EUROCONTROL

PRR 2020

Performance Review Report

An Assessment of Air Traffic Management in Europe during the Calendar Year 2020

Performance Review Commission

June 2021

Background

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

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FOREWORD

With the outbreak of the COVID-19 pandemic in Europe in early 2020, the focus changed entirely from solving the European en-route capacity crisis to managing an unprecedented global crisis of the aviation industry affecting the entire value chain.

Without a doubt, 2020 was a devastating year for the aviation industry which has been hit harder than many other industries due to the measures implemented by States to contain the pandemic and the subsequent reduced demand for air travel.

In the EUROCONTROL area, the number of flights decreased on average by -55.2% in 2020, dropping as low as -88% in April 2020. This corresponded to 6.1 million fewer flights in 2020 with grave consequences on the aviation industry's income and employment levels.

According to the Airports Council International (ACI), European airports lost 1.72 billion passengers (-70.4% vs 2019) which translates into an estimated revenue shortfall of around €30 Billion in 2020. For airlines in Europe, the International Air Transport Association (IATA) estimates a loss of €22 Billion in 2020. With air navigation services (ANS) in Europe being almost entirely funded through route charges, the en-route revenue shortfall in 2020 is estimated to amount to some €5 Billion at system level.

Moreover, the outlook for the coming years remains uncertain as the recovery depends on many factors, which include vaccine effectiveness and availability, government policies on travel restrictions, passenger behaviour and trust as well as the evolution of the general economic climate. The latest EUROCONTROL traffic forecast expects a recovery to pre-COVID-19 levels between 2024 and 2029, with the rate of recovery depending on the aforementioned factors.

The dramatic drop in demand, combined with the uncertain recovery path, has forced the entire aviation industry to downscale and to reduce costs where possible. In the coming years, the European Air Navigation Service Providers (ANSPs) are likely to face significant challenges in finding and ensuring sufficient funding while at the same time preparing for the anticipated traffic recovery in terms of capacity (investments, staff planning and training, integration of drones) as well as investing in digitalisation and environmental sustainability. Hence, it is clear that the road to recovery will be long and challenging - but there will also be opportunities to make the air traffic management (ATM) system better and more resilient on the way.

Notwithstanding the challenges imposed by the COVID-19 pandemic on the aviation industry, safety levels remained high in Europe and will continue to remain pivotal during all recovery stages and beyond. This will also include a necessary discussion on the future challenges to safety in a changing ATM environment and how to measure them. An initial discussion has started but requires more efforts and cooperation to achieve results.

On the operational side, the severity of the COVID-19 pandemic completely overshadows the European capacity crisis of 2018/19 as - judging from the current traffic forecasts - capacity issues are not expected to occur in the immediate future. Nonetheless, the downturn provides an opportunity to review "lessons learned" from the past capacity crisis, in order to avoid making the same mistakes and to prepare for the time when traffic returns. Before any action is taken by ANSPs to reduce or cancel capacity and improvement plans, including staffing, the potential short-term cost reductions should be considered against potential future capacity problems and the resultant financial consequence this could cause to airspace users. It is conceivable that savings for one entity could be outweighed by costs for another (and therefore a considered response would be preferable).

Flight efficiency improved notably in 2020, following the dramatic drop in demand which illustrated the link between capacity provision and operational efficiency. Improved flight efficiency with subsequent environmental (CO_2 emissions) and economic (fuel) benefits was already high on the agenda before the COVID-19 crisis and will remain so during the recovery and beyond. Here, the crisis offers an opportunity to review and evaluate operational constraints imposed by ANS and to further improve existing ATM operations (Free Route Airspace, Continuous Descent Operations, etc.), where possible, with a view to providing better service levels also when traffic returns.

On the economic side, the COVID-19 pandemic showed that the current ANS cost recovery schemes in Europe were not designed to cope with a crisis of this magnitude. With ANS being funded primarily through route charges, the dramatic drop in traffic resulted in a €5 Billion estimated loss in revenue in 2020. To mitigate the effects of the lack of liquidity and to ensure business continuity some immediate measures had to be taken (e.g. State aid, loans and cost-containment initiatives). ANSPs were required to take action to downscale operations and to adjust to the reduced demand, whilst still providing reliable services to airspace users.

However, with demand likely to be muted in the short term and an uncertain recovery path there is a need to find solutions on how to best address the unfolding gap between ANS revenues and costs. Simply applying the existing charging schemes (based on the full-cost recovery or SES regulations) would not solve ANSPs cash flow issues in the short term and would also lead to excessively high user charges as incurred revenue shortfalls are, by design, to be recovered in the future through unit rate adjustments. In view of the exceptional situation, the PRC has prepared a special analysis in its latest "Performance Insight" looking at the impact of this unprecedented crisis on the ANS system and the implications for the future [1].

The coming years will be focussed on the ANS industry's ability to adjust its operations in step with demand, while at the same time preparing for the future in terms of capacity provision, higher levels of digitalisation and environmental sustainability. In addition, policy makers and States should explore how to modify the current ANS cost recovery schemes in order to ensure fair financial income to meet the demand for capacity while keeping ANS charges at an acceptable level over the coming years.

It will take time and close collaboration between all the stakeholders to ensure as smooth a recovery as possible from the effects of the COVID-19 pandemic. It is evident that there is substantial underlying demand so, as travel restrictions ease, we can expect a notable increase in traffic. The aviation industry has demonstrated its strength and resilience in the past: together we should be able to overcome this global 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
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This report of the Performance Review Commission analyses the performance of the European Air Traffic Management System in 2020 under the Key Performance Areas of Safety, Capacity, Environment and Cost-efficiency.

Keywords

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EXECUTIVE SUMMARY

This report assesses the performance of Air Navigation Services (ANS) in the EUROCONTROL area for the calendar year 2020 for all key performance areas, except for cost-efficiency, which analyses performance in 2019 as this is the latest year for which actual financial data are available.

TRAFFIC

Although there were already signs of weakening traffic towards the end of 2019 because of an economic slowdown in Europe, nobody was prepared for the crisis emerging from the outbreak of the new SARS-CoV-2 virus in Wuhan, China in the closing months of 2019. With the COVID-19 pandemic sweeping its way across the globe, the aviation industry is facing an unprecedented challenge.

Without a doubt, 2020 was a devastating year for the aviation industry which has been hit harder than many other industries due to the measures implemented by States to contain the pandemic and the subsequent reduced demand for air travel.

The number of flights in the EUROCONTROL area decreased on average by -55.2% in 2020, dropping as low as -88% in April 2020. This corresponded to 6.1 million fewer flights in 2020 with appalling effects on the aviation industry's income and employment levels.

After passing the turning point in April, there has been a small but sustained increase in flights with a more pronounced increase towards the end of June 2020 which was partly driven by flights to holiday destinations (Spain, Italy, Greece and Turkey).

Following the resurgence of COVID-19 in September 2020 and the subsequent travel restrictions implemented by States, traffic started to decrease again with only a small increase during the holiday season at the end of the year.

The high international share of traffic in Europe (72.6% in 2019) complicates recovery because of the large number of different rules in terms of quarantine and testing requirements which have proved to be a major obstacle for passengers. Observations in other world regions confirm that the recovery rate is higher in markets with a large domestic share (US, China) where the same set of rules applies.

Consequently, the impact of the COVID-19 crisis on air traffic differed also by State depending on the measures taken and the mix of traffic. All traffic zones, except Norway, show a fall of 50% or more compared to 2019. The traffic reductions at traffic zone level range from -41.9% in Norway to -69.2% in Armenia.

The lower decrease in Norway for instance is due to its comparatively high share of domestic traffic to peripheral areas which continued during the pandemic. In absolute terms, five traffic zones (France, Germany, UK, Italy, and Spain) lost more than 1 million flights compared to 2019.

The recovery scenarios published in the latest STATFOR forecast in November 2020, expect to return to 2019 levels between 2024 (most optimistic) and 2029 (most pessimistic scenario). The most likely scenario estimates traffic to be at 92% of the 2019 level by 2024. Compared to the baseline scenario in the last pre-COVID forecast in Autumn 2019, the most likely scenario would correspond to a total loss of 21 million flights in Europe between 2020 and 2024.

Without doubt, the dramatic drop in demand as a result of the pandemic creates major challenges to ANS in terms of funding and adjusting the operation to the reduced demand while preparing the future in terms of capacity and staff planning and without forgetting to invest in digitalisation and sustainability.

ENVIRONMENT: Together with new technological developments, the European Green Deal with the objective to make Europe climate neutral by 2050 has put digitalisation and decarbonisation of transport at the very heart of EU aviation policy.

The environmental impact of aviation on climate results from greenhouse gas (GHG) emissions (CO_2, NOx, etc.) and contrails, generated by aircraft engine exhaust.

Whereas CO_2 emissions are directly proportional to the fuel burn, non-CO_2 emissions and their radiative forcing effects are more difficult to quantify as they depend, inter alia, on engine settings, atmospheric conditions and altitude. EUROCONTROL is working with stakeholders to better understand the effects of non-CO_2 emissions and possible mitigation measures.

The analysis in this report focuses on CO_2 emissions which are considered to be one of the main contributors to climate change. Based on the figures of the European Environment Agency (EEA), aviation accounted for approximately 4.0% of total EU27+UK GHG emissions (4.8% of CO_2 emissions) in 2018 (the latest year for which information is available). While this share appears to be comparatively small, aviation is one of the fastest growing sources of GHG emissions in Europe.

As a result of the COVID-19 pandemic and the dramatic drop in air traffic demand, CO_2 emissions from aviation in Europe in 2020 more than halved compared to 2019. Despite this reduction, it is clear that the environmental challenge for aviation will remain throughout the recovery phase and beyond.

The strategies are essentially based on four pillars: (1) Aircraft technology (airframes and engines), (2) Sustainable aviation fuels (SAF), (3) Economic measures, and (4) Improved infrastructure and operations.

While the use of SAF is considered to be the most important pathway to achieving the aviation industry's climate goals with the potential to reduce CO_2 emissions from fossil fuel by up to 80%, the ANS contribution is closely linked to operational performance (fuel efficiency) which is largely driven by inefficiencies in the flight trajectory and associated fuel burn (and emissions).

The level of operational inefficiencies in the European ATM network is estimated to be between 6-8% of the total gate-to-gate fuel burn (2019). Although there is clearly scope for further improvement, it is important to point out that the inefficiencies cannot be reduced to zero nor can they be attributed entirely to ANS. A certain level of "inefficiency" is in fact necessary (separation minima, adverse weather, avoidance of 'Danger Areas') or even desirable (trade-offs).Taking the theoretical upper ceiling, the ANS contribution to reduce emissions is limited to some 0.3-0.4% of the total CO_2 emissions in Europe (SAF ≈ 3.8%).

Following the dramatic drop in traffic due to the COVID-19 pandemic in March 2020 all operational metrics improved with a positive effect on fuel burn and environmental impact. For example, at the top 30 airports in Europe the additional taxi-out time dropped on average by 2 minutes while airport holdings decreased by almost 1 minute in 2020. Vertical efficiency during approach at the top 30 airports, measured as average time flown level, decreased by 48 seconds compared to 2019. Achieving this performance with the traffic level of 2019 would have saved 3.2 million minutes in level flight with the corresponding savings in terms of fuel and CO_2 emissions.

Since the beginning of the COVID-19 pandemic in March 2020, ANSPs - in collaboration with the Network Manager - removed 1,200 Route Availability Document (RAD) measures in the network which enables more direct routings and hence more efficient flights. Horizontal flight efficiency improved by 0.3 percent points in 2020. Although this seems small, achieving the 2020 efficiency level with the traffic of 2019 would have saved a total of 29.7 million kilometre of additional distance flown.

The observed operational improvements are largely the result of the dramatic drop in traffic and the subsequent free capacity en-route and at airports which helped to remove existing constraints in the ATM system. The analyses in the various chapters of this report show that the observed improvements varied notably among ANSPs and airports which may be partly linked to local specificities but also differences in the ability and flexibility to remove ATM constraints and to adjust to traffic demand.

As the expectations to help reducing carbon emissions will remain, or become even more pressing on the way to recovery from the COVID-19 crisis, there is a need to review current processes and procedures to remove constraints affecting flight efficiency in the ATM network and to try to maintain the achieved performance as much as possible when traffic returns.

EXECUTIVE SUMMARY

SAFETY

Notwithstanding the challenges imposed by the COVID-19 pandemic on the aviation industry, safety levels remained high in Europe and will continue to remain pivotal during all recovery stages and beyond.

After two decades, the discontinuation of the safety data collection through the Annual Summary Template (AST) reporting mechanism resulted also in the discontinuation of the corresponding performance review section in the PRR report. The 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 is currently exploring ways of accessing reliable ATM safety data in order to be able to continue its review of Safety performance in the EUROCONTROL area. The PRC will report in future publications on the status and progress made in this pivotal area.

In early 2020, the PRC initiated a dialogue with safety experts in EUROCONTROL Member States and other international organisations in order to identify future challenges to safety in an evolving ATM environment and how to measure them. This work represents a first step toward building a safety performance framework for the future that will include views about the future safety system and how to measure its performance. Overall, this is a complex undertaking but nonetheless a vital prerequisite for the measurement of safety performance in the future ATM environment.

OPERATIONS

(EN-ROUTE)

Operational en-route ANS performance traditionally reviews the en-route capacity situation and en-route flight efficiency. When the COVID-19 pandemic started hitting the aviation world in an unprecedented way in the first quarter of 2020, everything changed. As a result, air traffic in Europe dropped to the level of 1989 and the focus moved from capacity and ATCO staffing shortages in 2018/19 to downscaling of operations and funding to ensure business continuity.

At EUROCONTROL level, traffic dropped by 55.2% in 2020 which corresponds to 6.1 million lost flights compared to 2019. At ANSP level, the traffic reductions range from -41.9% (-49.5% Mar.-Dec.) for Avinor (Norway) to -69.2% (-80.4% Mar.-Dec.) for ARMATS (Armenia). In absolute terms, DSNA (France), DFS (Germany), NATS (UK), ENAIRE (Spain), ENAV (Italy) and Maastricht UAC showed the highest year on year reduction with more than 1 million fewer flights than in 2019.

Following a first quarter with higher en-route ATFM delay levels than in 2019 there was virtually no en-route ATFM delay for the remainder of 2020 as a result of the unprecedented drop in traffic and the resulting capacity surplus. The virtual elimination of all delays categories including adverse weather shows how capacity constraints stemming from weather are generally aggravated by other capacity constraints e.g. sector capacity and staffing availability.

Nonetheless, the downturn provides an opportunity to review “lessons learned” from the past capacity crisis to avoid the same mistakes and to prepare for the time when traffic returns. There is a risk that reducing or cancelling capacity improvement plans, including staffing, whilst potentially providing a short-term cost reduction for the ANSPs could result in capacity problems for many years ahead, with adverse financial consequences for airspace users of much greater magnitude than were ‘saved’ by the ANSP.

Vertical and Horizontal en-route flight efficiency improved notably in 2020, following the dramatic drop in demand which illustrates the link between capacity provision and operational efficiency.

Horizontal en-route flight efficiency at EUROCONTROL level improved by 0.3 percent points from 97.2% in 2019 to 97.5% in 2020. The observed improvement was not distributed evenly across the network. In some areas, where flight efficiency was already high, the scope for further substantial improvements was limited while in other areas the limited flexibility to adjust the route network to the completely different situation seems to have hindered higher improvements.

The efficiency of the filed flight plans and the shortest constrained routes available to aircraft operators also improved but at a notably lesser rate than the actual trajectories which resulted in a further widening of the gap between flight plan and the actual flown trajectories.

For a number of states, the efficiency of the actual trajectory improved notably more than the filed or the shortest constraint trajectory which suggests that the actual trajectories were improved on a tactical basis whereas the flight planning and the route network showed a lower flexibility to adjust to the low traffic levels.

Vertical en-route flight efficiency has gained more attention over the past years, particularly following the implementation of additional flow measures to manage the capacity crisis in 2018/19. Although difficult to quantify at network level in terms of additional fuel burn and CO_2 emissions, the analysis shows a considerable reduction of altitude constrained flights in 2020, following the removal of a large number of Route Availability Document (RAD) measures in the ATM network.

As the expectations to improve flight efficiency will remain or become even more pressing on the way to recovery from the COVID-19 crisis, the dramatic drop in traffic offers an opportunity to get a better understanding of possible performance boundaries while identifying and removing constraints affecting flight efficiency in the ATM network with a view to maintain the achieved performance as much as possible when traffic returns.

OPERATIONS
(@ AIRPORTS)

As a result of the COVID-19 crisis, European airports accommodated 55% less flights than in 2019, with an even higher loss in passengers (-70.4% vs 2019, according to ACI) and revenues. The pandemic forced airport operators to reinvent their operation trying to reduce costs while still providing the required services and adapting to restrictions and new requirements in terms of passenger handling.

In an effort to contain costs, airports have furloughed many of their staff and closed runways and terminals. In the meantime, the massive grounding of aircraft has packed aprons across all airports, and specialised storage airports have reached their maximum capacity.

The market segments and the regions served by these airports played a role in how they were impacted by the pandemic. While traffic at most airports dropped dramatically, airports with major cargo operations were less affected and, as a result, Cologne airport entered the top 30 busiest airports in Europe. Thanks to the substantial number of domestic routes ensuring connectivity in Norway, even during the pandemic, traffic at Oslo Gardermoen airport declined less than at other European airports.

With airlines concentrating their reduced long distance operation at their main hubs, more than half of the international traffic to or from the EUROCONTROL area took place at the top 5 airports in Europe: (Amsterdam (AMS), Paris (CDG), Frankfurt (FRA), London (LHR), and Istanbul (IST)).

Following the dramatic drop in traffic due to the COVID-19 pandemic in March 2020 all operational metrics improved with a positive effect on fuel burn and environmental impact. At the top 30 airports in Europe the additional taxi-out time dropped on average by 2 minutes while airport holdings decreased by almost 1 minute in 2020. Vertical efficiency at airports during approach, measured as average time flown level, decreased by 48 seconds compared to 2019.

The capacity shortage observed at many airports in previous years has given way to a low demand well below the capacity, where the key is to scale down but still be able to provide sufficient capacity where and when the demand increases. Looking forward, airport capacity is still a major concern and every movement counts. The PRC, through the study on Airport Capacity Imbalance brings awareness on the potential capacity loss due to change in runway configurations, trying to support stakeholders in preparing the recovery.

