertically or laterally, penalises the airspace users.

In effect the aviation industry is being asked to make a choice: take a long delay, or take a shortened delay with a horizontal (and vertical) penalty, when what they are really expecting is to be able to fly the desired route according to their prescribed schedule free of ATM constraints.
Previous PRRs highlighted the inconsistent manner in which ANSPs attribute ATFM delays either according to the delay cause or according to the geographical location to where the delay is being assigned. These inconsistencies make it difficult to identify the actual delay causes and therefore impede effective mitigation or resolution.

2019 was no different and the PRC analysis highlights that ATC staffing is much more of a problem, and possible solution, to capacity constraints than is currently being acknowledged by ANSPs.

Through the review of declared capacity of the most penalising locations, it is apparent that some ANSPs are failing to deploy available capacity, by relying on collapsed sectors, and are failing to add capacity in significant capacity bottlenecks – indeed there are several instances where capacity in 2019 was less than what was already declared in 2012.

The issues raised in regards to ATC staffing, combined with the reluctance of certain ANSPs to add, or deploy, capacity raises significant questions about the plausibility of ANSP capacity plans and on future capacity performance.

En-route flight efficiency has a horizontal (distance) and vertical (altitude) component, both with a high relevance for fuel efficiency and the environment.

Horizontal en-route flight efficiency at EUROCONTROL level remained relatively constant over the past five years with a slight deterioration in 2019. The efficiency of actual trajectories decreased by 0.1 percentage points to 97.2% in 2019.

The significant gap between the efficiency of the filed flight plans (95.6%) and the actual flown trajectories (97.2%) remained also in 2019. In 2019, the actual trajectory is on average 1.6% more efficient than the filed flight plan and still 1.3% more efficient than the shortest constrained route. Or expressed differently if airspace users would have flown the filed flight plans they would have flown an additional 156 million kilometres in 2019.

The efficiency of the shortest constrained routes (95.9%) is only slightly more efficient than the filed ones which means that the inefficiencies are mainly due to the constraints imposed by the route network.

En-route flight efficiency is comparatively low in the core area where traffic density is highest and where Free Route Airspace (FRA) is not yet implemented. The envisaged implementation of Free Route Airspace on a H24 basis above flight level 305 throughout the entire EUROCONTROL area by 2022 and optimised cross border implementation is expected to be one of the main contributors towards improving horizontal en-route flight efficiency as it provides airspace users with more choices to optimise their flight plans. Although expected benefits can vary by airspace, States where FRA has been implemented show a 0.5% higher flight efficiency compared to the other states and the gap between filed flight plans and the actual flown trajectory narrows which in turn improves the level of predictability for all players involved.

The average flight efficiency masks notable differences in performance at airport pair level. While the vast majority of airport pairs have already a relatively good flight efficiency there is a comparatively small share with high inefficiencies. On short haul flights operating on airport pairs with complex terminal manoeuvring areas (TMA) and affected by segregated airspace, the inefficiency can be in some cases above 25%.

Although FRA implementation will help to file more efficient trajectories to avoid segregated areas, it will not improve the information flows necessary to optimise the use of segregated airspace in Europe. As shown in previous analyses, there is further scope to improve the civil/military cooperation and coordination. Generally flight efficiency is better on weekends when no military training activities take place and therefore more airspace is available to be used for civil traffic.

Another important factor affecting horizontal en-route flight efficiency is the lack of capacity. Horizontal flight efficiency is clearly worse in summer. The more granular analysis shows that the lack of capacity in summer and the resulting ATFM constraints have a clear negative impact on horizontal flight efficiency. Days with high en-route ATFM delays tend to have notably lower flight efficiency.
The vertical component of en-route flight efficiency has been gaining more attention over the past years, not least because of the impact of measures implemented by the Network manager to mitigate delays at network level during summer 2018 (4ACC) and 2019 (eNM/19). Although difficult to quantify at network level in terms of additional fuel burn and CO₂ emissions, the analysis shows a considerably higher number of altitude constrained flights since spring 2018.

Although there are numerous initiatives aimed at improving flight efficiency underway and even with traffic growth slowing down, it appears to be challenging to meet the set ambitions within the given timeframes considering the existing lack of capacity in some parts of the core area.
4 Operational ANS Performance @ Airports

The slowest growth at the top 30 since 2013 does not prevent most indicators from slightly deteriorating.

### System Trend (Top 30 Airports in Terms of Traffic)

<table>
<thead>
<tr>
<th>System Trend (Top 30 Airports in Terms of Traffic)</th>
<th>2019</th>
<th>Trend</th>
<th>change vs. 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily movements (arrivals + departures)</td>
<td>23,649</td>
<td>↑</td>
<td>+1.7%</td>
</tr>
<tr>
<td>Arrival flow management (per arrival)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Airport Arrival ATFM Delay</td>
<td>1.14</td>
<td>➔</td>
<td>+0.1 min</td>
</tr>
<tr>
<td>Average Additional ASMA Time (without Turkish airports)</td>
<td>2.20</td>
<td>↑</td>
<td>+0.16 min</td>
</tr>
<tr>
<td>Average time flown level during descent (without Turkish airports)</td>
<td>3.2</td>
<td>➔</td>
<td>+0.1 min</td>
</tr>
<tr>
<td>Departure flow management (per departure)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average additional Taxi-out Time (without Turkish airports)</td>
<td>4.26</td>
<td>➔</td>
<td>+0.1 min</td>
</tr>
<tr>
<td>Average time flown level during climb (without Turkish airports)</td>
<td>0.6</td>
<td>➔</td>
<td>+/-0.0 min</td>
</tr>
</tbody>
</table>

#### 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.

This chapter evaluates the top 30 airports in terms of IFR movements in 2019, which have the strongest impact on network-wide performance. Together the top 30 airports accounted for 43.8% of all arrivals in the EUROCONTROL area in 2019.

The new Istanbul Grand airport became fully operational in April 2019, joining the Top 30 as the 8th busiest airport in Europe (6th in the period April-December). While all scheduled passenger traffic has been transferred from Istanbul Atatürk to Istanbul Grand airport (IATA code: IST; ICAO code: LTFM), business aviation and military flights still operate from Atatürk. It is the most important airport development in Europe since the opening of the new airport in Munich in 1992, and significant growth is expected to be observed at Istanbul Grand in line with the development plans that include up to 6 independent runways and the capacity to accommodate 200 million passengers a year, which would potentially position this airport as the busiest in the world. The new airport should also help reduce the congestion at Istanbul Sabiha Gökçen, but at the same time it will have an impact in the surrounding airspace.

Any atypical performance observed at an airport not included in the top 30 airports is commented on in the respective sections of the chapter. Despite repeated attempts to implement the EUROCONTROL’s standard Airport Operator Data Flow at the main Turkish airports, the data is still not available and consequently these airports could not be reflected in all analyses throughout this chapter.
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.

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 4-1.