EXECUTIVE SUMMARY

ECONOMICS

In 2019, the latest year for which actual financial data is available, en-route ANS costs per en-route service unit (TSU) pan-European system level reduced by -1.4% compared to 2018 and amounted to €47.8 – the lowest value recorded to date. This improvement in en-route cost-efficiency, recorded for the seventh year in a row, reflects the fact that the increase in en-route ANS cost-bases (+1.4%) was more than compensated by the growth in TSUs (+2.9%).

In 2019, the European terminal ANS costs per terminal navigation service unit (TNSU) amounted to €176.5, which was -0.2% lower than the previous year. This performance improvement reflects the fact that TNSUs grew at a slightly faster rate (+2.3%) than terminal ANS costs (+2.1%).

The benchmarking analysis of pan-European ANSPs indicates that gate-to-gate ATM/CNS provision costs increased by +1.8% in 2019 and amounted to some €8.7 Billion at system level. At the same time traffic, expressed in composite flight-hours, grew by +1.7%. As a result, the gate-to-gate unit ATM/CNS costs rose by +0.1% in 2019, which is the first increase observed since 2012.

To account also for the quality of service provided by the ANSPs, the PRC uses an indicator of economic costs, which combines 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 reduced by -1.6% since the unit costs of gate-to-gate ATFM delays decreased by -7.4% in 2019.

The outbreak of COVID-19 pandemic in 2020 had a devastating impact on pan-European aviation, with the TSU levels falling by -58% below those recorded in 2019. While the actual ANS cost figures for 2020 are not yet available at the time of the release of this report, it is already possible to estimate the impact of this crisis on the anticipated en-route revenues in 2020. Current estimates show that the shortfall or "loss" in en-route revenues amounts to €4.8 Billion at system level, with the ANSPs operating in the SES States bearing a loss of €0.3 Billion resulting from the application of the traffic risk sharing mechanism, based on the application of the Regulation (EU) No 2019/317.

The exact amounts to be shared between airspace users and ANSPs are not known at the time of writing this report due to the application of the RP3 exceptional measures regulation [2] and the RP3 target-setting process that will take place in the second half of 2021. This being said, due to the construct of the ANS costs recovery schemes, it is expected that the majority of the ANS revenue losses incurred in 2020 will be recovered in the coming years from airspace users. However, the timing of these revenues may result in significant challenges for ANSPs in the short term and, in particular, have an impact on their ability to meet various payment obligations. For this reason, the majority of pan-European ANSPs have implemented measures aimed at mitigating the impact of this crisis and the associated potential cash shortage. These include the implementation of cost-containment initiatives, taking up loans to alleviate liquidity risk as well as, in some cases, receiving support from national governments. The PRC will continue to monitor the impact of these mitigation measures on pan-European ANS in the coming years.

PRC Recommendations 2020

Recommendation A	***Rationale***
The Provisional Council is invited to: encourage Member States to A.1 **encourage** States to ask their ANSPs to continue managing their costs in accordance with demand levels, whilst still providing reliable services to airspace users; and A.2 **encourage** States to consider new financing options for ANS which could complement the existing charging regulations and ensure that, in the case of exceptional traffic downturns, ANSPs receive sufficient funding to operate while being in a position to keep ANS charges at an acceptable level**;**	As highlighted in the PRC Performance Insight on the economic impact of COVID-19 on the ANS system, the pandemic has shown that the current ANS cost recovery schemes in Europe were not designed to cope with a crisis of this magnitude. With ANS funded primarily through route charges, the dramatic drop in traffic resulted in a EUR 5 billion estimated loss in revenue in 2020. In the meantime, several ANSPs have implemented measures in order to mitigate the impact of the COVID-19 pandemic.

Recommendation B	***Rationale***
The Provisional Council is invited to **request** States to task their ANSPs with ensuring that their staffing levels, given the time needed to recruit and train ATCOs, are sufficient to meet current traffic demand and also future capacity requirements.	The PRR highlights that many ANSPs have identified ATC staffing as a major capacity constraint (pre-COVID). Several of these ANSPs have reported reviews of the planned staffing levels due to COVID-19 and cost-cutting measures. The PRC is mindful that ANSPs need to recruit staff simply to replace ATCOs who are retiring, in order to prevent any further loss of capacity, but also to introduce additional capacity in order to prevent significant problems when traffic levels recover, which, this happens as expected in 2024, is just over two years away.

Recommendation C	***Rationale***
The Provisional Council is invited to: C.1 **take** the necessary steps to ensure that its recommendations at PC/51 (2019) on the strengthening of the ATFCM process, by developing strict procedures for attributing ATFM delay causes, are implemented; **C.2 request** the relevant States/ANSPs to work with the PRC/PRU to optimise transparency for airspace users regarding capacity bottlenecks and planned mitigation measures;	Continuing previous work, including the technical note on en route capacity, published in December 2020, the PRC is seeking to work with ANSPs and the Network Manager in order to: • improve transparency regarding capacity performance; and, • assure airspace users that ANSPs are working to address existing and potential capacity shortfalls and improve both the provision and deployment of capacity within their airspace.

Recommendation D	*Rationale*
The Provisional Council is invited to **request** States/ANSPs and the Network Manager to use the lower traffic level to review and evaluate operational constraints to flight efficiency and to further improve existing ATM operations (free route airspace, continuous descent operations, etc.), where possible, in order to allow better flight efficiency;	Following the dramatic drop in traffic due to the COVID-19 pandemic since March 2020, all operational metrics improved, with a positive effect on fuel burn and the environmental impact. The observed improvement was not, however, distributed evenly across the network. In some areas, where flight efficiency was already high, the scope for further substantial improvements was limited, whilst in other areas the limited flexibility to adjust the route network to the completely different situation seems to have hindered greater improvements. Expectations regarding the improvement of flight efficiency will remain or become even more pressing on the way to recovery from the COVID-19 crisis. The dramatic drop in traffic offers an opportunity to get a better understanding of possible performance boundaries. It also offers an opportunity for the identification and removal of constraints affecting flight efficiency in the ATM network, with a view to maintaining the achieved performance as far as possible when traffic returns.

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1 Introduction and context

1.1 About this report

Air Navigation Services (ANS) are essential for the safety, efficiency and sustainability of Civil and Military aviation, and to meet wider economic, social and environmental policy objectives.

This Performance Review Report (PRR 2020) has been produced by the independent Performance Review Commission (PRC) with its supporting unit the Performance Review Unit (PRU).

It gives an independent holistic view of Air Navigation Services (ANS) performance in all EUROCONTROL Member States across all key performance areas.

In 2016, EUROCONTROL signed an agreement with Israel and Morocco with a view to fully integrating both States into its working structures. Where available, data for these two States have been included in the analysis.

The report's purpose is to provide policy makers and ANS stakeholders with objective information and independent advice concerning the performance of European ANS, based on analysis, consultation and information provided by relevant parties.

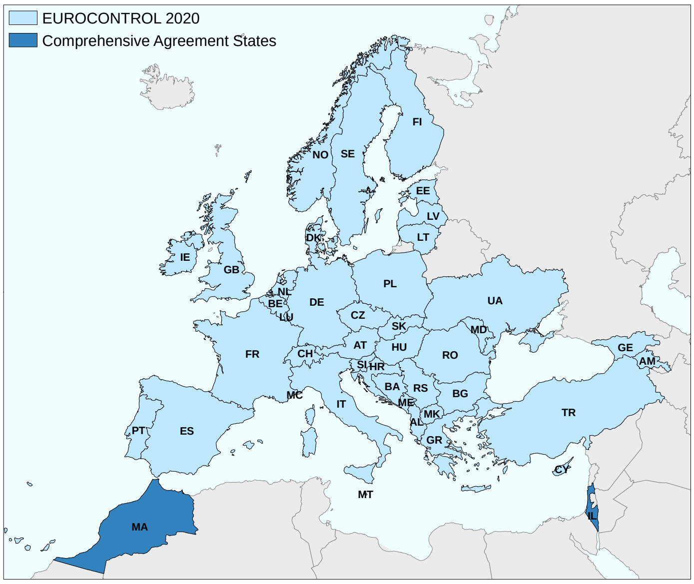

Figure 1-1: EUROCONTROL States (2020)

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.

With the COVID-19 pandemic hitting aviation in an unprecedented way at the end of the first quarter of 2020, the focus of the industry changed from managing the capacity crisis of 2019 to managing the devastating effects of the COVID-19 crisis. Clearly also ANS performance review needs to adjust to this new situation and this year's report has been adjusted to reflect the changed situation.

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 29 March to 23 April 2021.

1.2 PRC/PRU Tasks

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 [3]. More information about the PRC is given on the inside cover page of this report

EUROCONTROL and the European Union have a long-standing relationship and history of cooperation in ATM and in the implementation of the Single European Sky (SES) and other related policies.

Of central importance is the contribution that the EUROCONTROL Performance Review System and the Performance Scheme of the Single European Sky (SES) jointly make towards improving the overall performance of air navigation services and network functions. The PRU provides support to the European Commission (EC) under a service contract, signed in 2017, which runs for four years. Activities include, inter alia, 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.

The PRC's work avoids potential overlaps with that of the Performance Review Body (PRB) which assists the European Commission (EC) in the implementation of the SES Performance Scheme.

The PRC/PRU tasks can be categorised as follows:

- **Data collection and analysis:** Collection and analysis of performance-related data and make independent recommendations to the EUROCONTROL States;
- **Reporting:** Provision of impartial, independent and unbiased information to facilitate stakeholder dialogue. The PRC publishes an annual PRR and an annual ATM Cost-Effectiveness (ACE) Benchmarking report. In 2019, the PRC placed more focus on researching specific topics, in consultation with stakeholders, and in publishing the results as PRC Technical Notes. The PRC is constantly reviewing its work programme to ensure that it remains relevant and useful to stakeholders. It publishes "Performance Insight" short papers on topical themes

  The Aviation Intelligence Portal (www.ansperformance.eu) provides a variety of interactive dashboards for more detailed analysis and offers monthly updates of performance information covering all EUROCONTROL Member States.
- **Research and development:** Conducting of research to further improve the performance measurement framework and to test new indicators;
- **International benchmarking:** Provision of assistance to ICAO and other regions of the world in benchmarking different systems and promoting/developing harmonised standards for data collection and sharing, including the establishment of an open data platform for performance benchmarking. The PRU ensures a strong input to the global developments of the performance based approach benefitting from the European experience.

1.2.1 Report structure

The report is structured in five chapters:

Chapter 1 — **Introduction and context**

- *Chapter 1 provides the "bigger picture", and informs about the latest traffic trends in the EUROCONTROL area.*
- *It also addresses cross-dimensional topics including the COVID-19 crisis, the environmental impact of aviation and ATM, and digitalisation.*

Chapter 2 — **Safety**

- *Chapter 2 reviews ANS safety performance.*
- *It addresses the issue of safety data availability for performance review, explains the Composite Risk Index (CRI) which is an innovative methodology for use in safety performance review.*
- *Finally the chapter explores the complex but important topic of future challenges to safety performance.*

Chapter 3 — **En-route ANS performance**

- *Chapter 3 provides an overview of the evolution of en-route ATFM delays which virtually disappeared in April 2020 as a result of the COVID-19 outbreak and the subsequent drop in traffic. With a view to the traffic recovery, the chapter reviews the lessons learned from the capacity crisis in 2018/19.*
- *The second part looks at the horizontal and the vertical dimension of en-route flight efficiency in 2020.*

Chapter 4 — **ANS performance @ airports**

- *Airport capacity was seen as one of the key challenges for future growth but the COVID-19 pandemic changed the situation entirely for the next years.*
- *Chapter 4 reviews ANS related performance at the top 30 airports in 2020 and the impact of the COVID-19 pandemic on operations at airports.*

Chapter 5 — **ANS Cost-efficiency**

- *The final chapter evaluates ANS cost-efficiency performance for 2019 (which is the latest year for which actual financial data is available).*
- *Furthermore the chapter details the impact of the COVID-19 pandemic on cost-effectiveness in the longer term and estimated losses in en-route revenues in 2020.*

1.3 The COVID-19 pandemic and the aviation industry

Although there were already signs of weakening traffic towards the end of 2019 because of an economic slowdown in Europe, nobody was prepared for the crisis emerging from the outbreak of the new SARS-CoV-2 virus in Wuhan, China during the closing months of 2019. With the COVID-19 pandemic sweeping its way across the globe, the aviation industry is facing an unprecedented challenge.

Without a doubt, 2020 was a devastating year for the aviation industry which has been hit harder than many other industries due to the measures implemented by States to contain the pandemic and the subsequent reduced demand for air travel.

Unlike previous crisis or outbreaks (SARS, MERS) which had V-shapes and were more regional in scope, the COVID-19 crisis is different. The intensity (depth) and persistence (length) of the crisis is unprecedented. Following the deep global shock in 2020 there is still great uncertainty about the shape and form of the recovery over the coming years.

For 2020, the International Civil Aviation Organisation (ICAO) estimates a 60% reduction in passengers globally [4] with appalling effects on the aviation industry's income and employment levels.

World passenger traffic evolution
1945 – 2020

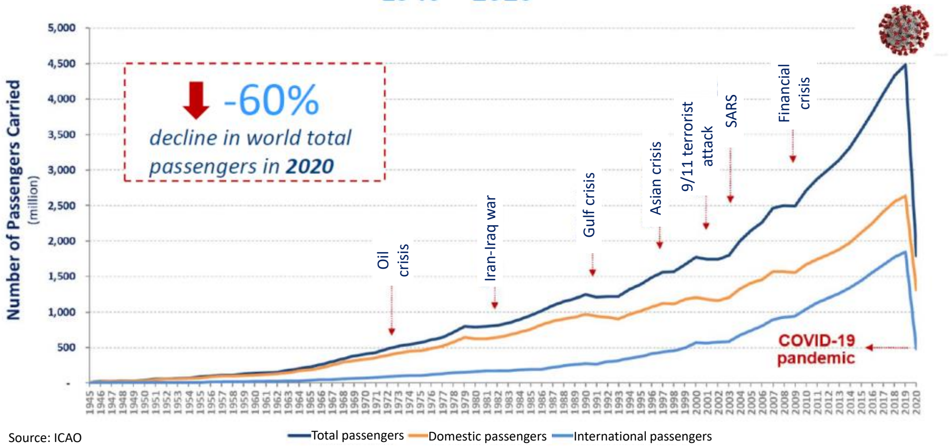

Figure 1-2: World passenger traffic evolution (1945-2020)

The impact of the pandemic differs by world region (see Figure 1-3) with Europe being hit particularly hard due to the large share of international air traffic. For Europe, the Airports Council International (ACI) estimates a 70% decrease in passengers which corresponds to a total loss of 1.72 billion passengers in 2020 [5].

Comparison of total seat capacity by region
(7-day average, YoY compared to 2019)

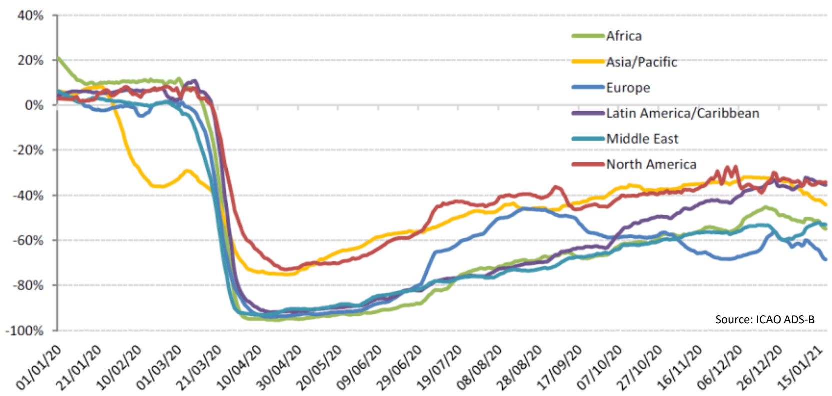

Figure 1-3: Traffic evolution by world region (ICAO 2020)

1.4 ANS performance on the road to recovery

With the arrival of the COVID-19 pandemic in March 2020, the number of flights in Europe dropped dramatically and revenues in aviation evaporated overnight. In many cases, existing systems and schemes proved not to be prepared for a crisis of this magnitude and persistence which required urgent action to mitigate the immediate impacts while putting in place the building blocks for a more robust and adaptable post-COVID aviation system.

Notwithstanding the challenges imposed by the COVID-19 pandemic on the aviation industry, safety levels remained high in Europe and will continue to remain pivotal during all recovery stages and beyond.

On the operational side, the severity of the COVID-19 pandemic completely overshadows the European capacity crisis of 2018/19 as - judging from the current traffic forecasts - capacity issues are unlikely to occur in the immediate future. With the dramatic drop in air traffic in 2020 en-route and airport ATFM delays virtually disappeared and both horizontal and vertical flight efficiency improved notably which illustrates the link between capacity provision and operational efficiency.

With decarbonisation already being high on the agenda before the COVID-19 pandemic, policy makers more and more link their support to the industry with the European Green Deal [6] objectives to make Europe carbon neutral by 2050.

Despite the significant temporary reduction in emissions from aviation as a result of the drop in demand and the flight efficiency gains, it is clear that the pressure on the entire industry to make aviation greener will continue throughout the crisis and beyond.

On the economic side, the COVID-19 pandemic showed that the current ANS funding schemes in Europe were not designed to cope with a crisis of this magnitude. With ANS being funded primarily through route charges in Europe, the dramatic drop in traffic resulted in a corresponding drop in revenues.

To mitigate the effects of the resulting lack of liquidity and to ensure business continuity some immediate measures had to be taken, such as State aid, loans and various cost-containment initiatives. ANSPs were required to take action to downscale operations and to adjust to the reduced demand whilst still providing reliable services to airspace users.

Figure 1-4 summarises the key challenges to European aviation and expected changes in terms of priorities from pre-COVID-19 to post COVID-19 times.

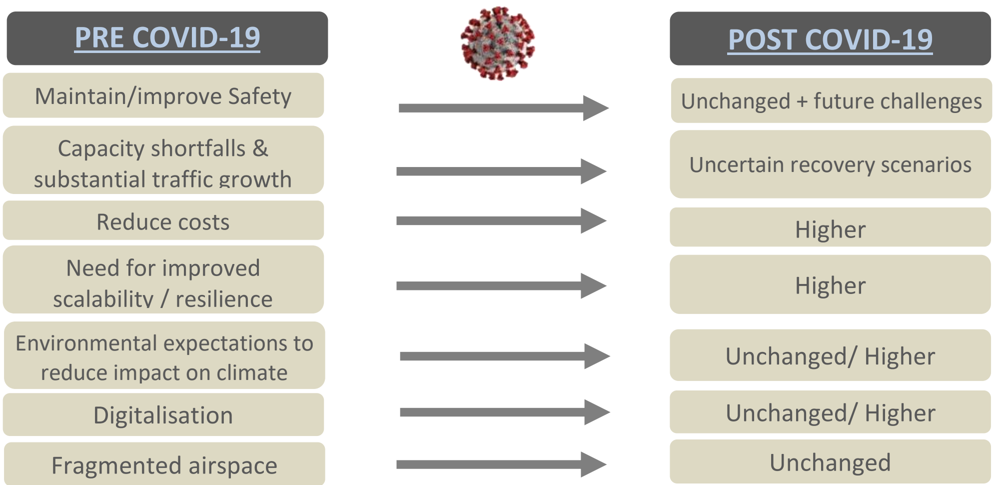

Figure 1-4: Challenges and expectations for European aviation pre- and post-COVID-19

Without a doubt, the focus of ANS performance in the coming years will be on the ability to adjust its operations in step with any drop in demand, while at the same time preparing for the future in terms of safety, capacity provision, higher levels of digitalisation and environmental sustainability.

Figure 1-5 provides an overview of the key ANS performance aspects over the coming years, including the changing priorities over time. The relevant topics are also reflected in this year's report.

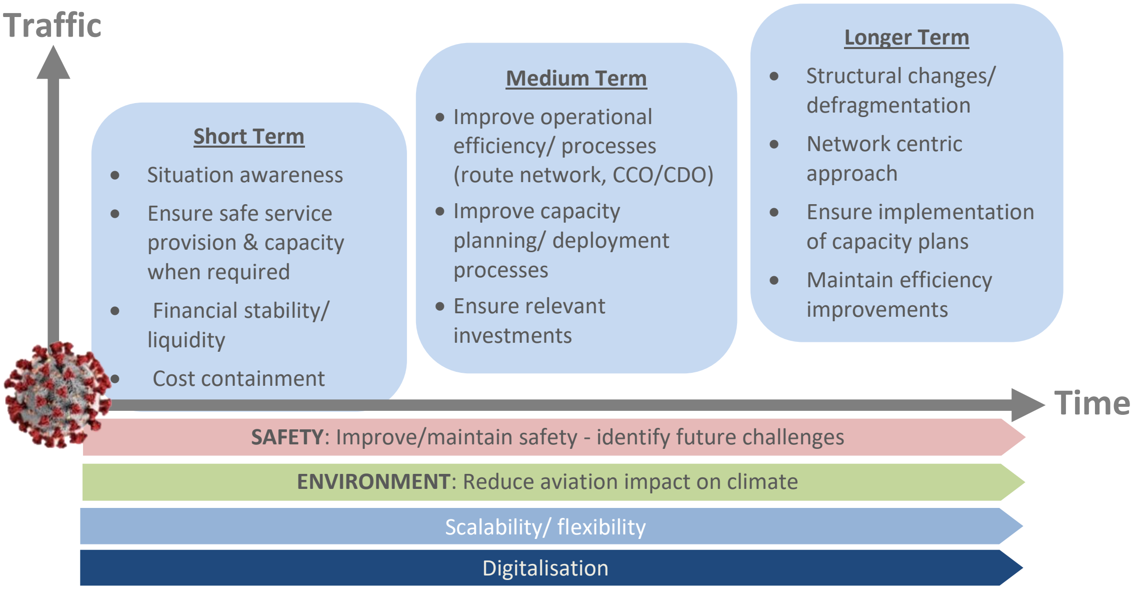

Figure 1-5: ANS performance aspects on the road to recovery

In the short term, the focus will be on understanding the dynamics of the COVID-19 crisis to adjust operations whilst ensuring business continuity and financial stability. Fast and reliable facts are essential for decision making in these challenging times and the Aviation Intelligence Portal (www.ansperformance.eu) offers unique, frequently updated high quality data for all aviation stakeholders, covering all EUROCONTROL Member States.

The evolution of traffic demand in 2020 and possible recovery scenarios are described in Section 1.5 of this chapter.

An estimation of the impact of COVID-19 on en-route revenues including an initial overview on cost containment measures of ANSPs is provided in Section 5.4.1 in Chapter 5.

In the medium term, the focus will be on the improvement of operational efficiency to remove constraints imposed by ANS where possible and to enable improved environmental performance when traffic will continue to rise again.

Operational performance improved notably after April 2020 when traffic levels dropped as a result of the COVID-19 pandemic. Flight efficiency in the en-route phase and in the climb and descent phase at airports are addressed in Chapters 3 and 4 respectively.

In parallel, it will be important to continue to analyse, identify and understand issues that led to the capacity crunch in 2018/19. Even though capacity is not expected to be a problem in the near future, there is a need to analyse and identify shortcomings in the past to ensure that the same problems will not occur again when traffic returns. The lessons learned from the capacity crisis, including the key findings of a PRC stakeholder workshop held in October 2020, are detailed in Chapter 3.

In the longer term, the challenge will be to maintain achieved efficiency gains when traffic continues to rise and to ensure that capacity is available when needed. The capacity crisis in 2018/19 painfully highlighted the disproportional increase of delay when insufficient capacity is available to airspace users. The COVID-19 crisis stressed again the need for close cooperation and coordination between all stakeholders and the importance of a proactive, harmonised network centric approach with less operational fragmentation in Europe.

As illustrated in Figure 1-5, the focus on safety, environmental performance, digitalisation and improved scalability and resilience will remain relevant throughout the entire recovery phase.

Environmental performance and digitalisation are addressed in Section 1.6 and Section 1.7 of this chapter. The PRC's view on future challenges to safety is provided in Chapter 2 of this report.

1.5 Traffic evolution and outlook in the EUROCONTROL area

In order to better manage and overcome the COVID-19 crisis, it is essential to understand its dynamics, characteristics and evolution. The latest traffic data on which the analysis in this section is based is available on the aviation intelligence portal (www.ansperformance.eu) which is frequently updated.

1.5.1 The high level picture

Figure 1-6 summarises the unprecedented reduction in all European air traffic indices[1] in 2020, as a result of the COVID-19 pandemic.

Compared to 2019, the number of flights at ECAC[2] level decreased by -55.2% in 2020 which corresponds to 6.1 million fewer flights.

Flown distance (-58.2%), en-route Service Units[3] (-57.6%), passengers (-70%) but also CO_2 emissions (-56.9%) decreased at an even higher rate than flights in 2020, as a result of the pandemic.

The higher decrease is because international (long haul) flights using larger aircraft were more affected by the traffic restrictions imposed to fight the pandemic.

Consequently, the average aircraft mass decreased by -1.7% in 2020.

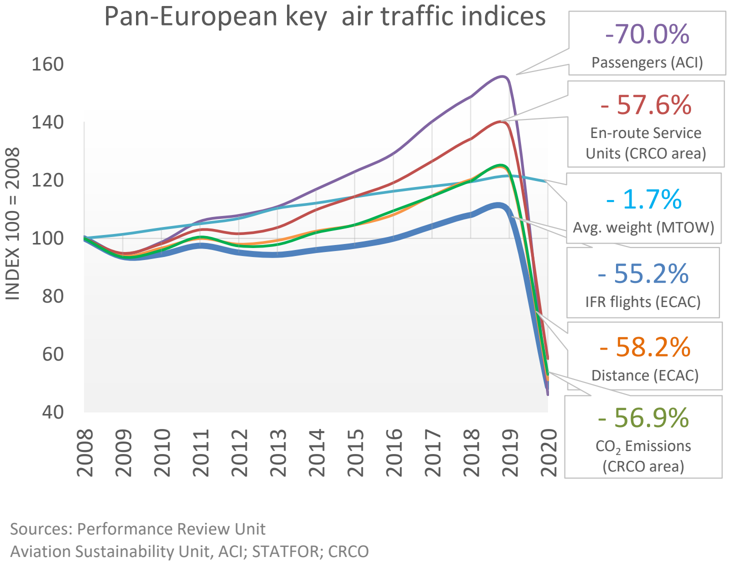

Figure 1-6: European air traffic indices (2008-2020)

However, the annual view in Figure 1-6 hides the evolution and the dynamic of the crisis in Europe unfolding in early 2020. Figure 1-7 shows the daily flights in the EUROCONTROL area together with the reported COVID-19 cases.

Following the shock in March 2020, the 7-day moving average reached its lowest point in April when traffic was 88.2% below the level of 2019.

If only the March to December period is compared, the traffic reduction rises to 63.9% compared to the same period in 2019.

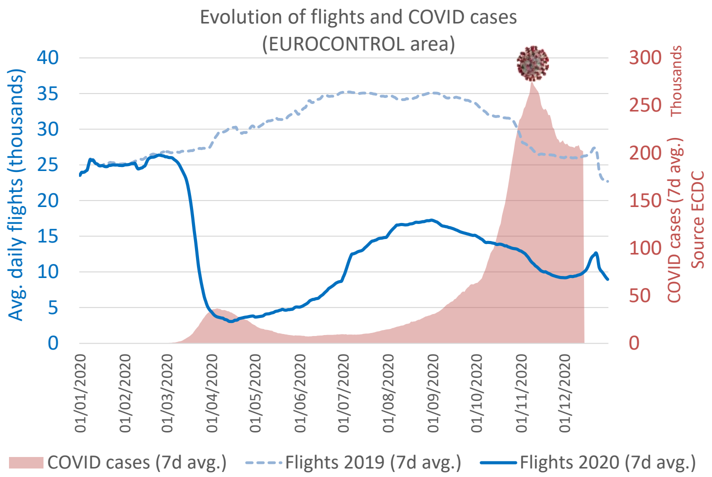

Figure 1-7: Traffic and COVID cases in the EUROCONTROL area (2020)

After passing the turning point in April 2020, there has been a small but sustained increase in flights with a more pronounced increase towards the end of June 2020 which was partly driven by flights to holiday destinations (Spain, Italy, Greece and Turkey).

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

2 The European Civil Aviation Conference (ECAC) is an intergovernmental organization which was established by ICAO and the Council of Europe. ECAC now totals 44 members, including all 27 EU, 31 of the 32 States which are part of European Aviation Safety Agency (EASA), and all 41 EUROCONTROL Member States.

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

Following the resurgence of COVID-19 in September 2020 and the subsequent travel restrictions implemented by States, traffic started to decrease again with only a small increase during the holiday season at the end of the year.

Figure 1-8 shows the monthly evolution of flights, average distance and average aircraft mass compared to 2019 in the EUROCONTROL area.

Following the dramatic drop of traffic by up to 88.2% in April, average distance and aircraft mass in fact increased because of cargo aircraft supplying goods and equipment to fight the pandemic.

As of May 2020, traffic started to operate again, mainly on domestic and intra-European routes (see Figure 1-9).

With long-haul flights on larger aircraft still largely suspended, the average mass and distance decreased compared to traffic in 2019.

Zooming in even further, the analysis by market and traffic segment reveals further insights on the dynamics of the crisis.

Figure 1-9 shows that international flights within the EUROCONTROL area and domestic flights in Member States recovered quicker in summer 2020 but dropped again as of September with airlines adjusting their schedules as a result of the second wave of the COVID-19 pandemic hitting Europe.

Figure 1-10 shows the traffic evolution by market segment in 2020. Although all cargo flights account for a comparatively small share of the total flights (2.9% in 2019), the need for goods and equipment to fight the pandemic resulted in a +1.7% increase of dedicated all-cargo flights in 2020 [7].

Business aviation accounted for 6.4% of the traffic in 2019. Following the drop in March 2020, business aviation recovered faster than the other segments reaching the pre-COVID level in August before declining again after the summer.

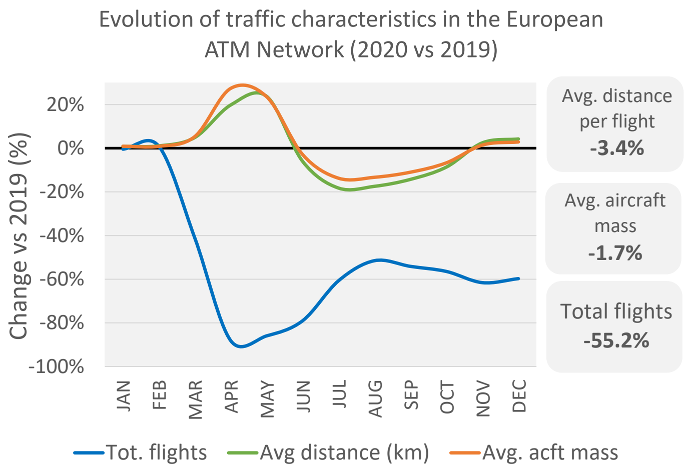

Figure 1-8: Evolution of traffic characteristics vs 2019

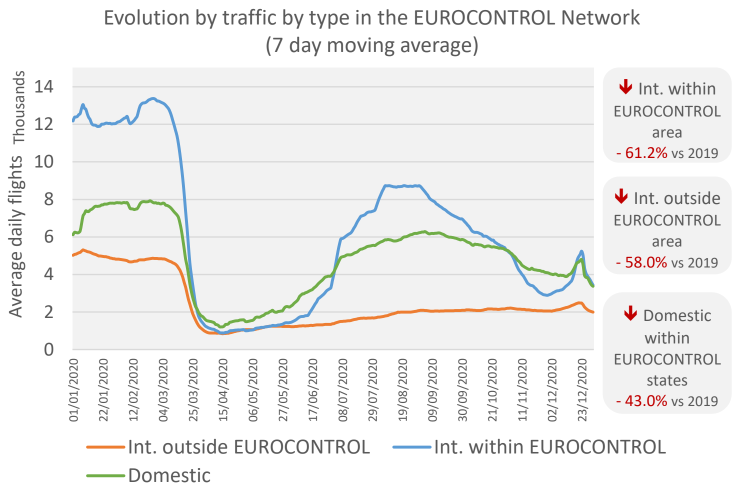

Figure 1-9: Evolution of traffic by type in 2020

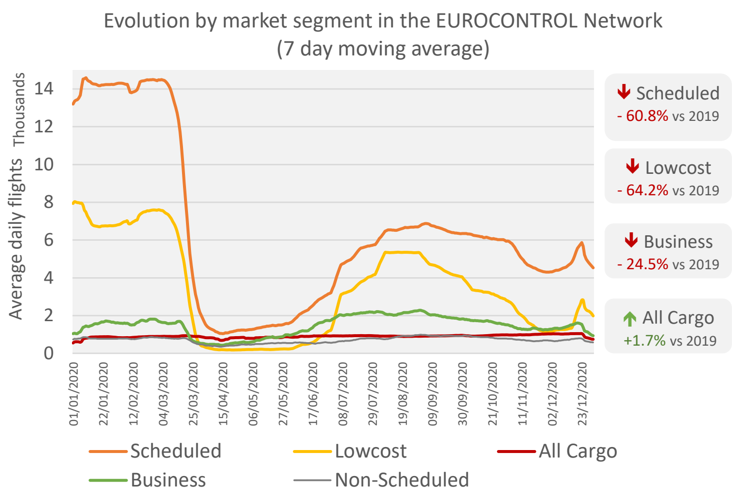

Figure 1-10: Traffic evolution by market segment in 2020

Traditional scheduled and low cost traffic account for the largest share of traffic but are slower to recover as they are heavily affected by measures implemented by States to contain the pandemic and the subsequent reduced demand for air travel in Europe.

The high international share of traffic in Europe (72.6% in 2019) adds to the difficulty on the way to recovery because of the large number of different rules in terms of quarantine and testing requirements which have proved to be a major obstacle for passengers to fly. Observations in other world regions confirm this observation, as the recovery rate is higher in markets with a large domestic share (US, China) where the same set of rules applies.

Figure 1-11 shows the relative (y-axis) and absolute (x-axis) traffic change compared to 2019 by world region and traffic type in the EUROCONTROL area.

With 81% of all flights operating within the EUROCONTROL are in 2019, it is no surprise that those markets showed the highest decrease in absolute terms in 2020.

In relative terms, domestic flights in EUROCONTROL Member States showed the smallest decrease (-43% vs 2019) while the highest decrease compared to 2019 was observed for traffic to Russia/Other Europe, international flights within the EUROCONTROL area, and for flights to the U.S. and Canada.

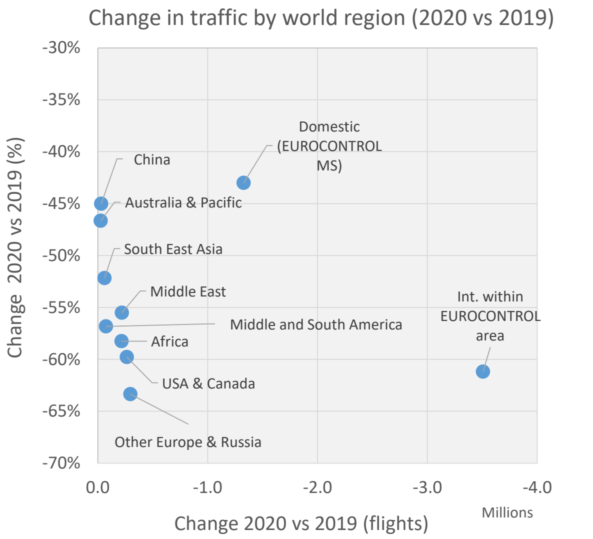

Figure 1-11: Change in traffic by world region (2020 vs 2019)

1.5.2 Grounded aircraft in the EUROCONTROL area

The drastic reduction in traffic forced many aircraft operators to withdraw a significant part of their fleet from service, be it temporarily or permanently.

Figure 1-12 shows the share of the inactive fleet by duration as a result of the COVID-19 crisis in Europe.

On 31 December 2020, 28% of the aircraft in Europe were inactive for at least 30 days (16% for more than 180 days) which corresponds to more than 3600 aircraft.

Aircraft parking is an additional cost factor for airlines and a number of airlines therefore relocate aircraft from larger airports to specific storage facilities which also offer maintenance services.

A more detailed analysis by airport is provided in Section 4.2.1.3 in Chapter 4 of this report.