![Arrival flow management](image1)

Arrival flow management
- Airport arrival ATFM delay
- Additional Arrival Sequencing and Metering Area (ASMA) time
- Average level time in descent

![Departure flow management](image2)

Departure flow management
- ATC-related departure delay
- Additional taxi-out time
- ATFM slot adherence
- Average level time in climb

<table>
<thead>
<tr>
<th>Related indicators</th>
<th>Expected benefits</th>
<th>Supporting projects/initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Airport ATFM arrival delay [ICAO GANP KPI 12]</td>
<td>• Reduction of airborne terminal holdings</td>
<td>• Continuous descent operation (CDO)</td>
</tr>
<tr>
<td>• Additional Arrival Sequencing and Metering Area (ASMA) time [ICAO GANP KPI 08]</td>
<td>• Support to fuel efficient descent trajectory</td>
<td>• Performance based navigation (PBN)</td>
</tr>
<tr>
<td>• Average level time in descent</td>
<td>• Maximise airport throughput</td>
<td>• Arrival manager (AMAN/XMAN)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arrival flow management</th>
<th>Departure flow management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ATC-pre departure delay</td>
<td>• Minimise ANS-related departure delays</td>
</tr>
<tr>
<td>• Additional taxi-out time [ICAO GANP KPI 02]</td>
<td>• Optimise push back time sequencing</td>
</tr>
<tr>
<td>• ATFM slot adherence [ICAO GANP KPI 03]</td>
<td>• Optimum taxi routing (distance &amp; time)</td>
</tr>
<tr>
<td>• Average level time in climb</td>
<td>• Adherence to ATFM departure slots</td>
</tr>
</tbody>
</table>

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

Figure 4-2 shows the implementation status (end of 2019) of some of the initiatives listed in Figure 4-1.

![Implementation status](image3)

Several projects and initiatives, whether or not part of the SESAR Pilot Common Project, have
contributed to improve efficiency and predictability. Still to be implemented widely, the Airport Operations Plan-Network Operations Plan integration (AOP-NOP), a collaborative concept developed under the SESAR programme, together with Total Airport Manager (TAM) /Airport Operations Center (AOPC) implementation are expected to allow airport stakeholders to better handle their local capacity and bring local and network benefits in terms of predictability enhancement. The AOP is a rolling plan that covers the pre-tactical and tactical phases by providing dynamic data updates as an operational situation evolves. Through the timely two-way exchange of relevant airport and network information between airports and the Network Manager, AOP-NOP integration is expected to improve both the airport’s and the network’s operational performance through enhanced situational awareness facilitating decision making. In 2020, airports like Frankfurt, Amsterdam, Madrid, Gatwick and Heathrow are working on the establishment of this AOP-NOP integration.

Improving operational performance at airports requires the joint effort of all involved stakeholders, therefore for the interpretation of the analyses in this chapter it should be borne in mind that the results are driven by complex interactions between these 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 2019 increased by 1.7% compared to 2018, without taking into account the new Istanbul airport. This corresponds to 379 additional movements each day. At the same time, the number of passengers at the top 30 airports in 2019 increased by 3.8% compared to the previous year. According to ACI Europe the highest year on year passenger growths are observed at Vienna (+17.1%), Milan (+16.6%) and Antalya (+13.6%) [20]. This goes in line with the evolution observed on the number of flights, where only three of the top 30 airports showed a traffic growth above 5% in 2019: Vienna (VIE), Milan Malpensa (MXP) and Antalya (AYT). Figure 4-3 shows the evolution of average daily IFR movements at the top 30 airports in absolute and relative terms[24].

The most significant traffic increase is observed at Milan Malpensa (+20.3%) due to the closure of Milan Linate from the 27th of July to the 26th of October for maintenance works of the runway and terminal, when Malpensa absorbed Linate’s traffic. Nevertheless, outside of that period, Malpensa still shows an important increase of almost 10% in traffic. In Vienna, Wizzair opened a base in June 2018, which together with new Anisec operation has resulted in a notable increase in traffic during 2019 (+9.9%).

On the other hand nine airports observed a decrease in traffic in 2019, five of them above 1%: Paris (ORY), Stockholm (ARN), Oslo (OSL), Palma (PMI) and Copenhagen (CPH). Airlines’ bankruptcies/cease of operations, runway works and a slowdown in domestic travel in Scandinavia are the main contributors to these reductions in traffic.

[24] The ranking is based on IFR movements, which is different from commercial movements (ACI Europe statistics).
Airport systems

Thirteen of the top 30 airports are part of a larger airport system. Figure 4-4 shows the distribution of traffic per cities where the top 30 airports are located.

London, Paris, and Istanbul are the most significant airport systems, representing a much higher share of the traffic than the airports individually show.

When capacity at an airport has reached limits and expansion is not possible, additional airports in the same area provide extra capacity, although there is a potential impact in TMA complexity.

On the other hand, some cities with only one airport, like Dublin, Lisbon and Athens show high saturation levels and limit the traffic increase to/from these destinations.
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, among other things, runway layout, mode of operation, and available runway configurations and societal factors such as noise and environmental policies.

As in previous reports Figure 4-5, compares the declared peak arrival capacities (red mark) 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.

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 [27].

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 4-5: Arrival throughput at the top 30 airports (2019)
The “peak service rate” 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 total throughput at the airport. The wider the ranges, the more spread out the distribution of the throughput.

Looking only at Figure 4-5 might give the idea that, although several airports show a narrow distribution relatively close to the maximum arrival capacity, most of the top 30 airports still could accommodate extra arrivals in the hours analysed. However, at airports where the schedule and runway configuration (i.e. single runway mixed mode) result in a balanced mix between arrivals and departures along the day (instead of alternate arrival and departure peaks), the maximum arrival or departure capacities might not be the limiting factor, but the capacity for the total number of movements. Therefore Figure 4-6 offers the same view for total throughput, where it is very clear that several airports are working at the limits of their declared total capacity (in red).

Figure 4-6: Total throughput at the top 30 airports (2019)

London Heathrow (LHR), Gatwick (LGW), Dublin (DUB), Istanbul Sabiha (SAW), Lisbon (LIS), and Warsaw (WAW) show a comparatively narrow distribution with a compact interquartile range (blue box) very close to the declared peak capacity, which suggests a constant high traffic demand throughout most of the day, leaving little room for recovery from situations when no optimal conditions apply.

Figure 4-7 shows the historic evolution of the total hourly throughputs between 2009 and 2019 (median and peak service rate). The narrow gap between peak and median throughput indicates again a narrow distribution or a continuous operation close to the peak capacity.

25 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.
Frankfurt, Amsterdam, Istanbul Sabiha and Antalya showed the highest increase in hourly throughput over the past few years. At airports like Lisbon, Warsaw or Dublin the gap between peak and median throughput is closing, showing once more the saturation some airports are reaching.

**Airport capacity imbalance**

In saturation conditions, it is important to understand the different limitations that the airports have to deliver their maximum capacity. Among all factors affecting the runway system capacity, the runway layout and configuration is considered as the most relevant. While some airport layouts allow for very similar operation conditions in one runway configuration or another, resulting in equal or similar capacities for all possible runway configurations, other layouts do not offer that balance as the different configurations might have very different operating conditions, dependencies and limitations.

To assess this potential capacity imbalance for the top 30 airports, their runway configurations during 2019 have been analysed together with their maximum hourly throughput and percentage of usage.