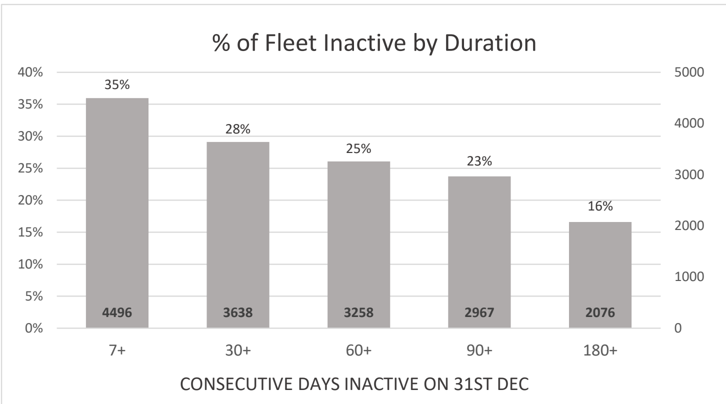

Figure 1-12: Percentage of aircraft fleet inactive in 2020

1.5.3 Traffic by state

At EUROCONTROL level, the number of flights decreased on average by -55.2% in 2020 which corresponds to 6.1 million fewer flights than in 2019. However, the impact of the COVID-19 crisis on air traffic differed by State depending on the measures taken and the mix of traffic.

Figure 1-13 shows the change in the number of flights compared to 2019 in absolute terms (top chart) and relative terms (bottom) by state. The figure is sorted according to the relative change versus 2019.

As the crisis started at the end of the first quarter in 2020, the bottom chart provides a complementary view of the traffic reduction between March and December 2020 (shown in light red).

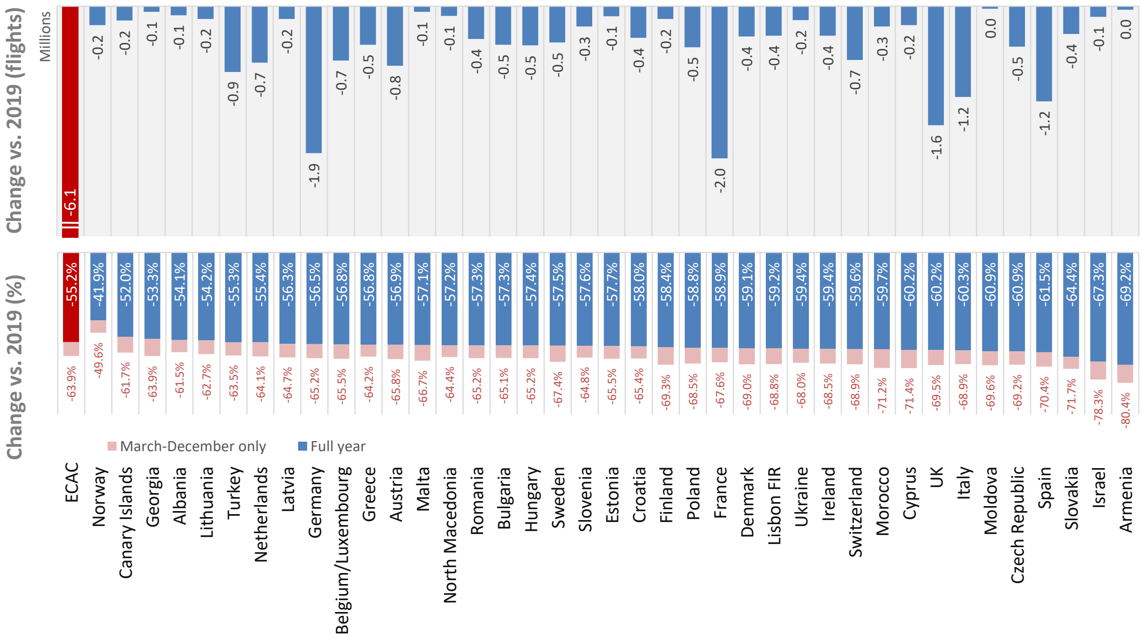

Figure 1-13: Traffic evolution by traffic zone (2020 vs 2019)

All traffic zones but Norway show a fall of 50% or more compared to 2019. The traffic reductions at traffic zone level range from -41.9% in Norway to -69.2% in Armenia.

The level of traffic decrease in each zone is influenced by a number of factors including government rules to fight the pandemic, airline behaviour and the type of traffic. The lower decrease in Norway for instance is due to its comparatively high share of domestic traffic to peripheral areas which was continued also during the pandemic.

In absolute terms, five traffic zones (France, Germany, UK, Italy, and Spain) lost more than 1 million flights compared to 2019.

Without a doubt the dramatic drop in all traffic zones as a result of the pandemic creates major challenges to ANS in terms of funding and adjusting the operation to the reduced demand while preparing the future in terms of capacity and staff planning and without forgetting to invest in digitalisation and environmental sustainability.

1.5.4 Traffic recovery scenarios and forecast

Moreover, the outlook for the coming years remains uncertain as the recovery depends on many factors, including vaccine effectiveness and availability, government policies on travel restrictions, passenger behaviour and trust as well as the evolution of the general economic climate.

Commercial air traffic is particularly vulnerable to the aforementioned factors and with the pandemic continuing there is a possibility of more permanent structural changes in consumer behaviour (e.g. video conferencing, modal shifts, etc.).

As can be expected, there is a considerable level of uncertainty linked to any traffic scenario or forecast given the multitude of factors influencing the recovery path from the COVID-19 crisis.

Figure 1-14 provides an overview of the EUROCONTROL short term traffic scenario published in April 2020 and updated in September 2020 and January 2021, to account for situational changes.

Following the more optimistic spring 2020 scenario, there has been a continuous downward revision in response to the resurgence of COVID-19 in Europe in September 2020 and the risks associated with new variants which resulted in many States imposing stricter travel restrictions and strongly discouraging air travel.

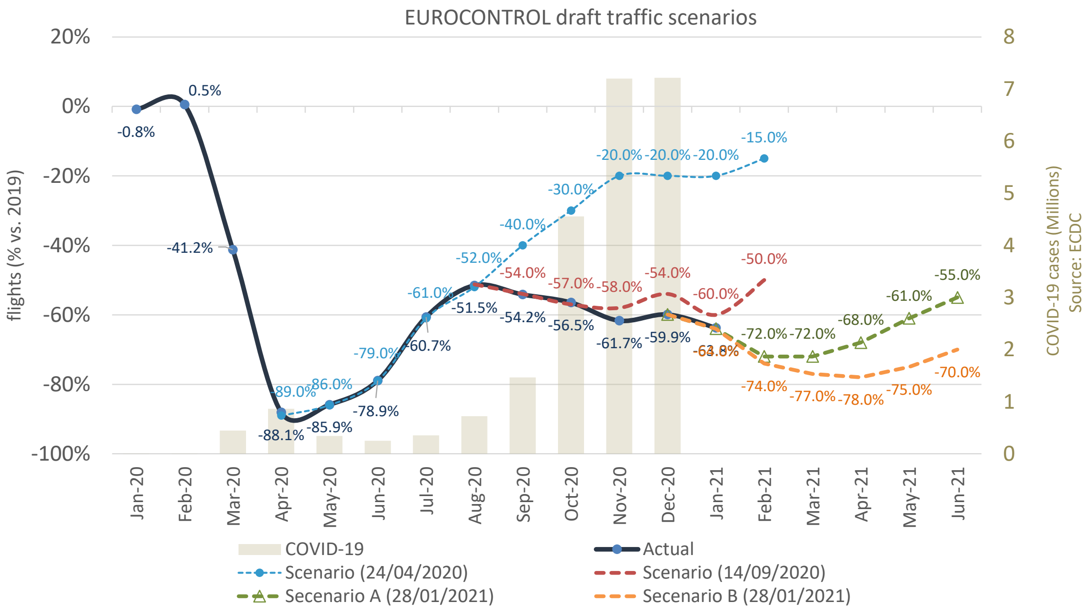

Figure 1-14: EUROCONTROL traffic recovery scenarios

Figure 1-15 shows the first initial longer term forecast up to 2024, produced by STATFOR in November 2020 [8]. It is based on traffic trends, economic forecasts and expert judgement and includes three scenarios (1) Vaccine widely available for travellers by Summer 2021 (2) Vaccine widely available for travellers by Summer 2022, and (3) Vaccine not effective.

In the most optimistic scenario, traffic is forecast to return to 2019 levels by 2024. However, in the second scenario (most likely), 2024 traffic would only be at 92% of the 2019 figure. In the third scenario, traffic in 2024 would be 75% of the 2019 figure and would not reach numbers seen in 2019 until 2029.

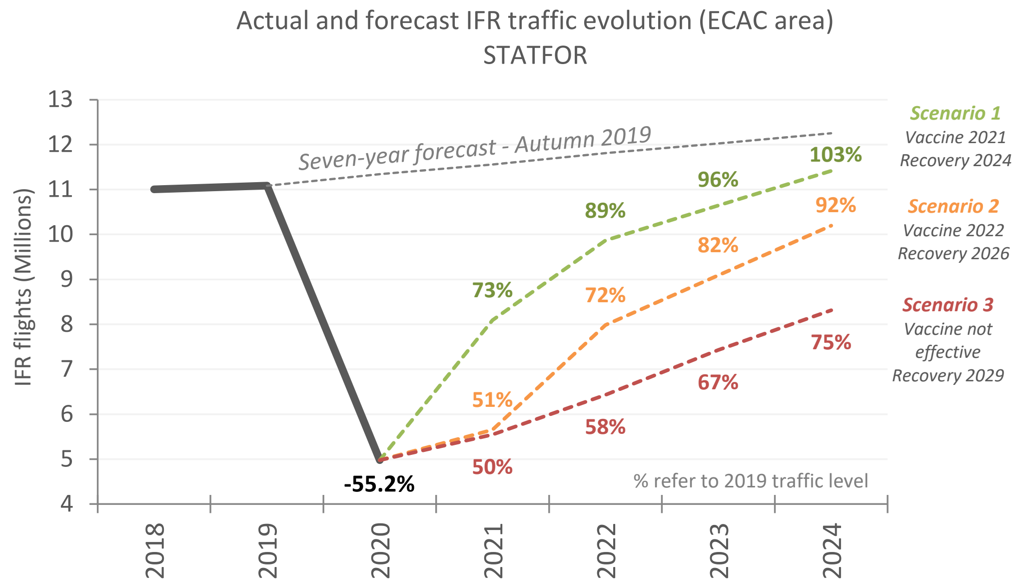

Figure 1-15: STATFOR traffic forecast (2020-2024)

Additionally, Figure 1-15 shows the last STATFOR pre-COVID-19 forecast dating from Autumn 2019 [9]. When comparing the baseline scenario in Autumn 2019 to the most likely scenario (2) of the November 2020 forecast there are approximately 21 million less flights in the ECAC area between 2020 and 2024.

The size of the shock combined with the uncertainty when and if traffic demand will return to pre-COVID-19 levels severely affects all elements of the aviation value chain, including air traffic management, and reiterates the urgent need to adapt and downsize in the short term while enabling sufficient scalability to adjust to various recovery scenarios.

1.6 Environmental impact

Together with new technological developments, the European Green Deal [6] with the objective to make Europe climate neutral by 2050 has put digitalisation and decarbonisation of transport at the very heart of EU aviation policy.

As a result of the unprecedented traffic reduction in 2020, CO_2 emissions in the EUROCONTROL area dropped by 56.9% compared to 2019. Although emissions from aviation more than halved as a result of the COVID-19 crisis it is clear that the environmental challenge for aviation will remain throughout the recovery phase and beyond and ANS will have to contribute to reducing the environmental impact of aviation.

ANS performance can help reducing 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.

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.

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[4] and help to avoid unnecessary exposure to aircraft noise. CCO/CDO is addressed in more detail in Section 4.4.3 in Chapter 4.

1.6.1 Impact on global climate

The environmental impact of aviation on climate results from greenhouse gas (GHG) emissions[5] (CO_2, NOx, etc.) and contrails, generated by aircraft engine exhaust. Whereas CO_2 emissions are directly proportional to the fuel burn, NOx emissions are more difficult to quantify as they depend on engine settings and prevailing atmospheric conditions. Moreover, the radiative forcing effect of non-CO_2 emissions depends on altitude, location, and time of the emission. EUROCONTROL is working with airlines and ANSPs to better understand the formation and impact of condensation trails (contrails) and to identify possible measures to mitigate those effects while keeping a positive balance between contrail avoidance and additional fuel burn.

The remainder of this section focuses on CO_2 emissions of which are considered to be one of the main contributors to climate change. Based on the figures of the European Environment Agency (EEA) aviation accounted for approximately 4.0% of total EU27+UK GHG emissions (4.8% of CO_2 emissions) in 2018 (the latest year for which information is available) [10]. Although this share appears to be comparatively small, aviation is one of the fastest growing sources of GHG emissions in Europe.

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

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

5 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_2 equivalent. For example: 1 kg of N_2O is equivalent to 298 kg of CO_2 in terms of global warming effect. An important natural GHG that is not covered by the protocol is water vapour.

Whilst the focus of the PRR is on ATM performance, it is helpful to briefly set out the overall context with regard to aviation and CO_2 emissions, before discussing ATM and environmental performance.

With the relative share of fuel cost in airline operational costs increasing, there has historically been a strong focus on increasing overall fuel efficiency.

Aircraft technology: Fuel efficiency improvements over the past decade were remarkable. According to the manufacturers, the latest generation of aircraft (e.g. A350, B787) burn about 15-20% less fuel than the previous generation they replace. Although airlines announced to retire less fuel efficient aircraft as a result of the COVID-19 pandemic it will take some time (aircraft lifespan = 20-30 years) until efficiency gains through fleet replacements will fully filter through the entire aircraft fleet.

While manufacturers find it increasingly difficult to deliver further efficiency gains from conventional engine and airframe design, radical new concepts such as the plans for zero-emission commercial aircraft presented by Airbus in September 2020 could bring significant future environmental effects through aircraft technology.

Electric or hydrogen powered aircraft could be an option to help decarbonising aviation but only make sense when based on renewable sources. Although still at least a decade away, electric aircraft offer the highest potential to substitute short haul flights of up to 1500 km after which the batteries become too heavy.

Even though this would have the potential to replace some 70% of all departures from the EUROCONTROL area (2019), the corresponding reduction in terms of CO_2 emissions would be limited to 25% (see Figure 1-16).

Longer flights which generate some 75% of the total CO_2 emissions are expected to continue to rely on liquid fuels for some time to come.

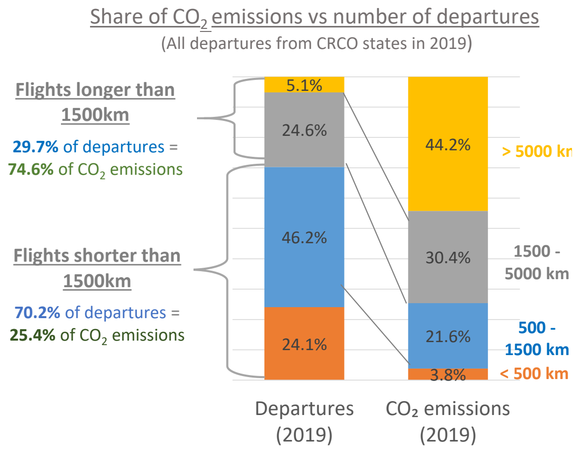

Figure 1-16: Distribution of flights and estimated CO_2 emissions by distance category (2019)

Especially for those flights Sustainable aviation fuels (SAF) would be a real game changer in decarbonising aviation. The Air Transport Action Group (ATAG) considers SAF as the most important pathway to achieving the aviation industry's climate goals [11] with the potential to reduce CO_2 emissions from fossil fuel by up to 80%.

However, the SAF production processes are energy intensive: blending SAF with fossil fuels or switching to SAF only helps decarbonising aviation if the production is fully based on renewable sources. According to IATA, SAF is currently on average between 2-4 times more expensive than fossil fuels and production is limited to just 0.1% of the total aviation fuel consumed by the industry. Initiatives such as the ReFuelEU Aviation initiative are expected to create economic stimulus to commercialise SAF production which will help narrowing the price gap between SAF and fossil fuel and boost production levels and hence the SAF uptake in the aviation sector with a direct impact on reducing CO_2 emissions.

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 CO_2 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 CO_2 savings. Work is ongoing to develop specific indicators for the measurement of environmental performance in the future.

Previous PRC work [12] has indicated that the benefit pool that can be influenced by ANS is approximately 6-8% of the total gate-to-gate fuel burn[6] (emissions) in the ECAC area[7]. Although there is clearly scope for further improvement, it is important to point out that the inefficiencies cannot be reduced to zero nor can they be attributed entirely to ANS. A certain level of "inefficiency" is in fact necessary (separation minima, adverse weather, avoidance of 'Danger Areas') or even desirable (trade-offs).Taking the theoretical upper ceiling, the ANS contribution to reduce emissions is limited to some 0.3-0.4% of the total CO_2 emissions in Europe (SAF ≈ 3.8%).

Figure 1-17 provides an overview of the various factors influencing aviation's CO_2 efficiency, including a high level estimate of the potential benefit pool for further improving environmental performance.

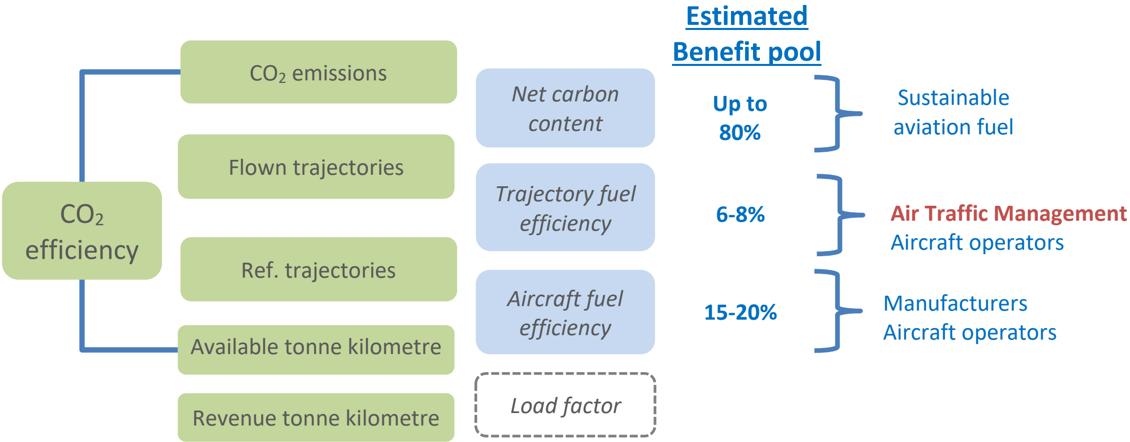

Figure 1-17: Factors affecting aviation CO_2 efficiency

So what can ATM do to help?

Increased operational efficiency leads to increased fuel efficiency and a subsequent reduction in emissions. Figure 1-18 provides an overview of the gate-to-gate efficiency by phase of flight including an indication of the supporting ATM related projects/ enablers.

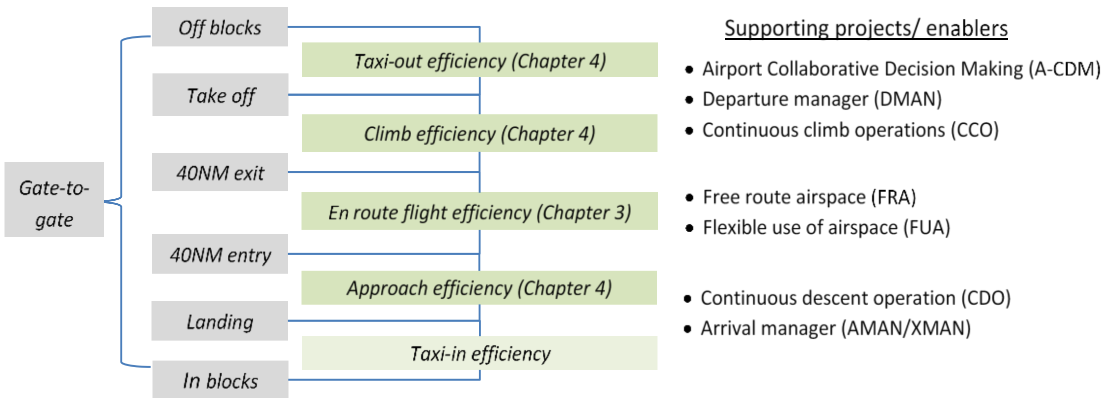

Figure 1-18: Gate-to-gate efficiency by phase of flight

6 Only the share of the trajectories in the ECAC area are considered.

7 The PRC is aware that there are many different studies aimed at quantifying fuel and flight efficiency. While those studies provide useful and valuable insights, the differences in scope and methodologies make direct comparisons often difficult if not impossible. For instance, a recent EUROCONTROL study focusing only on flights within the EUROCONTROL Network Manager area (long haul flights excluded) estimated the average fuel inefficiency from take-off to landing between 8.6% and 11.2% [26]. The PRC is fully supportive of the continued work to further develop and refine the understanding of (1) the level of inefficiency in the European ATM system (gate-to-gate), (2) the underlying drivers, and (3) the scope for improvement in each area.

Figure 1-19 provides an initial high level summary of the evolution of the ANS operational metrics with environmental impact detailed in the respective chapters of this report and outlined in Figure 1-18.

Following the dramatic drop in traffic due to the COVID-19 pandemic in March 2020 all operational metrics improved, with a positive effect on fuel burn and environmental impact. This provides a unique opportunity for ANS to review and remove existing constraints in the ATM system, to further improve the efficiency of the ATM system and to maintain the achieved efficiency levels when traffic returns after the COVID-19 crisis.

For example, at the top 30 airports in Europe the additional taxi-out time dropped by 2 minutes on average while airport holdings decreased by almost 1 minute in 2020. Vertical efficiency at the top 30 airports during approach, measured as average time flown level, decreased by 48 seconds compared to 2019. Achieving this performance with the traffic level of 2019 would have saved 3.2 million minutes (6.1 years) in level flight with the corresponding savings in terms of fuel and CO_2 emissions (see Chapter 4 for more details).

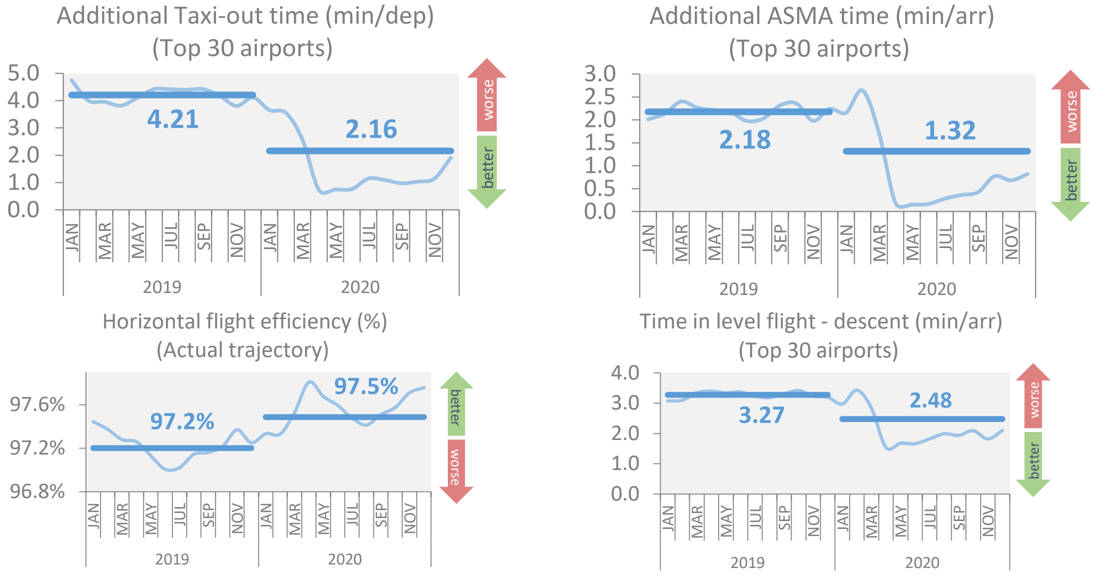

Figure 1-19: Flight efficiency improvements in 2020 – The big picture

Since the beginning of the COVID-19 pandemic in March 2020, ANSPs - in collaboration with the Network Manager - removed 1,200 Route Availability Document (RAD) measures in the network which enables more direct routings and hence more efficient flights. Horizontal flight efficiency improved by 0.3 percent points in 2020. Although this seems small, achieving the 2020 efficiency level with the traffic of 2019 would have saved a total of 29.7 million kilometre of additional distance flown (see Chapter 3 for more details).

The observed operational improvements are largely the result of the dramatic drop in traffic and the subsequent free capacity en-route and at airports which helped to remove existing constraints in the ATM system.

The analyses in the various chapters of this report show that the observed improvements varied notably among ANSPs and airports which may be partly linked to local specificities but also differences in the ability and flexibility to remove ATM constraints and to adjust to traffic demand.

As the expectations to help reducing carbon emissions will remain or become even more pressing on the way to recovery from the COVID-19 crisis, there is a need to review current processes and procedures to remove constraints affecting flight efficiency in the ATM network and to try to maintain the achieved performance as much as possible when traffic returns.

With this in mind, the current low level of traffic enables to identify an initial baseline of achievable performance in different areas but also clearly shows that a certain level of operational inefficiency will remain in the system for necessary (safety) or desired (trade-offs) reasons.

1.7 Digitalisation – Digital Transformation

Despite its recent popularity, digitalisation is not a fundamentally new concept in air traffic management (ATM). Higher levels of operational efficiency will require the introduction of novel concepts of operation and supporting technology.

The introduction of new technologies, in particular in concert with airborne capabilities, will be a key requirement over the next years.

This is amplified by the financial impact of the COVID crisis and an anticipated postponement of investment. Efficiency and capacity constraints observed in 2018/2019 can only be overcome by focussing on closing the backlog in terms of deployment.

In this edition of the PRR, the PRC looks at the merits of measuring the digitalisation impact on ATM performance. Digitalisation is widely expected to have a big impact on the industry but, as it is not always clear what is meant and what it relates to, it is useful to establish a framework.

Before doing this, there is a need to take a look at the terminology and to introduce some definitions which ensures a better understanding about what is discussed by different stakeholders regarding digitalisation or a sometimes related term: digital transformation.

In particular the discussion needs to address whether digitalisation is a means of delivering a similar performance level as before (but with different tools or ways of working) or, if digitalisation is directly impacting on performance which may lead to organisational changes and new ways of service delivery. A third element is the use of digitalisation as a tool for the better measurement and understanding of ATM performance.

The PRC's intention is not to duplicate the work of others but to focus and set priorities with regard to digitalisation for its future work related to ANS performance.

1.7.1 Terminology

To set the scene, there is a need to clarify some of the terminology used in this context:

- **Digitalisation** is the use of digital technologies and digitised data/communication to enable or enhance/improve business processes.
- **Digital transformation** refers to the broader aspects of digitalisation including organisational (and societal) culture change on top of the adoption of digital technologies.

A proper differentiation between digitalisation and digital transformation will help to address political and policy discussions on the change in ATM versus the perceived lack/backdrop of deployment of newer technologies in ATM.

The "transformation" comprises three elements: culture, process, and technology. Hence, "digital transformation" is wider than the simple adoption of new technology, it requires a move towards a more agile and evolving organisation embracing dynamic (system) change methodologies (e.g. continuous integration/continuous delivery, fail-fast), supported by organisational policies and processes.

In future work also attention has to be paid to the role of Artificial Intelligence (AI) and Machine Learning (ML). Both have to do with the advances in terms of computing power, data processing and data availability. In the digitalisation context, AI represents a toolbox from which developments are driven, while ML is a set of tools to address specific problems or functions. AI/ML are therefore not an end in itself. Existing ANS functionality may be well served with current technologies while in other areas AI/ML techniques may help to increase the level of system support to human decision-making or automation, or to reduce uncertainty in terms of operational planning, estimation, etc.

1.7.2 Scope

The advent of the Internet of Things (IoT), cloud computing, and big data have been the key drivers for the digital transformation of many business areas. The concept of "digital economy" evolved with the beginning of the 21st century. Although digital technologies are pervasive in all businesses there is a public debate whether digital technologies are used to their full potential. The potential to redesign business processes through the update and uptake of technology, including the development and deployment of technology and systems, is widely seen as a critical milestone in terms of enhancing efficiency and competitiveness. Efforts to measure the level of, and better understand, digital transformation in different sectors have been promoted by the OECD and European Union.

The ATM Master Plan proposes a Digital Index for ATM based on the Digital Economy and Society Index [13] and addresses the technological dimension of the "digital economy" thinking. Today's discussions about "digital transformation" include also a political and strategic dimension affecting the organisation of air navigation including the distinction between air traffic service and air traffic management service provision and associated infrastructure provision expanding the classical CNS conception. The spectrum of "Digital Transformation" also entails higher levels of transparency and access to data by the public, research and development, and 3rd party service providers. Figure 1-20 depicts this spectrum and its dimensions.

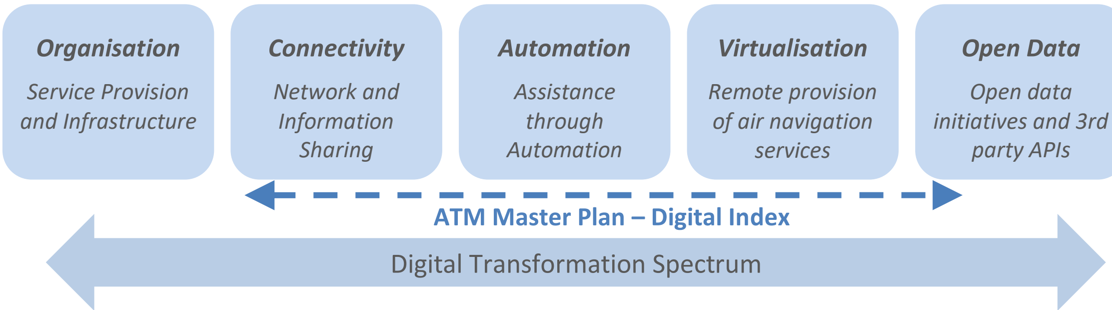

Figure 1-20: Digital Transformation Spectrum

The recent years have seen the application and utilisation of the underlying technological capabilities in many industries. Figure 1-20 shows the intensity and development in ICT related technologies for the years 2005-2015 [14]. It highlights the advent and innovation cycle of enabling technologies in terms of patent bursts (x-axis: start of burst, y-axis: duration of burst, bubble-size: frequency of new patents). There is an accelerated innovation in particular data communication, data communication and transfer. Many of these technologies are now being discussed as part of innovative technologies in aviation / air traffic management (e.g. virtual tower – based on digital video processing, data transfer, and video analytics). They also form the basis for higher levels of decision-support or automation.

ATM modernisation is a core theme since the beginning of the 21st century. The concept of a "digital European sky" was proposed back in 2016/2017 and represents a building block of the 2020 edition of the ATM Masterplan. Critics point out that the level of modernisation and innovation in air navigation over the past decade has been minimal and requires acceleration. The "digital transformation", e.g. higher levels of deployment of latest technologies and uptake of innovations, is seen as a step towards the required level of collaboration and automation in ATM. Both dimensions are essential to meet the future demand and ensure the decarbonisation goals through higher levels of efficiency.

Aviation/ATM by its very nature is a digital-intense industry/sector. However, the traditional approach to system development and deployment led to a varied set of systems. Defragmentation on the system level has been approached by bundling ATM R&D and placing a strong focus on standardisation. Despite many efforts, Europe has fallen behind on the deployment of key enabling technologies, for example SWIM and air-ground data-link. Higher levels of ground-ground and air-ground communication and data exchange will be key enablers for the future.

Additional efficiency gains are expected to come from the further digitalisation and automation of the industry. This will enable the better use of data-driven technologies like Artificial Intelligence (AI).

For ATM, AI offers the potential to improve the speed and accuracy of traffic flow planning and to achieve higher levels of predictability, while incorporating dynamic aspects like changing meteorological conditions. Trajectory-based operations will see higher levels of on-going interactions between air traffic services and aircraft. Last but not least, AI may support controllers and aircrew in their separation tasks. The perceived backlog on the implementation of latest technologies in aviation and ATM is linked to the strong safety focus in our industry. The system certification process of AI and self-learning/evolving systems vs the classical deterministic approach requires also a new techniques and understanding by regulators, manufacturers, operators, and supporting research and development.

There is a need to further speed up digitalisation and the development of a common infrastructure for data sharing including agreed standards. This will be a crucial enabler for efficiency gains and the way stakeholders in the ATM system interact with each other at the operational level. Higher levels of inter-connectivity are achieved through system wide information management (SWIM) protocols and business to business (B2B) interfaces. The deployment and inter-connectivity on a pan-European level shows some of the problems in terms of fragmented decision-making and funding. There should be a focus deployment execution. Future operational efficiency gains will depend on access of supporting processes, e.g. performance analysis, case analytics, environmental impact modelling, to this data. 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.

1.7.3 Performance impact

From a performance point of view, an interesting question is when organisational/cultural change kicks in to differentiate between (pure) digitalisation and digital transformation. Particularly within air navigation, which is defined by a distinct interface between air navigation service provision and airspace user “service consumption/utilisation”. Along this interface the aspect of “disruption” (understood as “fundamentally new”) offers a good differentiation criterion. The interface perspective allows for recognising internal change (e.g. technology adaption) versus step-changes in operational concepts or organisation of the service provision. The latter serves as identifying “categorically new” outside-in changes (or “disruptions”).

1.7.4 Focus of the PRC for the coming period

The focus of the PRC on a “digital transformation” will be related to the aspirational goal that “higher levels of performance” of the air navigation system are achieved. Related topics for possible further exploration include: Human performance, cost-efficiency, security and cybersecurity as well as the unbundling of service provision and dependency risks. This will also include the consideration of questions related to the organisation of ANS within Europe and a stronger outside-in perspective.

Some caution is also required when speaking about the impact of digital transformation. Higher performance levels may be driven by the introduction and deployment of new technology. However, real step-changes may require a more structural change to introducing new operational concepts (supported by enabling technologies) or the organisation of the service provision, including novel ways of managing the airspace/network. There might be a need to differentiate between network and local level when evaluating performance. Digital transformation efforts need investments which on the one hand may require economies of scale beyond what is achievable at national or ANSP level but which on the other hand may attract new players from outside the traditional ATM industry.

A question to be addressed with the on-going implementation of revised operational concepts and supporting technology is the suitability of current performance measures to detect and/or verify claimed performance benefits.

The characteristics of a “transformation” imply a categorical change of service provision in terms of organisation, stakeholder relationships, and processes. Today’s discussion however intermingles the concepts of digitalisation and digital transformation. Both terms are interchangeably used to describe developments related to enhanced capabilities, including technological support for advanced or novel operational concepts. Often these developments reflect the system engineering lifecycle. Technological change is not exclusively ‘digitalisation”. More discussion and analysis is needed if enhancement is specifically the result of digitalisation, or if digitalisation is a step in an on-going process of evolutionary improvements.

The on-going work in terms of introducing a more stringent link between the planning and implementation of technological change will be important to:

- Frame the future discussion: it will be clear from a programme perspective whether the discussion is about a technological change (i.e. new operational concept, supporting technology) or the introduction of new actors (change of providers, unbundling of services).
- Identify change vs breakthrough: while there are many opportunities to enhance operations (and supporting processes in ATM), the question of whether a change is part of the "regular" evolution of systems or represents a categorically different way of operating (e.g. automation). Systems engineering as a holistic approach is a corner stone of the way how change is implemented in aviation/ATM. Accordingly, adaptation of new(er) technology and techniques are not necessarily breakthroughs, but part of the ongoing system engineering lifecycle.
- Understand methods and the hype around methods: the discussion about AI/ML shows that a better understanding of the functions that benefit from the adaption of new(er) techniques is a system engineering question (and will ultimately be addressed). In the digitalisation context, AI is a toolbox and ML represents a set of tools for specific problems. In that respect, technology is not an end in itself.

The potential of a "digital transformation" is inherently linked with data service provision. The PRC underscores that such a fundamental change of technology and organisation of the service provision in ATM must adhere to the principles of a "safe, secure, and efficient" system. This will require new entrants to demonstrate – at a minimum – the same service levels the air navigation system observes today. In a new organisational context, the dependency risk of operations from underlying data is not categorically changed.