Figure 4-8 shows a view of this analysis per airport. Each bubble represents a runway configuration (only those used at least 3% of the time are considered) with the corresponding maximum hourly throughput (vertical axis) and share of utilization (size of the bubble).
While most airports show very similar throughput for all runway configurations, some airports present configurations with a significant share that reaches a maximum throughput significantly lower than the best configuration.

This analysis is based on the actual throughput which is also driven by demand, therefore it is not possible to conclude that these configurations are limiting the delivery of required capacity. However, it was also observed that in many cases the runway configuration had a clear impact on the performance indicators.

The runway configuration and its probability is therefore an important factor in the particular monitoring of performance for each airport, and should be considered for the planning as far ahead as possible. Runway configuration prediction models can support the decision making to minimize the impact on operations.

What is presented above constitutes only a part of the results of this study. The PRC will publish further details and results, including the impact on performance, in a Technical Note available online in summer 2020 on the ANS performance data portal.
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.

In 2019, the top 30 airports generated 75.5% of all airport arrival ATFM delay in the EUROCONTROL area, with only the first three in terms of generated delay accounting for more than 30% (Amsterdam, Lisbon and London Heathrow).

Overall, 6.1% of the arrivals at the top 30 airports were delayed by airport arrival ATFM regulations, while the EUROCONTROL average is lower (4% of arrivals)

One more year, and despite a 10 points reduction, the main reason for airport ATFM regulations was still adverse weather (47.6%), followed by insufficient Airport Capacity (23%) and ATC attributed (17.4%). The delay due to ATC related regulations or those associated to other reasons like special events, have increased significantly in 2019.

The constant efforts to increase capacity through new infrastructure, systems and procedures take an important toll during the works or the implementation phases, resulting in a detrimental effect that can be observed in both arrival metrics during those periods. It is only through careful planning, coordination and mitigation measures that airports can minimize the impact of these events on performance.

Figure 4-11 shows the breakdown and evolution per airport of arrival ATFM delay (left of figure) and the additional ASMA time (right of figure) per arrival at the top 30 European airports in 2019.

Both average **airport ATFM delays** and average additional **ASMA time** at the top 30 European airports increased by 0.05 and 0.1 minutes per arrival respectively compared to 2018, with arrival ATFM delays reaching the 1.14 minutes per arrival in 2019 and the additional ASMA times 2.17 minutes per arrival.

The most important deterioration in terms of arrival ATFM delay is observed at Athens associated to ATC capacity problems due to traffic growth combined with lack of ATCOs and other systems/tools (i.e. A-CDM) to maximize capacity and improve planning. Measures to improve the situation are planned for 2021-2022.

Amsterdam (AMS) also shows a significant increase in arrival ATFM delays (mainly due to strong winds in March, works on taxiways in May and June, and the Electronic Flight Strip system implementation at the tower in April and May), becoming the airport with the highest arrival ATFM delay in the top 30.

![Figure 4-9: Share of total on-route ATFM delay in 2019](image)

![Figure 4-10: Repartition arrival ATFM delay 2019](image)
Additional ASMA times also showed a deterioration in this period from March to July.

**ANS-related inefficiencies on the arrival flow at the top 30 airports in 2019**

![Airports Arrival ATFM Delays and ASMA Additional Time]

Figure 4-11: ANS-related inefficiencies on the arrival flow at the top 30 airports in 2019

Milan Malpensa (MXP) shows an important increase in the additional ASMA times (+1.2 min. vs 2018) due to two main factors: the additional traffic transferred from Linate from August to October due to the closure of Linate for works, and the implementation of the trombone approaches at the end of March. The closure of Linate also impacted the arrival ATFM delays, resulting in an increase of +0.3 min/arr.

The second airport with the highest ATFM delays per arrival in 2019 is Lisbon (LIS), where airspace management issues due to military activity contributed to a further increase in these delays.

At London (LGW) ATC Capacity regulations had an important effect in summer (also partially due to Staffing). A clear deterioration can also be observed in the additional ASMA times until the month of October, when XMAN started operating in cooperation with MUAC with a notable reduction of the holdings.

Madrid (MAD) arrivals observed no change in additional ASMA time, but higher arrival ATFM delay mainly due to regulations associated with ATC capacity, runway works in March, and the implementation of the new approach procedures in June-July.
In Barcelona (BCN), the absence of regulations due to special event (compared to the implementation of new approach last year) and a reduction of weather delays results in an improvement of the arrival ATFM delays in 2019.

Arrival ATFM delays at the new airport Istanbul Grand (0.30 min/arr) represent only a small part of the delays that arrivals at Istanbul Atatürk suffered in 2018 (1.84 min/arr) thanks to the increased capacity but also slightly lower traffic than Atatürk (-4% in the May-Dec period)

In both Palma (PMI) and London Stansted (STN) weather delays have significantly decreased and aerodrome capacity issues have practically disappeared, resulting in a reduction of the overall arrival ATFM delay.

There was also in 2019 a further reduction of airport capacity delays at Istanbul Sabiha (SAW) where the ATFM capacity attributed delays have evolved from almost 10 minutes per arrival in 2016 to practically zero in 2019.

Paris Orly (ORY), despite heavy works and closing one runway in August-October period, observed almost no negative impact on the performance indicators. This was achieved through careful planning and coordination which included a reduction in the schedules.

As was the case already last year, London (LHR) shows a further reduction of the additional ASMA times in 2019, mainly due to the improvement in Jan-Feb 2019 compared to Jan-Feb 2018 before the implementation of the enhance Time Based Separations using RECET-EU.

Warsaw (WAW) had a runway closed for works during part of the year, which resulted in longer arrival ATFM delay and ASMA times.

Figure 4-12 shows the combined delays affecting the arrival flow at the top 30 airports, due to both the additional ASMA times and arrival ATFM delay, and the evolution with respect to 2018. The figure can only show those airports where both metrics could be calculated (27 airports). The size of the bubble represents both delays combined.

Most of these 27 airports maintain a combined delay below the 4 minutes per arrival. However, there are several outliers that reach up to almost 9 minutes per arrival.

Amsterdam (AMS), Lisbon (LIS) and Athens (ATH) manage their flows with arrival regulations resulting in very high arrival ATFM delays, while keeping similar additional ASMA times as other airports. On the other hand, Heathrow (LHR) and Gatwick (LGW) stand out with very high additional ASMA times, having at the same time a higher than average arrival ATFM delay.

Overall, the most significant increases of the combined inefficiencies with respect to 2018 are observed at Amsterdam (AMS) and Athens (ATH) (above 2 min/arr in both cases) and Milan Malpensa (MXP) (above 1 min/arr). At the same time, Stansted (STN), Barcelona (BCN) and Palma (PMI) show combined reductions above 1 min/arr.

Regional Greek airports

Annual traffic to the Greek regional airports decreased by 1.8% compared to 2018. However the high delays remain, with Mikonos reaching the highest arrival ATFM delay in Europe (10.58 min/arrival
yearly average in 2019 and up to 22.6 min/arrival in July 2019).

Heraklion, Khania and Kos have significantly reduced their average arrival ATFM delay in 2019, but the positive effect is neutralised by the increases observed mainly at Rodos, Santorini and Mikonos.

Although the capacity constraints and the layout limitations at most of these airports are well known (in terms of runway exits, parallel taxiways and parking stands, and also terminal building capacity), the ATFM delays attributed to Airport Capacity only represent 3% of the total, whereas most of them are attributed to ATC Capacity (68%) and ATC Staffing (25%) issues. Improvement is expected from 2020 onwards with additional ATCOs.

The situation at Athens airport, with heavy arrival regulations and departure delays, has an adverse knock-on effect impacting the predictability at the regional airports.

The Network Manager, in cooperation with 14 of these regional airports is developing a system to foster the integration in the ATFM process. The plan includes the deployment of ADS-B receivers and the data exchange between the airports and NM during the summer of 2020, with the objective of improving the operational performance through common situation awareness enhancement.

### 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 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.

After 3 years of significant increase, the share of ATFM regulated departures at the top 30 European airports in 2019 (24.3%) slightly decreases with respect to 2018 (25.2%) (brown bar in Figure 4-13).

![Figure 4-13: ATFM slot adherence at the top 30 airports in 2019](image)

On the other hand, the share of regulated flights departing outside the ATFM slot tolerance window at these airports continues to decrease, from 6.1% in 2018 to 5.5% in 2019 which is positive in terms of network predictability.
Turkish airports, together with Paris Orly, continue to show the highest share of departures outside the ATFM slot tolerance window in 2019. However, the new Istanbul airport shows better slot adherence (11.7% departures outside of the ATFM window) than the previous Atatürk (19.3% in 2018). There is also a notable improvement at Istanbul Sabiha (-5 pp).

The sharing of Departure Planning Information (DPI) messages with the Network Manager by A-CDM airports or Advanced ATC Towers, helps improve the predictability of the network through more accurate take-off information.

In 2019, a total of 50 airports (27 A-CDM and 23 Advanced Tower) provided DPI messages to the Network Manager (44.8% of the departures in the EUROCONTROL area). Although London Gatwick and Stockholm Arlanda are A-CDM implemented, the DPI messages were temporarily suspended. Once they re-connect to the network, the provision of DPI messages will reach 47.4%.

Lisbon became an A-CDM airport in April 2019, showing a reduction in departures outside of the ATFM window (-5%). More airports (i.e. Warsaw) are planning implementation in the near future, which will further improve local performance and network predictability.

4.4.2.2 ANS-related inefficiencies on the departure flow

Figure 4-14 shows the local ATC departure delays and the taxi-out additional time at the top 30 airports in 2019. The average additional taxi-out time only increased by 0.01 minutes per departure in 2019 (excluding the Turkish airports for which no data was available), resulting in 4.22 min per departure.
ANS-related inefficiencies on the departure flow at the top 30 airports in 2019

Overall, 12 of the 27 airports for which data was available reported an increase in additional taxi-out time in 2019. As in 2018, the highest levels of average additional taxi-out times were observed at London (LHR), London (LGW), Rome (FCO) and Dublin (DUB), while the most notable year on year deterioration was observed at Malpensa (MXP) (+0.9 min vs. 2018), directly associated with the events impacting also the arrival flow performance (closure of Linate airport and implementation of new approach procedures).

London (LGW) and Rome (FCO), where additional taxi-out times were already high, registered also a significant increase. The runway closure at Warsaw (WAW) from March to June due to the construction of the new Rapid Exit Taxiway (RET) and double holding points had a strong impact in the additional taxi-out times, with an average increase of 1.1 minutes during those months.

Notable year on year improvements were observed at Palma (PMI) (-1.0 min vs 2018) followed by Stockholm (ARN), Berlin (TXL) and Barcelona (BCN).

As can be seen on the left side of Figure 4-14, data for the computation of local ATC pre-departure delay is still either not available or does not reach the minimum quality threshold for 7 of the top 30 airports. Despite multiple efforts and the new EUROCONTROL specification for the collection of
operational data at airports, there has been no improvement in the reporting of most of the concerned airports [17].

Lisbon (LIS) remains the airport with the highest ATC pre-departure delays (4.2 min/dep). Gatwick (LGW), Zurich (ZRH) and Warsaw (WAW) observe each an increase of 0.5 min in ATC departure delay in 2019.

Figure 4-15 shows the combined delays affecting the departure flows, due to the additional taxi-out time together with the ATC pre-departure delay, and their evolution with respect to 2018. The figure can only show those airports where both metrics could be calculated (23 airports). The size of the bubble represents both delays combined.

In the absence of London Heathrow (LHR) (the data quality does not allow the calculation of the ATC pre-departure delay), it is clear that most airports form a cloud where the combined delays sit below 6 minutes per departure. However, 4 airports (London Gatwick (LGW), Rome (FCO), Dublin (DUB) and Lisbon (LIS)) stand out with a total delay of 8 to 10 minutes per departure.

There is a general deterioration with respect to 2018. Gatwick (LGW), Warsaw (WAW) and Milan (MXP) have increased their combined delays by more than 1 min/dep with respect to 2018, while the best reductions (Stockholm (ARN) and Copenhagen (CPH)) are well below the min/dep.

![Figure 4-15: Combined inefficiencies on the departure flow at the top 30 airports in 2018-2019](image)

### 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 [21].

Free tailored analyses for many European airports are available from the online reporting tool accessible through the ANS performance data portal.

Figure 4-16 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 3.2 minutes per arrival compared to 0.6 minutes per climb out.

Flights arriving at Frankfurt (FRA), Paris Charles de Gaulle (CDG), London Heathrow (LHR), London Gatwick (LGW) and Paris Orly (ORY) showed the highest amounts of time flown level with more than 5 minutes of level flight on average in 2019.
Vertical flight efficiency during descent deteriorated significantly at Munich (MUC) and Milan (MXP) in 2019. Traffic and the additional ASMA times increased for Milan Malpensa (MXP) since April 2019 due to the implementation of the trombone approaches and also an increase in traffic diverted from Milan Linate (LIN) during its closure from 27th of July until the 27th of October. Notable efficiency improvements were observed at London Heathrow (LHR).

Vertical flight efficiency during climb stayed relatively stable in 2019 with increases at Zurich (ZRH) and Vienna (VIE).

![Average time flown level - top 30 airports (2019)](image)

**Figure 4-16**: Average time flown level in descent/climb at the top 30 airports

Figure 4-17 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 4-17.
As usual, 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. The results for climbs out of London Heathrow have however improved, mainly in terms of median CCO altitude.

Vertical flight efficiency during descent at Helsinki (HEL), Oslo (OSL) and Lisbon (LIS) 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), Frankfurt (FRA), Paris Charles de Gaulle (CDG), London Heathrow (LHR) and London Gatwick (LGW) are the airports with the worst vertical flight efficiency results during the descent.

4.5 Conclusions

The situation at airports appears stable but uneven with some airports at, or close to, saturation levels. Traffic growth in 2019 was the weakest (+1.7%) since 2013 with 9 of the top 30 airports actually showing reduction in traffic. In the current airline market, the biggest traffic fluctuations at airports are in fact driven by airlines pulling out or going bankrupt. The impact of the COVID-19 outbreak on the aviation industry remains to be seen but indications in early 2020 suggest an unprecedented reduction in traffic as a reaction on the drop in demand.