A further element of digitalisation is the possibility to use the resulting data for a better measurement and understanding of the ATM performance. As an industry, aviation and air navigation is a data rich environment ranging from passenger, fleet, weather, airport to operational traffic flow data, to name a few. The significant collection of data sets in European aviation today it is not efficiently used and shared. Initial approaches focus on presentation and outreach, but there is very limited access to the wider data for research and development, strategic planners and decision-makers. The PRC is working on expanding the performance related data availability beyond the current level. There is a clear call for open data initiatives within the aviation sector.

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2 Safety

2.1 Introduction

Safety is the primary objective of ANS and as illustrated in Figure 1-5 in Chapter 1, it needs to remain a primary focus area during all stages of the traffic recovery from the COVID-19 pandemic.

As pointed out by the PRC on several occasions, the changing safety reporting environment now resulted in the EUROCONTROL Annual Summary Template (AST) reporting being discontinued. This “end of an era” is addressed in Section 2.2. The PRC is currently exploring ways of accessing reliable ATM safety data as such access is important to enable the PRC to continue assessing Safety performance in the EUROCONTROL area.

With a view to further develop and improve innovative indicators to better understand the safety performance of the ATM system, Section 2.3 describes the latest improvements of the Composite Risk Index (CRI) to take account of local specific operating conditions, airspace size, and complexity.

The last section of the chapter (Section 2.4) aims at further stimulating the necessary discussion on future challenges to safety and how to identify and measure potential risks in a changing ATM environment.

2.2 End of an era

The first PRR 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 for the reporting and assessment of Safety Occurrences in ATM (ESARR2).

Over two decades, the safety data collected though the Annual Summary Template (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).

Unfortunately, 2019 was the last year of the AST reporting mechanism, as it has been 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 is currently exploring ways of accessing reliable ATM safety data in order to be able to continue its review of Safety performance in the EUROCONTROL area. The PRC will report in future publications on the status and progress made in this pivotal area.

2.3 PRC solution to measure total safety risk

In 2019 the PRC published its preliminary concept of Composite Risk Index (CRI) and the corresponding methodology as an innovative option to measure the performance of the European ATM system.

Since then, the PRC has refined its CRI methodology to take account of local specific operating conditions and has published the improved methodology in a Technical Note in January 2021. The updated CRI methodology contains four components: (1) safety data, (2) traffic/exposure data, (3) complexity and (4) reporting practices.

The methodology is scalable and can therefore be used to provide high-level information to decision and policymakers but also to provide more in-depth knowledge about risk exposure at local level to operational staff and safety specialists.

A further benefit of the refined methodology is that it is customisable to the local environment. It can be scaled up or down for the monitoring of individual entities. Due to this feature, the PRC can offer its Stakeholders the possibility to develop a personalised performance benchmarking report.

The key idea behind the CRI is to provide States, ANSPs, organisations with a composite index, as a tool for an easy overview to monitor and possibly compare the safety risks, either for one provider or for States to make an overview of annual developments. Ultimately, based on data availability, it can be used as a kind of benchmark between ANSPs, States or regions at a particular point in time or over several years.

Figure 2-1 shows the CRI in 2018 for all EUROCONTROL Member States in relation to the total number of reported occurrences.

It can be seen that the CRI not necessarily depends on the amount of reports and that the consideration of local conditions (such as reporting practices and airspace elements) prevents this potential distortion.

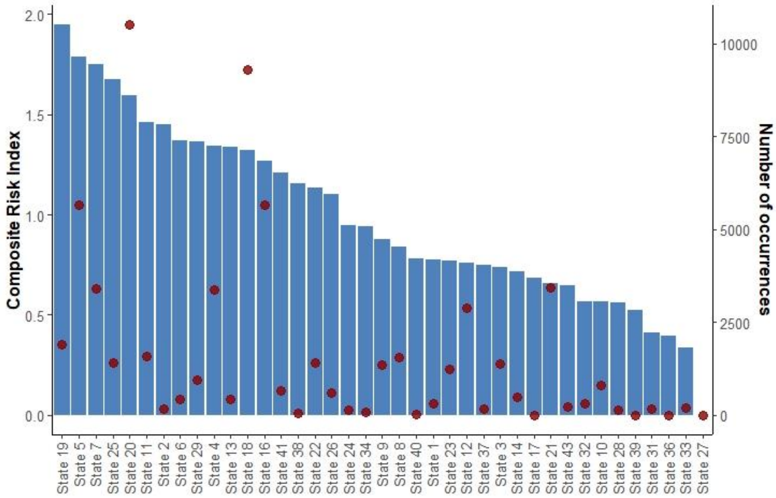


Figure 2-1: 2018 CRI vs the total number of occurrences reported

For more information please refer to the dedicated webpage and the PRC Technical Note which explains several statistical methods used to model index weights, overall CRI computation, the logic behind it, its use and limitations, and lastly areas of further improvement and expansion.

2.4 Challenges to Safety

In early 2020, the PRC initiated a dialogue with safety experts in EUROCONTROL Member States and other international organisations in order to identify future challenges to safety in an evolving ATM environment and how to measure them.

The PRC received a wide spectrum of expert opinions on future challenges to safety and how to identify and measure potential risks in a changing ATM environment.

Building on this initial exchange, the PRC held a workshop on 29 June 2020 that deepened the discussion. The workshop was a starting point in defining safety performance objectives/focus areas for the future ATM system. The workshop itself served as a platform to collect intelligence about “what do we know” and “what is available”. The outcome of the workshop, as well as other intelligence and views by the key safety experts collected afterwards, was summarised in a PRC Performance Insight #1 on Challenges to Safety (September 2020).

This work represents a first step toward building a safety performance framework for the future that will include views about the future safety system and how to measure its performance. Overall, this is an extremely complex undertaking but nonetheless a vital prerequisite for the measurement of safety performance in the future ATM environment.

2.4.1 PRC Position

The ultimate goal is to develop a safety performance framework that would support the implementation of changes (new concepts, technologies, and processes) in the future ATM environment. It should be seen as a contribution to better understanding of the possible changes to the ATM system and their possible impact on safety.

The development of safety performance framework for the future should be seen as a long-term project, not just to cover all relevant changes to the system that could potentially influence aviation safety, but also in order to reach the maturity needed to produce performance measurement that could be used on a Network level. The horizon for such changes is considered to be between 5 to 15 years.

Taking into consideration the necessity of various inputs to be used, as well as work partnerships needed to achieve the common goal and expected outcome (i.e. defining the safety performance framework for the future ATM system) this initiative indeed presents a complex and demanding mission.

The PRC has published the scope, main goals and key points to be considered in this future project in its PRC Position Paper on Challenges to Safety in December 2020.

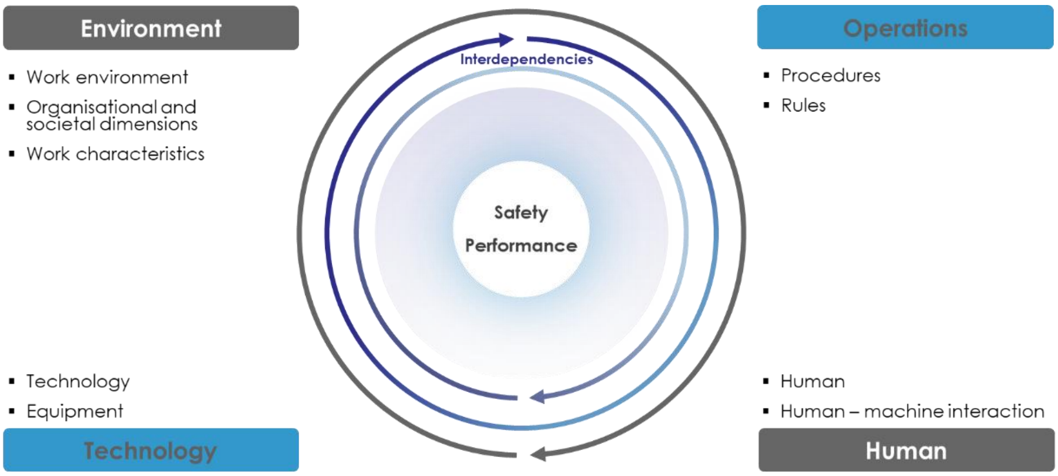


Figure 2-2: Changes within the system – the main safety Focus Areas

Based on all input received from safety experts and other international organisations, both prior to, during, and after the workshop, the Position Paper lists the key topics and safety concerns which can be broadly classified into thematic areas, or major categories of challenges facing safety performance of the ATM system, i.e. safety Focus Areas (Figure 2-2):

- Environment (e.g. including increased traffic, new entrants, institutional changes,); should provide a common understanding of what the future system is and how it will look like, what is considered 'safe' in the future environment, as well as what are the boundaries of the future system we are trying to measure;
- Operations (e.g. changes in operations and procedures); introduction of new technologies and equipment will possibly lead to changes in operations and procedures, these will have to be clearly defined and their impact on safety described and possibly assessed;
- Technology and equipment (e.g. including increased automation, the introduction of the ATM data service provider (ADSP), big data, digitalisation, cyber security); introduction of various new technologies and equipment into the future ATM system will lead to changes and challenges which will have to be clearly defined and their impact on safety described and evaluated;
- Human in the new system (e.g. roles and responsibilities, workload); the modernisation of

European ATM will inevitably lead to a new organisation of the work and workplace The proposed future ATM changes will have an impact on the people delivering the ATM services and the "human" role in the system. The identification of the future role of the human in delivering safety and how ATM safety can be protected is essential.

- Interdependencies (as transversal category, considers system thinking); the nature of future changes to the ATM system are entirely dependable on intractable systems. A consequence is the creation of additional and new complexity in the ATM system and up-and-coming properties that defy a priori knowledge of system behaviour. Definition and analysis of future safety performance framework must take into consideration interdependencies in the new ATM/aviation system. An overall framework or process for balancing safety against other key performance parameters (most notably capacity and cost) is required to be in place.

The PRC position paper provides initial guidelines on how to approach development of the future performance framework that is needed to support measurement of safety performance for various stakeholders in the ATM system. More specifically, it represents the first attempt to summarize all intelligence received during initial stages of "Future Challenges to Safety" initiative and to identify safety performance Focus Areas, around which possible work partnerships should take place.

During 2021, the PRC will seek to engage in partnership with different Stakeholders willing to work and cooperate on each Focus Area. A detailed work plan for each Work Package including their timelines, precise objectives and scope, and expected outcomes will be defined upon arrangement of separate partnerships. Dialogue with airports, airlines, States, new entrants, and Academia, not just ANSPs, will have to be established to define the safety performance framework of the future. Moreover, due to complexity of the work, it is envisaged and of utmost importance that each Work Package include different partners including Academia, SJU, EASA, ANSPs, airlines and airport, depending on the work requirements.

2.5 Conclusions

Notwithstanding the challenges imposed by the COVID-19 pandemic on the aviation industry, safety levels remained high in Europe and will continue to remain pivotal during all recovery stages and beyond.

Unfortunately, 2019 was the last year of the Annual Summary Template (AST) reporting mechanism, as it has been discontinued from 2020 onwards. After two decades, the discontinuation of the safety data collection through the AST resulted also in the discontinuation of the corresponding performance review section in the PRR reports. The 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 is currently exploring ways of accessing reliable ATM safety data in order to be able to continue its review of Safety performance in the EUROCONTROL area. The PRC will report in future publications on the status and progress made in this pivotal area.

With a view to further develop and improve innovative indicators to better understand the safety performance of the ATM system, the PRC has refined its Composite Risk Index (CRI) methodology to also take account of local specific operating conditions, airspace size, and complexity. The innovative methodology is scalable and can therefore be used to provide high-level information to decision and policymakers but also to provide more in-depth knowledge about risk exposure at local level to operational staff and safety specialists.

In early 2020, the PRC initiated a dialogue with safety experts in EUROCONTROL Member States and other international organisations in order to identify future challenges to safety in an evolving ATM environment and how to measure them.

This work represents a first step toward building a safety performance framework for the future that will include views about the future safety system and how to measure its performance. Although it is a complex undertaking, it is a vital prerequisite for the measurement of safety performance in the future ATM environment and requires more efforts and cooperation to achieve tangible results.

3 Operational en-route ANS Performance

3.1 Introduction

This chapter of PRR traditionally reviews operational en-route ANS performance in the EUROCONTROL area. As a result of the COVID-19 pandemic, air traffic in Europe dropped to the level of 1989 and the challenges and focus in 2020 changed entirely from capacity and ATCO staffing shortages in 2018/19 to downscaling of operations and funding to ensure business continuity.

Following the unprecedented drop in traffic starting at the end of the first quarter of 2020, there was virtually no en-route ATFM delay since April. For continuity reasons, this chapter will nevertheless provide a much shorter evaluation of the situation in 2020, particularly to highlight the situation in the first quarter of 2020.

Although it is unlikely that traffic will experience significant capacity problems in the near future, the traffic downturn provides an opportunity to review the “lessons learned” from the capacity crisis in 2019 to better prepare for the time when the traffic returns. En-route capacity and ATFM delays are addressed in Section 3.2 of this chapter.

Another notable effect of the significantly lower traffic level in 2020 was the improvement of horizontal and vertical en-route flight efficiency. The improvement of operational efficiency with subsequent savings in terms of fuel and CO_2 emissions was already a focus area before the COVID-19 crisis hit the industry and will remain important on the way to recovery over the years to come.

In this context the crisis also offers an opportunity to evaluate constraints imposed by ANS and to further improve existing procedures where possible. Horizontal and vertical en-route flight efficiency are discussed in more detail in Section 3.3 of this chapter.

3.2 En-route capacity and ATFM delays

3.2.1 ATFM delay: the high-level picture in 2020

As a consequence of the dramatic traffic reduction of -55.2% (-6.1 million flights) in 2020, en-route ATFM delays decreased by -90.6% compared to the same period in 2019.

This corresponds to 15.6 million minutes less en-route ATFM delay compared to 2019. Overall, 1.8% of the flights were delayed by en-route ATFM regulations (-8.1 percentage points vs 2019).

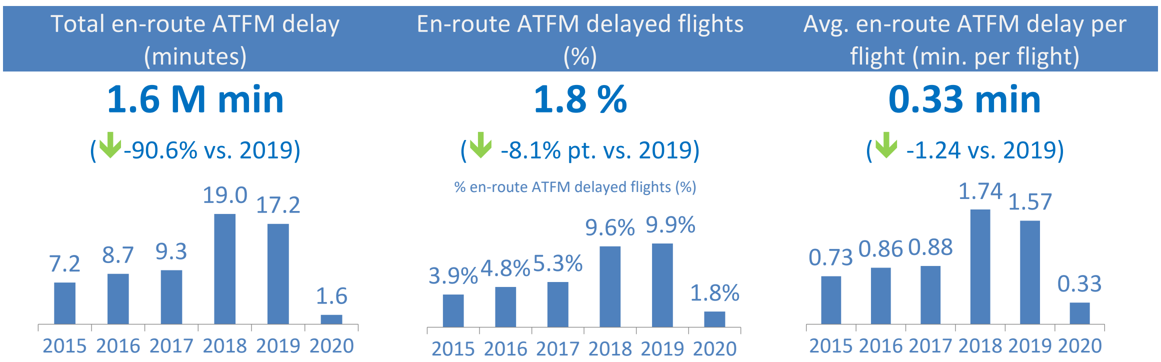


Figure 3-1: En-route ATFM delays in the EUROCONTROL area

Figure 3-2 shows the total annual en-route ATFM delay by attributed delay category in the EUROCONTROL area.

As a result of the COVID-19 related traffic decrease, en-route ATFM delay decreased in all categories except “ATC disruptions” and “Other” by more than 90% in 2020. The virtual elimination of delays attributed to adverse weather shows how capacity constraints stemming from weather are generally aggravated by other capacity constraints e.g. sector capacity and staffing availability.

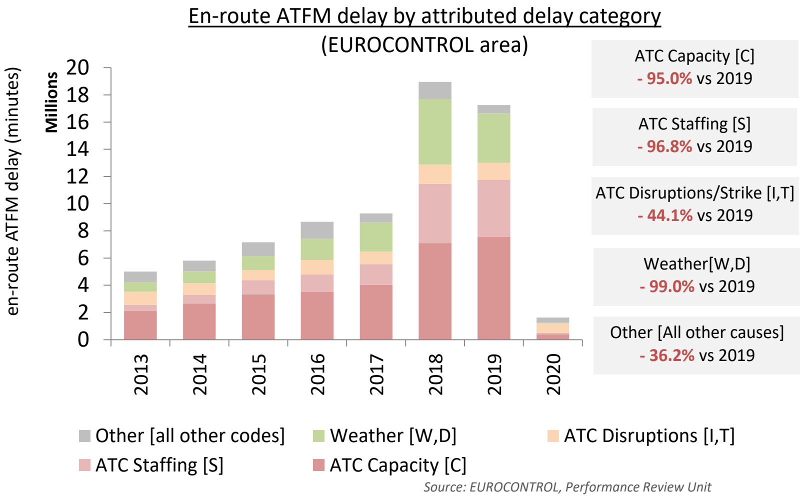


Figure 3-2: Evolution of annual en-route ATFM delay by attributed delay cause

Figure 3-3 shows the monthly evolution of en-route ATFM delay in the EUROCONTROL area. It is interesting to note that the en-route ATFM delay level before the COVID-19 outbreak in Europe was above the 2019 levels.

In response to the COVID-19 crisis starting in March 2020, the Spanish authorities introduced a staff reduction programme that required ATFM protective measures (14-16 March) for both en-route and airport locations which generated a substantial amount of delay (classified as “Other”).

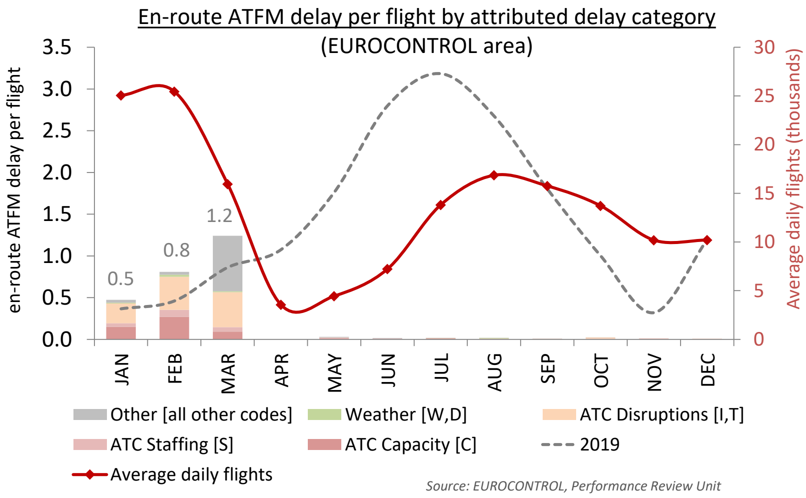


Figure 3-3: Monthly evolution of en-route ATFM delay by attributed cause (2020)

Following the outbreak of the pandemic in Europe and the corresponding drop in traffic starting in March there were virtually no en-route ATFM delays for the remainder of the year in the EUROCONTROL area.