The list of the top 30 remains unchanged with respect to 2018, except for Istanbul Grand replacing Istanbul Atatürk as operations were transferred from one airport to the other in April 2019.

Once more the number of passengers in 2019 grew faster than movements (+3.8% vs 2018) and although 9 airports showed less traffic, only 3 airports saw fewer passengers. Vienna had 17.1% more passengers than in 2018 thanks to new airlines’ operations, and Milan Malpensa saw an annual increase in passengers (+16.6%) due to the transfer of operations during the closing of Linate. Antalya, as in 2018, continued experiencing high passenger growth (+13.6%).

In 2019, 6.1% of all arrivals into these top 30 airports were delayed by arrival ATFM regulations, 0.3 percentage points more than in 2018. Although in average there was a slight deterioration in arrival ATFM delay (increasing from 1.09 to 1.14 minutes per arrival in 2019), the trend is heterogeneous among the airports. The most significant increases were observed at Athens (due to ATC capacity issues) and Amsterdam, that now shows the highest arrival ATFM delay per flight in the top 30 and is the biggest contributor to European airport ATFM delays.
Arrivals into Istanbul airports, that four years ago suffered the highest airport ATFM delays in the top 30, have now some of the lowest delays. However, the tactical holdings and delays both on the ground and on the air cannot be analysed. There are three Turkish airports in the top 30 representing 9% of the traffic. Due to the missing flow of airport operational data, the performance review at these airports is very limited. High level intervention is expected in this concern by the PRC.

The average additional ASMA times at the top 30 airports also increased in 2019 from 2.07 to 2.17 minutes per arrival. London airports Heathrow and Gatwick, despite improvements observed at Heathrow, still stand out with the highest additional ASMA times (7.0 and 4.6 minutes per arrival respectively), associated with a high TMA complexity at the biggest airport system in Europe and a maximization of runway capacity usage.

Although Lisbon was the only airport which implemented A-CDM in 2019, there are different projects to integrate airports in the network besides the full A-CDM implementation, like Advanced Towers or some specific projects planned in collaboration between NM and the airport operators aimed at sharing departure information based on ADSB data. As a result, each year more airports share their departure information with NM (currently almost 45% of departures share DPIs with NM) which helps improve slot adherence and network predictability. Turkish airports still show poor performance in this sense.

The average additional taxi-out time at the top 30 airports increased from 4.21 to 4.22 minutes per departure in 2019. Significant variations at airport level were directly related to special circumstances. ATC pre-departure delays, where measurable, showed as well noteworthy increases at some airports.

In this respect, the most significant deteriorations observed in the different performance indicators were associated to specific events, mainly works on the runway systems or implementation of new systems or procedures. Mitigation measures and careful planning are to be considered to avoid this detrimental impact on performance, following examples like Paris Orly, where runway 08/26 was completely rebuilt in the second half of the year and several measures were put in place to guarantee the level of service, including a reduction of the available slots. This resulted in no impact on arrival delays although there was a significant increase in additional taxi-out times during those months.

Planned developments during summer 2020 at already saturated airports (i.e. new runway construction at Dublin) are to be monitored carefully. Airports (like Dublin) implementing their own performance frameworks in collaboration with ANSPs and airlines in order to provide constant performance monitoring, together with the AOP-NOP integration and introduction of APOC/TAM, are expected to improve coordination and mitigation in the future.

Increasing predictability both at network and airport level however will not be enough to solve the capacity problem at some saturated airports where the infrastructure is the main constraint for growth and, at the same time, the development of new runways is extremely restricted due to environmental issues.

With respect to vertical flight efficiency during climb and descent, only slight increases were observed except for the arrivals into Munich (MUC) and Milan (MXP). Arrivals and departures into/from London (LHR) have on average experienced less level flight than in 2018.
## 5.1 Introduction

This chapter analyses ANS cost-efficiency performance in 2018 (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\(^2\) operating 38 en-route charging zones\(^3\) 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 2018 has already been scrutinised in accordance with the SES Regulations and the results have been reflected in the Performance Review Body (PRB) 2018 monitoring report\(^8\). 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 and aggregates it with the information provided by the non-SES States to present a pan-European view.

---

\(^2\) This is different from the 41 EUROCONTROL Member States in 2018 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.

\(^3\) 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).

\(^8\) 2018 Annual Monitoring Report is available online on [EU SES Performance website](https://www.eurocontrol.int/)
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’ 2018 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 2018, the financial indicators presented in sections 5.2, 5.3 and 5.4 are expressed in Euro 2018\(^2^9\).

### 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 2018 (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 [22] aiming at incentivising economic performance and driving cost-efficiency improvements.

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 2018 (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 2018.

5.2.1 Trends in en-route cost-efficiency performance at pan-European system level

The trend analysis presented in this sub-section focuses on the 37 en-route charging zones that consistently provided en-route costs data over the 2013-2018 period\(^3^0\).

Figure 5-2 shows that in 2018, at pan-European level, en-route ANS costs increased by +1.8%. This cost increase was compensated by robust TSU growth (+6.2%), resulting in a reduction of en-route unit costs (-4.1%) compared to 2017. This is the sixth consecutive year of reducing en-route unit costs at pan-European system level (-22.8% overall compared to 2012).

---

\(^2^9\) More information on the treatment and presentation of financial values for the purpose of this Report is available on p. 56 of PRR 2018 [23].

\(^3^0\) 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 [25]. 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 2013-2018 presented in this section. On the other hand, Georgia data is reflected in analysis of changes between 2017 and 2018.
Between 2013 and 2018, en-route unit costs for pan-European system reduced by -4.4% p.a., on average. This is a result of a slight increase of en-route ANS costs (+0.6% p.a.), in the context of continuous TSU growth over the entire period (+5.3% p.a.).

-36.0% reduction in en-route ANS unit costs between 2003 and 2018

Figure 5-3 shows the long-term trends in terms of en-route costs, en-route service units and en-route costs per TSU between 2003 and 2018.

Over the whole period, en-route TSUs grew much faster (+3.6% p.a.) than en-route costs (+0.6% p.a.).

As a result, the en-route costs per TSU decreased by -2.9% p.a. between 2003 and 2018 (or -36.0% over the entire period).

A more detailed analysis on historical cost-efficiency performance is available in PRR 2018 on p. 57 [23].

These long-term trends, however, mask the different dynamics observed for SES and non-SES States.

The analysis provided below focuses on the 2013-2018 period and highlights the observed differences in en-route cost-efficiency performance between the SES and non-SES States.

Figure 5-4 and Figure 5-5 present the cost-efficiency performance for SES and non-SES States. The map of en-route charging zones on the left hand side of these figures shows the annual changes in real en-route unit costs between 2013 and 2018 for each individual charging zone. At the same time, the index chart on the right-hand side provides an aggregated trends in TSUs, costs and en-route unit costs over this period.

---

31 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 Figure 5-3.

32 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.
Figure 5-4: Trends in en-route costs, TSUs and unit costs for SES States

Figure 5-4 shows that en-route unit costs for SES States decreased continuously at an annualised rate of -4.2% over the 2013-2018 period. This cost efficiency improvement was achieved by maintaining en-route costs mostly stable (+0.2% p.a.) in the context of significant TSU growth (+4.6% p.a.).

As also shown in the Figure 5-4, eight of these charging zones have managed to reduce their en-route unit costs by more than -6.0% per annum over this period (coloured light blue in the map). This includes Greece (-7.2% p.a.), Spain Continental (-7.0% p.a.), Lithuania (-6.9% p.a.), United Kingdom (-6.6% p.a.), Hungary (-6.3% p.a.), Germany (-6.1% p.a.), Norway (-6.1% p.a.) and Spain Canaries (-6.0% p.a.). The observed performance improvements for these States reflect a combination of reducing en-route ANS costs and TSU growth, with the exception of Hungary, for which the increase in en-route costs base was compensated by growth in TSUs.

On the other hand, for Poland (+3.7 % p.a.), Estonia (+3.4% p.a.) and Malta (+1.8% p.a.), highlighted in dark blue in the map above, the growth in TSUs was not sufficient to compensate the increase in en-route costs.

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

Figure 5-5 indicates that en-route unit costs also decreased for non-SES States (-2.1% p.a.) over the 2013-2018 period. This is primarily the result of a substantial TSU growth (+9.7% p.a.), while costs also rose by +7.4% p.a. over the period. It is noteworthy that these results are heavily influenced by trends for Turkey, since it represents some 67% of total costs and 76% of TSUs recorded for non-SES States.

It should be noted that, over this period, the TSUs grew for all non-SES States, with the exception of Moldova, which experienced a significant traffic downturn between in 2013 and 2016 (-75.1% overall over this period).

---

33 For the sake of completeness, the data for Georgia reflected in the left-hand side of Figure 5-5 refers to the changes in unit costs for the period 2014 to 2018, since Georgia only started providing data in 2014. However, Georgia is excluded from the index chart on the right side of the figure.
5.2.2 Breakdown of en-route costs by type

As shown in Figure 5-6, en-route costs in 2018 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 2018 are negative and represent less than 0.1% of total costs.

Figure 5-7 presents the breakdown of en-route ANS costs into main components as well as the changes in these cost categories over 2013-2018 period for SES and non-SES States.

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

![Costs by nature (2018)](image)

Source: PRU analysis

Figure 5-7: Changes in en-route cost categories - 2018 vs 2013 - SES & non-SES States (€2018)

![Chart showing changes in en-route costs](image)

Source: PRU analysis

Figure 5-7 shows that, over this period, en-route costs for non-SES States grew by +43.2% (+167.3M€2018) resulting from increases across all cost categories: staff costs (+51.3M€2018), other operating costs (+75.5M€2018), depreciation costs (+19.1M€2018) and the cost of capital (+21.3M€2018).

For SES States, the increase in en-route ANS costs (+67.4M€2018) mostly reflect increases in staff costs (+179.3M€2018) and cost of capital (+18.2M€2018), which were slightly compensated by reductions in other operating costs (-86.6M€2018) and exceptional item costs (-41.3M€2018). At the same time, the depreciation costs remained mostly stable over this period (-0.3%).

When interpreting this result for SES States, it is important to recall that Germany reported negative components in its en-route cost-base between 2016 and 2018 (some -50M€2018 annually), 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 43M€2018), are now financed by the Ministry of Transport and therefore are no longer reflected 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 2018 en-route costs for SES States would be some +2.9% higher than in 2013 (instead of +1.0% as currently shown).
5.2.3 Actual en-route unit costs at charging zone level

The bottom part of Figure 5-8 presents the level of en-route unit costs\(^\text{34}\) for each individual charging zone in 2018. En-route unit costs ranged from 83.1€\(_{2018}\) for Switzerland to 22.0€\(_{2018}\) for Turkey, a factor of almost four between these two charging zones. It is important to recognise the effect of currency exchange rate fluctuations, in particular for C\(\)Zs 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\(^\text{35}\).

Figure 5-8: 2018 Real en-route ANS costs per TSU by charging zone (€\(_{2018}\))

Figure 5-8 also presents the changes in en-route unit costs, TSUs and costs compared to 2017 (upper part). It indicates that in 2018, en-route unit costs increased for nine en-route C\(\)Zs out of the 38 included in the analysis.

Figure 5-8 indicates, that for five charging zones en-route ANS costs increases by more than 10%. In 2018, including Turkey (+14.7%), Greece (+13.0%) and Portugal Continental (+12.0%):

- Turkey (+49.2M€\(_{2018}\)), reflecting increases in other operating costs (+18.8%) and the cost of capital (+83.9%). The growth in other operating costs is understood to result from significant depreciation of Turkish Lira, which adversely affected the prices of goods and services purchased in foreign currency. At the same time, significant increase in cost of capital mostly reflects the use of higher rate of return on equity (7.9%) than in the previous year (4.5%).
- Greece (+15.6M€\(_{2018}\)), resulting from increases in other operating costs (+44.2%), depreciation (+40.1%) and the cost of capital (+129.6%). The observed increase in other operating costs reflects changes in accounting procedures applicable to the main ANSP introduced in the previous years, which resulted in exceptionally low other operating costs reported in 2017. At the same time, the increases in depreciation costs and cost of capital are understood to reflect the implementation of the investment programme.
- Portugal Continental (+15.1M€\(_{2018}\)), stemming primarily from significant increase in staff costs (+15.3%), which are understood to reflect: i) actuarial losses related to pensions and ii)

---

\(^{34}\) The actual unit costs reflected in Figure 5-8 only refer to the ratio of actual en-route costs and TSUs recorded for 2018 and should not be confused with chargeable unit rate.

\(^{35}\) This is, for example, the case of Turkey which experienced a depreciation of Turkish Lira vis-à-vis the Euro as of 2013. The Turkish en-route unit costs would amount to some 49.4€ in 2018 (instead of 22.0 €), assuming that the Turkish Lira had remained at its 2013 level. Further details on the variations in exchange rates can be found in Annex 7 of the ACE 2018 Report [26].
additional payments to operational staff aimed at mitigating the effects of capacity shortage. Other sizeable increases, in relative terms, can be observed for Armenia (+16.8%, or + 0.8 M€\textsubscript{2018}) and Moldova (+12.2%, or +0.5M€\textsubscript{2018}), resulting from higher staff costs and other operating costs in 2018.

On the other hand, Figure 5-8 indicates that for 7 CZs, en-route unit costs decreased by more than -10% in 2018, with substantial unit costs reductions observed for Lithuania (-17.1%), Serbia and Montenegro (-14.8%), Switzerland (-12.1%), Sweden (-11.8%), Finland (-11.1%), Italy (-10.6%) and Norway (-10.3%). Detailed analysis shows, that for most of these CZs, the reduction in unit costs reflects the combination of lower en-route costs and higher TSUs, with the exception of Norway, which managed to reduce its en-route cost base in the context of slight decrease of TSUs.

5.2.4 Pan-European en-route cost-efficiency outlook for 2019-2024

In November 2019, EUROCONTROL Member States submitted information related to planned en-route costs and service units in the context of the Enlarged Committee for Route Charges for the period 2019-2024.