The PRC is closely monitoring the crisis in the industry caused by COVID-19 and fully understands that traffic is unlikely to experience significant capacity problems over the near future.

To provide a better understanding of the magnitude of the COVID-19 crisis, Figure 3-4 shows the reduction of flights compared to 2019 in absolute terms (top chart) and in relative terms (bottom chart) by Air Navigation Service Provider (ANSP).

As the crisis started at the end of the first quarter in 2020, the bottom chart also provides an indication of the traffic reduction between March and December 2020 (shown in light red). The figure is sorted according to the absolute change compared to 2019.

At EUROCONTROL level, traffic dropped by 55.2% in 2020 which corresponds to 6.1 million lost flights compared to 2019. At ANSP level, the traffic reductions range from -41.9% (-49.5% Mar.-Dec.) for Avinor (Norway) to -69.2% (-80.4% Mar.-Dec.) for ARMATS (Armenia).

In absolute terms, DSNA (France), DFS (Germany), NATS (UK), ENAIRE (Spain), ENAV (Italy) and Maastricht UAC showed the highest year on year reduction with >1 million fewer flights than in 2019.

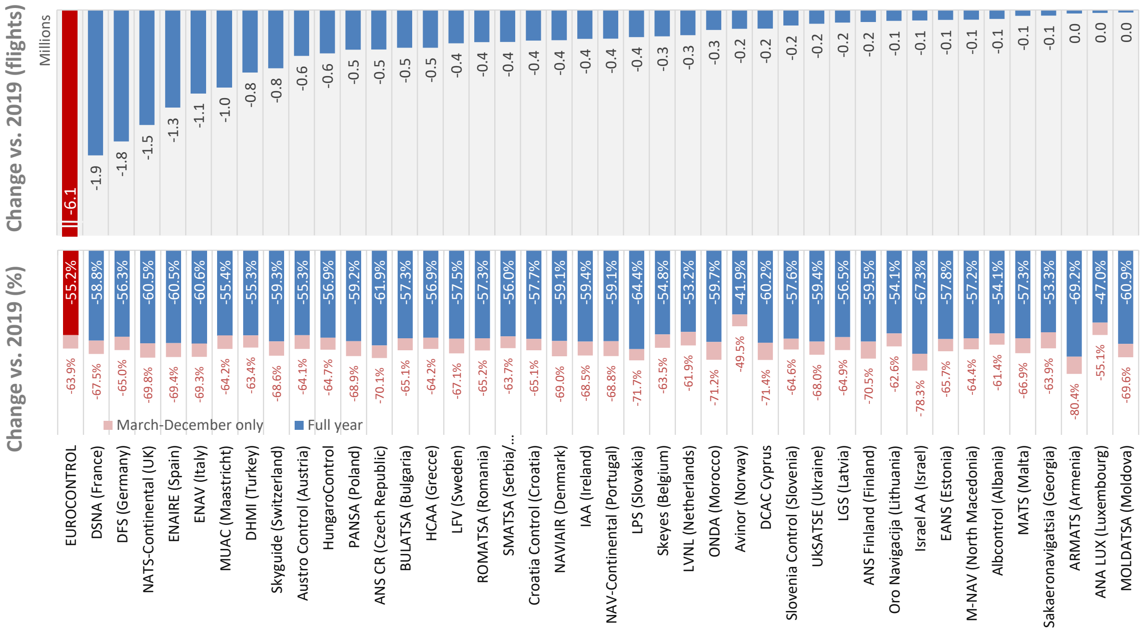


Figure 3-4: Traffic evolution by ANSP (2020 vs 2019)

3.2.2 Lessons to be learned from the capacity crisis in 2018/19

Following up from the capacity crunch in 2018/2019, in 2020, the PRC published a Technical note on En Route Capacity focused on en route capacity in 10 area control centres managed by seven ANSPs, and how the various facets of capacity are managed - from planning future capacity, right through to deployment. (The report is available at https://www.eurocontrol.int/publication/technical-note-en-route-capacity)

Although the situation with Covid-19 has somewhat diverted attention from capacity issues, it could be considered as an ideal opportunity for ANSPs to prepare for future capacity needs. Since ANSPs report a considerable lag time for implementing capacity improvements, the current downturn in traffic could actually enable them to get ahead of the demand curve – to ensure that sufficient capacity will be available when and where needed.

Whilst airspace users and national supervisory authorities may currently see more pressing priorities than adding capacity during the downturn in demand, the PRC believes that if ANSPs address capacity issues now, it will provide significant benefits in the future when traffic returns to more robust levels.

Through dialogue with various ANSPs (see below), the PRC noted that quite a few of them already planned to increase capacity by recruiting additional ATC staff. However, in several cases, the existing plans were subject to review in light of the Covid-19 situation – both the (temporary) reduction in traffic demand and increased pressure on costs.

In the short term, reducing or cancelling plans to increase capacity helps ANSPs in particular to save money. However, what could be considered a short term financial saving could result in the creation of capacity problems for many years ahead, with adverse financial consequences for airspace users of much greater magnitude than any short-term savings that were made.

A more pragmatic approach could be to consider the business case for the capacity improvements for both ANSP and airspace users against the lag time for realising those improvements, as well as the most likely traffic demand scenario then and in the future.

The PRC invites ANSPs, NM and airspace users to cooperate and work on planning and improving capacity for future demand.

Improving capacity performance involves identifying existing and future capacity constraints, planning and implementing effective mitigation or solutions to the capacity constraints. It also involves improving transparency about capacity for all stakeholders.

3.2.3 The PRC proposal for improving capacity

The PRC considers that capacity should be provided to meet user demands at peak times and locations; that restrictions on traffic flow should be minimised; that capacity must increase to respond to future growth and that airspace users want to see a reduction in impact of constraints imposed by service providers.

To ensure continuous performance improvement, constraints imposed by ANSPs need to be identified, highlighted and reduced.

The PRC introduced the process alongside for improving capacity performance at a workshop with invited stakeholders from NSAs, ANSPs, NM and airspace users.

The takeaway from the workshop was that this was an acceptable approach to follow, was in line with operational practices and was acceptable to all stakeholder groups.

Figure 3-5: Process for improving capacity performance

3.2.4 Defining the performance requirement

It is possible to define the performance requirement in several different ways:

- The SES performance scheme defines a performance requirement for en-route capacity using annual average ATFM delay per flight and sets targets both at union-wide level and at national / FAB level for each year of the reference period.
- Non-SES States may also define a performance requirement for en-route capacity in terms of average ATFM delay per flight over the entire year or over a certain period, for example the summer season.

The high-level methods above involve the aggregation of all en-route ATC sectors within the national / FAB airspace, the aggregation of the delays from the total number of en-route ATFM regulations applied within the individual sectors and the aggregation of the individual flights within the relevant airspace over the specified period.

Excellent capacity performance (zero delay) over off-peak periods can balance out poor performance (high delays) during peak periods. Specific sectors with no capacity issues can balance out specific sectors with significant capacity constraints. At FAB level, individual ANSP performance can balance out the performance of other ANSPs.

It is also possible to consider performance requirements at more operational-levels, more related to the operational characteristics of individual sectors.

- It is possible to define the performance requirement for individual sectors in terms of the declared capacity of the sector, for example requiring an ANSP to implement a 10% increase in current declared capacity within a certain timeframe.
- Alternatively, the performance requirement could be defined by the peak hourly traffic demand in the sector, for example, the ANSP should ensure that the specific sector can safely accommodate 99% of peak hourly traffic demand – either existing or forecasted, as defined by the appropriate authority.

Defining performance requirements at operational level provides ANSPs with clear operational objectives and enables the effective and transparent monitoring of ANSP efforts to improve capacity performance. Increasing the capacity of individual sectors, especially sectors subject to capacity constraints, will reduce the need for ATFM regulation and therefore reduce associated ATFM delay.

Defining the performance requirement in aggregated terms is appropriate for high level and political communications but there also needs to be performance requirements at operational level, which can be effectively monitored.

3.2.5 Identifying the performance gap

The ability to identify the performance gap depends greatly on the granularity of the performance requirement. If using a high-level indicator such as average ATFM delay per flight, one ANSP can hide the performance gap of another within the same FAB. Similarly, within the same State, the performance in one area control centre (ACC) can hide the performance gap in another. In both cases, the fundamental capacity constraints are not being highlighted and are likely to cause capacity problems again in the future.

En route ATFM delays resulting from capacity constraints in specific en route ATC sectors can be used to identify capacity bottlenecks. Ranking the sectors according to where the greatest amount of ATFM delays arise gives ANSPs a clear indication of where there is a gap in performance, and where capacity efforts should be addressed.

For this PRR, the PRC decided to assist ANSPs with identifying performance gaps. Following analysis of en route ATFM delays in 2019, the PRC identified capacity bottlenecks for 19 ANSPs and contacted them directly.

3.2.6 Identifying the precise problems

The PRC identified where significant ATFM delays were attributed to non-operational ATC sectors, which in the view of the PRC reduces transparency on the cause and potential solution to capacity constraints. The relevant ANSPs were asked if they planned to improve transparency by ensuring that all ATFM delays were associated with operational ATC sectors that experience the capacity constraint and that require attention.

LVNL (the Netherlands) attributes significant ATFM delay to a non-operational ATC sector (EHAACBAS), which also includes a significant portion of airspace outside its area of responsibility. LVNL replied that these delays should be considered as airport delay, since the cause is (total) airport capacity. Because the inbound traffic flows are regulated via the initial approach fixes rather than the operational sectors, LVNL attributes the delays to the non-operational sector.

Similarly, **NATS** (UK) attributes ATFM delays to several non-operational sectors. NATS report that they use these to regulate traffic flows arriving at specific London airports. NATS report that they have already increased transparency on operations by providing the Network Manager with dynamic sector opening information at D-1.

The PRC also reviewed the original attribution reason and the geographical locations where ATFM regulations led to significant delays, along with the declared capacities. Whenever the NM database defined a constrained sector as a collapsed sector, the PRC also showed the reported declared capacities of the constituent individual sectors.

The PRC asked the individual ANSPs to identify the main cause of capacity constraints in 2019 and to report their plans to mitigate / resolve the capacity constraints from recurring when traffic levels return.

3.2.6.1 Develop plans to mitigate / resolve the capacity constraints

Each of the ANSPs contacted kindly provided the PRC with their analysis of the reasons for capacity constraints and very importantly, with their plans to prevent, or to reduce the likelihood of, the constraints recurring to the same extent when traffic levels rise again.

Eleven of the contacted ANSPs reported that the **main cause of their capacity constraints in 2019 was the unavailability of ATC staff**. They also reported their plans to improve capacity performance in the future particularly referring to ATC staffing:

- **ANS CR** (Czech Republic) has developed an 'ATS optimisation' restructuring project with the main goal of closing the increasing gap between current and required workforce. Although COVID has slowed some particular steps, the project continues.

- **Austro Control** (Austria) runs continuous recruiting initiatives to increase the number of operational ATC staff. Austro Control plans to have 25 additional ATCOs by 2024.
- **DCAC** (Cyprus) has increased the recruiting efforts for new ATCOs: 30 [trainee] ATCOs recruited in the past two years and an additional 15 planned for 2021. This will allow seven more ATCOs to be on ACC roster in 2021 and additional ATCOs in subsequent years. A new ACC building, and ATM system, is planned for 2022 – allowing the deployment of ten sectors (from current six), which will improve performance.
- **DFS** (Germany) started a 'Capacity Initiative' in 2018 with approximately 90 measures to increase capacity. Besides obtaining agreement with unions on extra ATCO hours, there has also been a significant increase in ATCO training capacities to close the staffing gap in coming years. DFS remain committed to train high numbers of ATCOs every year but the current pandemic, with lower traffic levels, forces DFS to reduce training capacities compared to previous plan.
- **DSNA** (France) has plans for staff rostering and ATCO recruitment, although these are currently frozen in light of current financial situation and traffic forecast (COVID). In addition, DSNA has an airspace design project involving FABEC and NM and also plans to increase capacity at two ACCs through implementation of new ATM system by 2022.
- **HCAA** (Greece) has a recruitment plan to address operational needs based on the STATFOR forecast but, due to the pandemic emergency conditions, this plan was postponed for 2021. To address the performance requirements for summer 2021 onwards, HCAA is elaborating a more efficient rostering scheme.
- **HungaroControl** (Hungary & Kosovo) launched an intensive recruiting and training programme to address the lack of ATC staff. The first results of the programme were expected in 2021 with an additional 30% of ATCOs with ACC rating planned for the end of 2024. However, due to the COVID pandemic and extreme drop in traffic (with forecasted very slow recovery), HungaroControl has to revisit the staff planning.
- **LFV** (Sweden) has maximum training of new ATCOs in progress to increase capacity when high traffic demand returns. LFV also has several projects in place to increase efficiency in LFV services. The first of these airspace reconfigurations is planned to be implemented during 2024.
- **LPS** (Slovakia) has redesigned the concept of ATCO recruitment to intensify the training and add capacity. The substantial drop in traffic (due to COVID pandemic) allows the LPS to implement capacity in advance of the traffic demand [to avoid delays recurring]. In addition to increasing the number of ATCOs, LPS also plans to optimise sector design and sector opening hours.
- **NAV Portugal** (Portugal) started an ambitious recruitment programme in 2017, which is expected to continue until 2025 – with 24 trainees each year. In spite of significant number of ATCOs retiring in this timeframe, NAV Portugal expects to have 20% more ATCOs in 2024 than in 2019. A new OPS room with new ATM system will allow the simultaneous opening of additional sectors to increase capacity. Since COVID caused the suspension of several projects, NAV Portugal expects to start working on an airspace- restructuring project from 2023.
- **Skeyes** (Belgium) has implemented a new planning system that ensures that absences due to sickness leave are adequately covered, which was the main problem in 2019. In addition, Skeyes are still recruiting and training new ATCOs.

Four ANSPs reported that the main cause of capacity constraints was airspace design:

- **Croatia Control** (Croatia) reports that airspace design and sector capacities were the main issues; the number and utilisation of operational staff is sufficient from the cost optimum perspective. The ANSP implemented a fourth lateral sector in spring 2020, which enables more efficient configuration management. The ANSP considers that the current airspace organisation, combined with Free Route Airspace operations, would provide sufficient capacity to manage traffic demand efficiently.
- **EUROCONTROL** (MUAC) reports that the demand problems are structural requiring airspace solutions beyond the current MUAC boundaries. MUAC will implement internal airspace redesign solutions and will investigate external airspace redesign solutions, together with the external partners.
- **NATS** (UK) reports that the primary cause of capacity constraint is the current airspace design. The

Swanwick Airspace Improvement Programme will provide dedicated arrival routes for London Stansted Airport and London Luton Airport, and a new hold for London Luton Airport traffic. This will provide improved predictability of arrivals traffic for both Luton and Stansted delivering safety and capacity benefits in summer 2022.

- **PANSA** (Poland) states that the main cause of delays in 2019 was demand exceeding declared capacity in small and complex sectors with low occupancy values. PANSA plans to implement additional vertical division of the airspace. The first stage of implementation, including the most congested sectors, is currently foreseen for 2022.

One ANSP reported that a significant factor creating capacity constraints was the eNM19 measures.

- **ENAIRE** (Spain) recalled the limitation that an ATFM regulation can only be associated with one reason, stating that it was impossible to reflect the operational complexity causality for every ATFM measure. ENAIRE performs internal analysis to understand the operational complexity and cannot identify a single main cause of delay. ENAIRE highlights the deviation of considerable flows of traffic in its airspace due to the eNM19 measures, adding to existing complexity. ENAIRE has already created a new combination of sectors to mitigate some delays in Barcelona ACC and intends to split one of the constrained sectors, LECBBAS, in 2021.

The remaining ANSP, **Skyguide** (Switzerland), reported that the main capacity constraint was the result of a national legal decision about safe operations where, for 2 weeks, a temporary capacity reduction had to be applied. The proper consideration of just culture within the Swiss legal framework is now pursued on the political level to prevent a recurrence.

3.2.6.2 Monitoring the implementation of plans

The PRC intends to work more closely with ANSPs to monitor the implementation of the ANSP plans to mitigate or resolve capacity constraints. By working with the individual ANSPs, the PRC will be able to tailor the performance monitoring, analysis and reporting to reflect local circumstances.

The PRC intends to produce more localised reports, providing greater transparency to airspace users highlighting the efforts of ANSPs to improve capacity.

3.2.7 Findings on en route-capacity:

The majority of ANSPs reported that staffing issues were the main cause of capacity constraints in 2019. Staffing issues relate to the availability and deployment of qualified ATC staff as well as the number of ATCOs employed.

A number of ANSPs report plans to increase numbers of ATCOs. Several of these ANSPs report that they are reviewing existing plans for additional controllers due to the pandemic even though it can take several years between initial recruitment and deployment in operations.

Several ANSPs have plans to improve capacity by upgrading ATM systems or by upgrading equipment to enable the opening of more sectors at the same time.

Several ANSPs plan to add capacity by redesigning airspace within their area of responsibility; one ANSP indicates that it is also seeking to add capacity through airspace redesign occurring beyond its boundaries.

3.2.8 Way forward:

In line with the process outlined in 3.2.3 the PRC intends to work together with the ANSPs to improve capacity performance and to increase transparency for airspace users.

The PRC will continue to report on capacity bottlenecks within the network and, working with individual ANSPs, accurately identify the underlying causes for ATFM delays and the specific sectors wherein capacity needs to increase.

The PRC will work to improve transparency for airspace users, in regards to the attribution of ATFM delays, and on the efforts of ANSPs to resolve/mitigate the bottlenecks to improve capacity performance.

The PRC will monitor ANSPs' plans to improve capacity and will report on the implementation of those plans in terms of timeliness and effectiveness.