It is important to note that in parallel, the States bound by the SES regulation are preparing the draft performance plans for the RP3, including planned TSU and determined cost figures. These plans will be reviewed by the European Commission and the PRB.

It should also be noted that the forecast data might slightly differ from the information submitted in the draft RP3 performance plans. These figures are therefore subject to change pending the adoption of the final RP3 performance plans.

In addition, due to the changes in the method of calculating en-route TSUs (see grey box), the figures reflected for the period 2020-2024 are not entirely consistent with previous years’ data.

Finally, the COVID-19 outbreak at the beginning of 2020 has sparked an unprecedented crisis in Europe and elsewhere. While the full impact of the COVID-19 outbreak on the aviation industry remains to be seen, preliminary indications in early 2020 suggest an unprecedented reduction in traffic volumes at pan-European system level.

Indeed, the latest figures available at the time of the release of this report indicate that at pan-European system level, traffic is continuously declining every week with an average cumulative reduction of some -85% recorded for the last week of May compared to the same period in 2019 (in terms of IFR flights).

Undoubtedly, the COVID-19 outbreak will have a massive impact on future traffic growth and the TSUs plans made by the States in November 2019 are likely to be revised.

A thorough analysis of the impact of this crisis on the ANS industry will be provided in future PRR reports when updated States/ANSPs forward-looking plans in terms of costs and TSUs will be available.
5.3 Terminal ANS cost-efficiency performance

The analysis of terminal ANS cost-efficiency in this section refers to the SES States (see Figure 5-9) which are required to provide terminal ANS costs and unit rates information in accordance with EU legislation [22]. As detailed in section 5.1, the financial figures are expressed in Euro 2018 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 and France, and five for Belgium.

2018 is the fourth year for which the "determined costs" method is applied for terminal ANS.

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))9. Since 2015, in accordance with the Charging Scheme Regulation [24], all SES States use a common formula (MTOW/50)0.5 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 5-10 below provides a summary of actual terminal ANS performance at European system level for the period 2015-2018. As explained in PRR 2016 [25], 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.
Figure 5-10 shows the changes in terminal ANS costs, TNSUs and unit costs between 2015 and 2018 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.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total terminal ANS costs (M€2018)</td>
<td>1,236</td>
<td>1,248</td>
<td>1,247</td>
<td>1,254</td>
<td>-0.3%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Total terminal service units (T000 TNSUs)</td>
<td>6,310</td>
<td>6,622</td>
<td>6,891</td>
<td>7,215</td>
<td>4.7%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Real terminal unit cost per TNSU (€2018)</td>
<td>195.3</td>
<td>198.4</td>
<td>190.2</td>
<td>174.3</td>
<td>-3.2%</td>
<td>-3.7%</td>
</tr>
</tbody>
</table>

Source: PRU analysis

**Figure 5-10: Real terminal ANS cost per TNSU at European System level (€2018)**

In 2018, terminal ANS costs increased (+1.3%) in the context of continuous TNSU growth (+4.7%). As a result, the terminal costs per TNSU reduced by -3.3% compared to 2017. This is the third consecutive year of decreasing terminal unit costs at European level (-3.7% p.a. over the period covering 2015 to 2018).

As detailed on p.71 of this report, these results are significantly affected by the negative exceptional items reported by Germany in its terminal cost-base for the years 2016-2018 (amounting respectively to some -12M€, -46M€2018 and -45M€2018). Excluding these amounts arising from the German State intervention, the European system actual terminal ANS costs for 2018 would be +5.6% above those in 2015 (instead of +1.9% as currently presented).

Figure 5-11 below shows how the main components of terminal ANS costs changed between 2017 and 2018.

An increase in terminal ANS costs observed in 2018 (+1.3%, or +16.1M€2018) results mainly from increases in most of cost categories: staff costs (+1.3%, or +11.5M€2018), other operating costs (+3.3%, or +6.9M€2018), cost of capital (+0.7%, or +0.5M€2018) and exceptional item costs (+0.4M€2018). At the same time, these increases were slightly compensated by a reduction in depreciation costs (-2.4%, or -3.1M€2018).

5.3.2 Terminal ANS 2018 cost-efficiency performance at terminal charging zone level

Figure 5-12 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 2017 and 2018, while the lower part provides information on the level of terminal ANS unit costs in 2018. For the sake of completeness, the bottom chart of Figure 5-12 also shows the number of airports included in each of the charging zone (see number in brackets).

Figure 5-12 indicates that in 2018, the average terminal ANS costs per TNSU amounted to 174.3€2018 at system level. Figure 5-12 also shows that the terminal unit costs ranged from 1 564€2018 for Belgium Antwerpen TCZ, to 98€2018 for Poland TCZ 1, a factor of more than 15.
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 number of TNSUs across TCZs and the scope of ANS provided.

For instance, Figure 5-12 shows that the two Belgian TCZs (Belgium Antwerpen and Oostende-Brugge) with the highest unit terminal costs in 2018 only include one airport each and, together, 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 5-12 indicates that terminal unit costs reduced for 24 TCZs. Seven of these TCZs managed to reduce unit costs by more than -10% in 2018: Switzerland (-20.4%), Lithuania (-18.7%), Latvia (-17.3%), Italy TCZ 1 (-13.2%), Belgium Liege (-12.1%), Finland (-10.2%) and Belgium Oostende-Brugge (-10.1%). Detailed analysis indicates that the performance improvements observed for majority of these TCZs in 2018 reflect a reduction in terminal ANS costs in the context of TNSU growth. This is different for Belgium Liege and Belgium Oostende-Brugge TCZs, for which the growth in TNSUs more than compensated slight increase in terminal costs.

On the other hand, Figure 5-12 also indicates that, in 2018, terminal unit costs increased for 12 TCZs, with unit costs growing by more than +10% for Greece (+31.2%) and Estonia (+13.5%). Detailed analysis shows that for these TCZs, the increases reflect substantially higher terminal ANS costs in 2018.
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 2018 part of the SES, and hence subject to relevant SES regulations and obligations. Detailed analysis is given in the ACE 2018 Benchmarking Report [26].

Along the annual ACE Working Group meetings, the PRU has currently also embarked on a programme of bilateral visits to participating ANSPs. The objective of these visits is to raise the awareness of the ACE benchmarking activity to ANSPs top-management. The programme foresees two to three visits annually. The most recent of these bilateral meetings were organised with PANS, Sakaeronavigatsia and skeyes.

The ACE 2018 data analysis presents information on performance indicators relating to the benchmarking of cost-effectiveness and productivity performance for the year 2018, and shows how these indicators changed over time (2013-2018). 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 (2018) 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.

---

36 As indicated in section 5.1, the indicators analysed in this section are presented in Euros 2018. It is therefore important to recognise the effect of currency exchange rate fluctuations, in particular for ANSPs which operate outside the Euro zone. Further details on the variations in exchange rates can be found in Annex 7 of the ACE 2018 Report [26].
Figure 5-13 shows a detailed breakdown of gate-to-gate ATM/CNS provision costs. Since there are differences in cost-allocation between en-route and terminal ANS among ANSPs, it is important to keep a “gate-to-gate” perspective when benchmarking ANSPs cost-effectiveness performance.

Figure 5-13 indicates that in 2018, at pan-European system level, gate-to-gate ATM/CNS provision costs amount to some €8.4 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 at 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 2018 Benchmarking Report [26].

5.4.1 Economic cost-effectiveness performance (2013-2018)

Figure 5-14 shows the comparison of ANSPs gate-to-gate economic cost per composite flight-hour (“unit economic costs” thereafter) in 2018. The economic cost-effectiveness indicator at pan-European level amounts to €509 per composite flight-hour in 2018, and, on average, ATFM delays represent 23.5% of the total economic costs.

![Figure 5-14: Economic gate-to-gate cost-effectiveness indicator, 2018](image-url)
Figure 5-14 indicates that in 2018 unit economic costs ranged from €868 for skeyes to €213 for MATS, a factor of more than four. Figure 5-14 also indicates that DFS had the highest unit economic costs amongst the five largest ANSPs.

Figure 5-15 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\(^{37}\). The upper part of the Figure 5-15 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.

Between 2013 and 2018, economic costs per composite flight-hour increased by +0.9% p.a. in real terms. Over this period, ATM/CNS provision costs grew by +0.9% p.a. while the number of composite flight-hours also increased (+3.3% p.a.). At the same time, the unit costs of ATFM delays increased by +19.6% p.a., on average, over the period, primarily due to the significant increases recorded in 2014 (+11.1%), 2015 (+39.0%) and 2018 (+56.1%). More details on the development of the ATFM delays can be found in chapter 3 of this report.

In 2018, composite flight-hours rose much faster (+5.4%) than ATM/CNS provision costs (+2.0%). As a result, unit ATM/CNS provision costs reduced by -3.3% in 2018. In the meantime, the unit costs of ATFM delays increased by +56.1% and therefore unit economic costs grew by +6.2% compared to 2017.

Figure 5-16 shows the long-term trends in terms of ATM/CNS provision costs, composite flight-hours, ATFM delays and unit economic costs\(^{38}\).

The trend of decreasing ATFM delays, which began in 2011, stopped in 2014, when a new cycle characterised by higher delays started (+23.6% p.a. on average between 2013 and 2018).

\(^{37}\) Sakaeronavigatsia provided data for the first time for the ACE 2015 cycle. Thus, these data are not included in this 2013-2018 analysis.

\(^{38}\) 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.
The most recent available data shows that, while the ATFM delays have reduced in 2019, they still remain very high in absolute terms compared to previous years’ levels.

Figure 5-17 shows the contribution of each of the 38 ANSPs to the change in ATFM delays observed in 2018 at pan-European system level.

The right-hand side of the Figure 5-17 indicates that the increase in ATFM delays observed at system level in 2018 mainly reflects increases for a few ANSPs (DFS, DSNA, ENAIRE, Austro Control and HCAA). The right-hand side of Figure 5-17 shows that, as a result, for most of these ANSPs the share of ATFM delays in economic costs in 2018 is higher than the European average (24%). This is particularly the case for HCAA (43.0%), MUAC (49.6%) and DCAC Cyprus (56.1%).

The left-hand side of Figure 5-17 also shows that two ANSPs significantly contributed to the increase in ATFM delays observed at system level in 2018. Indeed, DFS and DSNA generated some 5.7 million additional minutes of ATFM delays in 2018. The higher ATFM delays recorded for these ANSPs in 2018 were mainly associated to en-route ATC capacity/staffing issues.
Figure 5-18 shows how the unit ATM/CNS provision costs (see blue part of the bar in Figure 5-18) 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 5-18 also shows how these various components contributed to the overall change in cost-effectiveness between 2017 and 2018.

Figure 5-18 indicates that in 2018, ATCO-hour productivity rose faster (+5.1%) than ATCO employment costs per ATCO-hour (+0.3%). As a result, ATCO employment costs per composite flight-hour substantially decreased (-4.6%). In the meantime, unit support costs fell by -2.6% since the number of composite flight-hours increased by +5.4% while support costs were +2.7% higher than in 2017. As a result, in 2018 unit ATM/CNS provision costs reduced by -3.3% at pan-European system level.

![Figure 5-18: Breakdown of changes in cost-effectiveness, 2017-2018 (€2018)](image)

More details on the changes in unit ATM/CNS provision costs at ANSP and pan-European system levels are available in the ACE 2018 Benchmarking Report [26].

In addition, time-series of ANSPs cost-effectiveness performance data for the period 2002-2018 are available online in the [ATM cost-effectiveness dashboard](#).

### 5.5 Conclusions

PRR 2019 analyses performance in 2019 for all key performance areas, except for cost-efficiency, which focuses on performance in 2018 as it is the latest year for which actual financial data are available.

In 2018, the **en-route ANS cost-efficiency performance** of the pan-European system improved for the sixth consecutive year, since real en-route unit cost per service unit (TSU) reduced by -4.1% to reach an amount of 47.8€2018. This performance improvement is driven by a significant growth in TSUs (+6.2%), which more than compensated the increase in en-route ANS costs (+1.8%).

Over the six year period covering 2013-2018, en-route unit costs reduced continuously at an average rate of -4.4% annually, reflecting cost-efficiency performance improvements achieved by both SES (-4.2% p.a.) and non-SES (-2.1% p.a.) States. The decrease in unit costs observed for SES States over this period was achieved by maintaining ANS costs mostly stable (+0.2% p.a.) in the context of robust TSU growth (+4.6% p.a.). This is slightly different for non-SES States, for which en-route cost-efficiency improvement was entirely driven by substantial TSU growth (+9.7% p.a.), which outweighed the increase in en-route ANS costs (+7.4% p.a.).

Real **terminal ANS costs** per terminal navigation service unit (TNSU) decreased by -3.3% compared to 2017 and amounted to 174.3 €2018. The drivers for this improvement are similar to those observed for en-route ANS, since TNSUs increased at a higher rate (+4.7%) than terminal ANS costs (+1.3%).

Detailed benchmarking analysis focusing on ANSPs cost-efficiency shows that in 2018 the **gate-to-gate unit costs** of the pan-European system reduced by -3.3% since the increase in ATM/CNS provision costs (+2.0%) was more than compensated by the traffic growth (+5.4% in terms of composite flight-hours). In the meantime, the ATFM delays generated by the ANSPs rose for the fifth consecutive year in 2018 (+64.5%). As a result, the unit economic cost-effectiveness indicator for pan-European system increased by +6.2% in 2018.


This page was intentionally left blank
About the Performance Review Commission

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”.

The PRC provides objective information and independent advice to EUROCONTROL’s governing bodies on European air traffic management (ATM) performance, based on extensive research, data analysis and consultation with stakeholders. Its purpose is “to ensure the effective management of the European air traffic management System through a strong, transparent and independent performance review.” The PRC reviews ATM performance issues on its own initiative, at the request of the deliberating bodies of EUROCONTROL or of third parties.

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 PRC reports to the EUROCONTROL Permanent Commission through the Provisional Council and is supported by the Performance Review Unit (PRU) operating under the EUROCONTROL Agency with the appropriate level of independence.

The PRC publications can be found at: www.eurocontrol.int/air-navigation-services-performance-review where copies can also be ordered. The PRC can be contacted at: pru-support@eurocontrol.int