3.3 En-route flight efficiency

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

With fuel being a big part in airlines' operating costs, there has been a considerable focus on reducing fuel burn over the past years. Those economic considerations are now intensified by the additional environmental focus, which makes reducing fuel burn even more important (see also Chapter 1.5). Complementary to the existing operational indicators, work is ongoing to develop specific indicators for the measurement of environmental performance in the future.

The COVID-19 outbreak in Europe at the end of the first quarter in 2020 resulted in an unprecedented drop in traffic (-55.2%) compared to 2019. Virtually from one day to the next the restrictions required to deal with the lack of en-route capacity which were negatively impacting flight efficiency and fuel burn disappeared.

Flow measures such as the Enhanced NM/ANSPs Network Measures (eNM) implemented to manage the capacity crisis by removing traffic from congested areas, either by re-routing or level-capping flights were no longer necessary.

Direct routes in a given airspace vs origin/destination of flight

The indicator adopts a gate-to-gate perspective by using as reference for the entire flight the great circle distance between its origin and destination (which for most of the flights correspond to the location of the two airports).

A direct route within a given airspace is no guarantee of shorter flight length because the direction might not be the correct one (interfaces with other airspace).

It is possible to break down the additional distance for a specific airspace into a local component (additional distance with respect to the direct between entry and exit) and an interface component (additional distance due to the direct between entry and exit).

When airspaces are aggregated, the additional distance is the same but the local component increases because part of the interface becomes local.

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

As in every crisis there are also opportunities. While traffic levels remain low, ANS has a unique opportunity to review and remove constraints in the ATM system where possible while further progressing on the implementation of Free Route Airspace (FRA) to provide airspace users with more choices to file and fly their preferred trajectories.

Since the beginning of the pandemic in early 2020, ANSPs - in collaboration with the Network Manager- removed around 1,200 Route Availability Document (RAD) measures in the ATM network, enabling more efficient flights.

3.3.1 Horizontal en-route flight efficiency

Horizontal en-route flight efficiency is measured in this report as a ratio of distances and is therefore an average per distance within a given airspace (distance achieved per distance flown). It is available for three different trajectories: (1) the actual flown trajectory, (2) the planned trajectory according to the flight plan and (3) the shortest constrained route[8], all provided by the NM.

The shortest constrained route (SCR) reflects the effect of the constraints imposed by ANSPs (route structure, etc.) or the effects of the constraints imposed by States e.g. due to military requirements (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). When considering the entire flight, 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 changes in weather and tactical ATC routings. Some of these modifications will lead to a lengthening of the trajectory, while others will lead to a shortening of it.

.[8] 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.

Horizontal en-route flight efficiency – the high level picture

Figure 3-6 shows that the average horizontal en-route flight efficiency at EUROCONTROL level[9] remained relatively constant over the past five years but improved notably in 2020 for all three trajectories, when traffic level dropped as a result of the COVID-19 pandemic.

At EUROCONTROL level, horizontal en-route flight efficiency improved from 97.2% in 2019 to 97.5% in 2020.

Although the improvement appears to be small in view of the dramatic drop in traffic, achieving the 2020 efficiency level of 97.5% for actual trajectories with the traffic of 2019 would have saved 29.7 million kilometres of additional distance and the corresponding substantial reductions in fuel burn and CO_2 emissions.

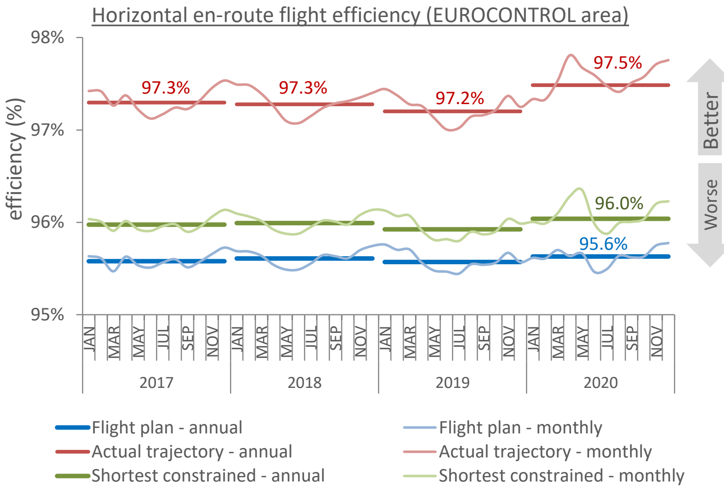


Figure 3-6: Horizontal en-route flight efficiency (EUROCONTROL area)

The efficiency of the actual trajectory improved at a notably higher rate (+0.28 pp) than the filed trajectories (+0.06 pp) and the shortest constrained route (+0.11pp) which led to a further widening of the gap between the planning and the actual operations. It suggests that the actual trajectories were improved on a tactical basis whereas the flight planning and the route network showed a lower flexibility to adjust to the low traffic levels.

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 operational flexibility is used to compensate the effect of conservative constraints.

The expectations to further improve flight efficiency are high and a key question is why flight efficiency did not improve more considering the fact that traffic demand fell by more than 50 percent in 2020?

Due to the complexity of the route network and the number of stakeholders involved, the answer is unfortunately not that simple.

First it is worth pointing out that, the flight efficiency of the actual flown trajectory in Europe is already notably higher (+1.85 percent points) than in the filed flight plans or the shortest available routes due to tactical ATC improvements on the day of operations. Hence, in some areas where flight efficiency is already high, the scope for further improvements of the actual trajectories is limited.

In this context, it is worth recalling that a certain level of flight inefficiency is in fact necessary (safety) or desirable (trade-offs) to operate the ATM system in an efficient manner. Hence the flight efficiency will never reach 100% at system level and even less so at local level (the inefficiency is calculated with respect to the entire flight).

Lastly, the European ATM network is formed by a large number of different ANSPs with different ATC systems and processes and used by different airspace users with differing needs and requirements. As a result of the pandemic, not only traffic demand changed radically but also traffic composition changed with a higher relative share of shorter domestic flights in many States. International (long haul) markets were more affected than domestic markets and all cargo flights even increased compared to 2019 (see also Chapter 1.5).

With flight efficiency being largely determined by constraints imposed in the ATM route network, improvements depend on the ability of ANSPs to quickly adjust to the completely different situation.

9 The airspace analysed in this section refers to the NMOC area.

On the one hand, the reduced traffic levels provide an opportunity to better identify and understand the remaining constraints in the ATM route network that hinder a more substantial improvement of flight efficiency. What are the main constraining factors and who can influence them? On the other hand, the current situation could help to better understand what level of horizontal en-route flight efficiency could be realistically achieved at system level, given necessary constraints.

Horizontal en-route flight efficiency by distance band

Figure 3-7 shows the level of flight efficiency in actual trajectories (y-axis) and the average additional distance per flight (x-axis) by distance band. The size of the bubble gives an indication of the total additional kilometres flown in each category.

As shown in previous reports, horizontal en-route flight efficiency generally increases with the length of the flight. It is however interesting to note that the level of improvement compared to 2019 was highest for shorter flights which is most likely linked to tactical ATC routings and very low traffic demand. The efficiency of flights shorter than 500 kilometre increased by 0.58 percent points compared to 2019 while flights longer than 3,000 kilometres only increased by 0.12 percent points in 2020.

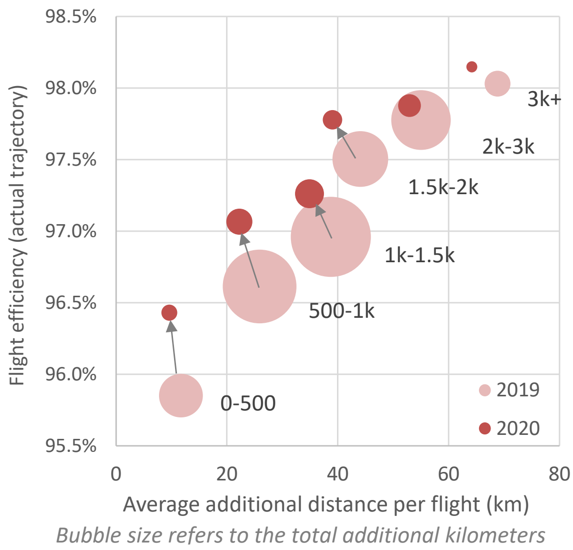


Figure 3-7: Horizontal en-route flight efficiency by distance range

Horizontal en-route flight efficiency by State

Figure 3-8 analyses how the efficiency of the three trajectory categories changed in each State compared to 2019 which provides a first indication of the flexibility of the ANS system to adjust to the completely different situation in 2020.

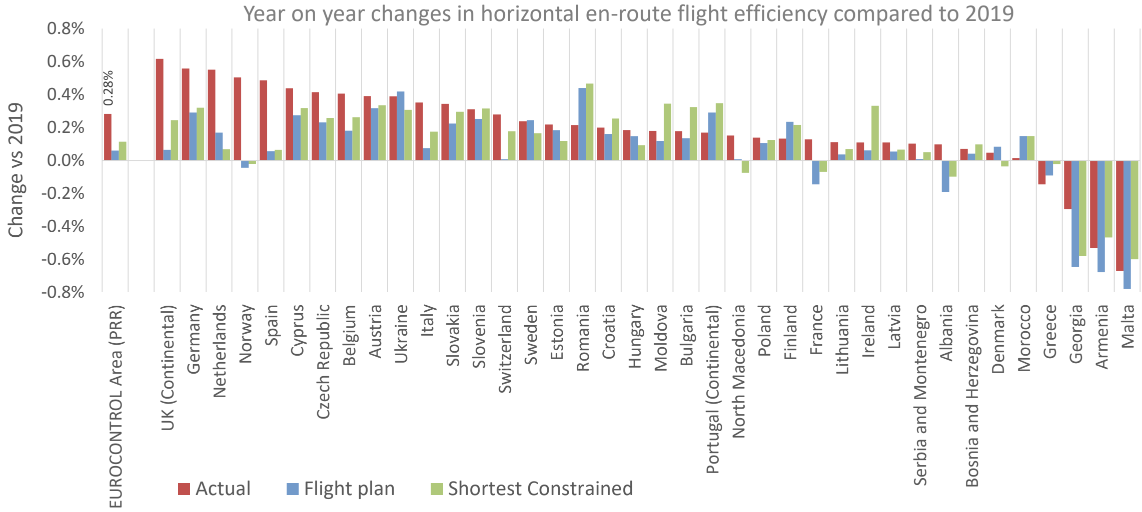


Figure 3-8: Changes in horizontal en-route flight efficiency by State vs 2019

All but 4 States (Malta, Armenia, Georgia, Greece) show an improved efficiency of the actual trajectory within their respective airspace. The observed changes vs 2019 range from an improved flight efficiency of the actual trajectory of +0.6% points (UK) to a deterioration of -0.6% points (Malta).

For four States (Spain, Netherlands, UK, Germany) the efficiency of the actual trajectory improved notably more than the planned or shortest constrained trajectory. For two States (Norway, France), the efficiency of the flight plan trajectory and the shortest constrained trajectory deteriorated while the efficiency of the actual trajectory improved.

While the efficiency of the actual flight trajectories improved in most States when traffic levels dropped in 2020, there is a need to better identify and understand the remaining constraints in each State, particularly in those States where the results indicate a lower flexibility to adjust processes and the route network to the new situation.

Figure 3-9 shows the horizontal en-route flight efficiency of the actual trajectory and the total additional distance flown by State in 2020. The total additional distance is determined by the length of the flight segment in the airspace, the flight efficiency and the number of flights

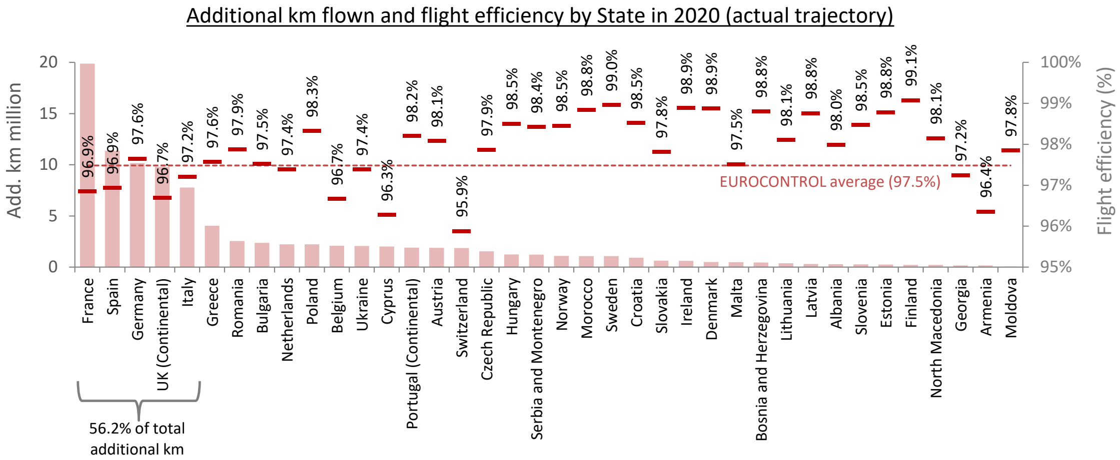


Figure 3-9: Horizontal en-route flight efficiency by State (actual trajectories – 2020)

More than half (56.2%) of the total additional distance in the EUROCONTROL area is concentrated in five States (France, Spain, Germany, UK and Italy) which combine a high traffic volume with a below average flight efficiency (except Germany which is above average).

To provide a more complete picture, Figure 3-10 shows the average additional distance (x-axis) and the traffic volume (bubble size) in addition to the flight efficiency of the actual trajectory in 2020 (y-axis).

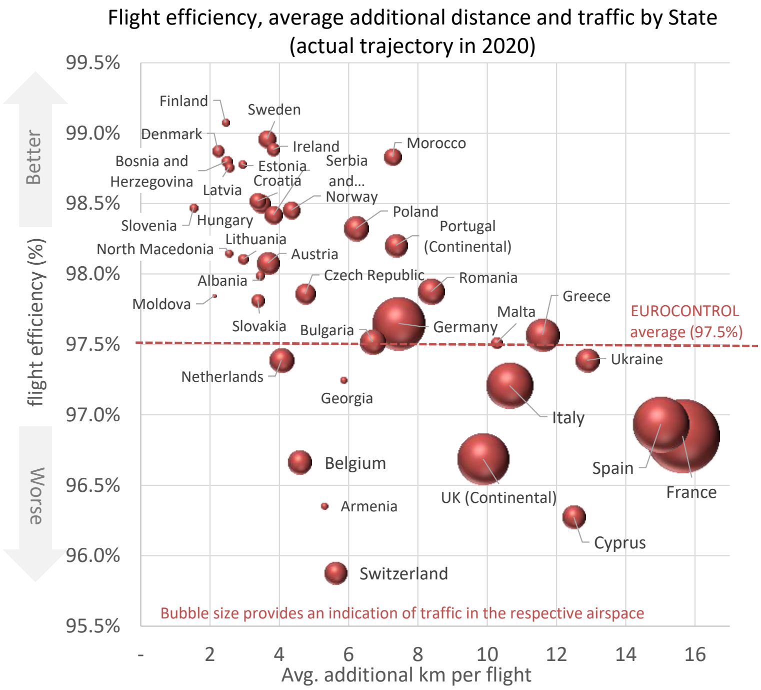


Figure 3-10: Horizontal flight efficiency, avg. add. distance and traffic

Switzerland has the lowest flight efficiency in 2020 but also a comparatively short additional distance per flight.

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.

In States like France and Spain, which combine a comparatively low flight efficiency with a high traffic volume, even small flight efficiency improvements will result in substantial benefits in terms of fuel efficiency and environmental impact.

Particularly in France and Spain, the continued implementation of Free Route Airspace (FRA) is likely to be a main contributor towards further improving horizontal en-route flight efficiency in Europe over the coming years. This is because it offers a more flexible environment compared to a rigid route network and therefore more choices to airspace users and more opportunities for reduced fuel consumption and emissions as well as greater flight efficiency.

Figure 3-11 shows the FRA implementation status by the end of 2020. As can be seen, FRA is now partly or fully in place in a large part of the European airspace.

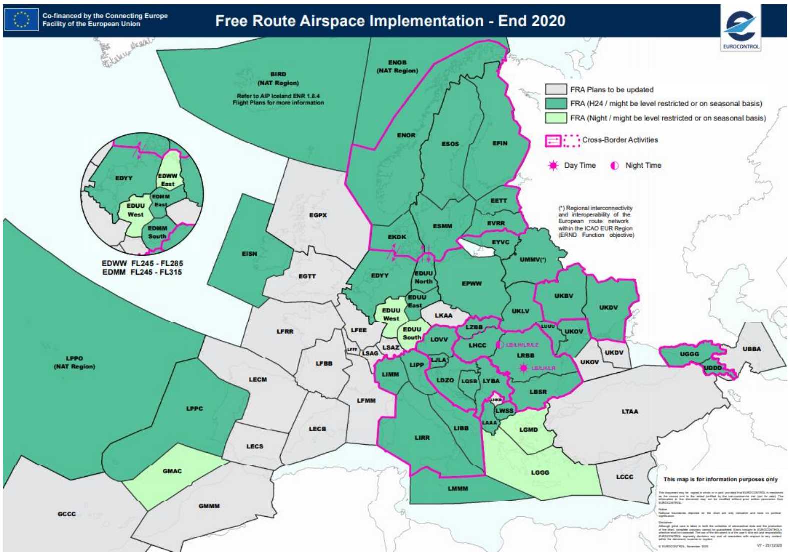


Figure 3-11: Implementation status of Free Route Airspace (FRA) – End 2020

Although more challenging, FRA implementation in the dense European core area will have a notable positive effect on fuel burn and the environmental as even small improvements would have a higher impact because of the higher number of flights.

According to the European ATM Master Plan [15] and European Commission Implementing Regulation No. 2021/116 [16], Free Route Airspace implementation will be implemented in two phases:

- initial FRA: with time and structure constraints (to be implemented by 31 December 2022);
- final FRA: constant free route implementation with cross-border dimension and connectivity to TMAs (to be implemented by 31 December 2025).

Even with the local implementation of FRA in each State some inefficiencies related to the interface between adjacent States and the connectivity to TMAs remain which need to be addressed in the "final FRA" phase.

Figure 3-12 provides a breakdown of the additional distance per flight 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 shown in dark red at the bottom of each bar.

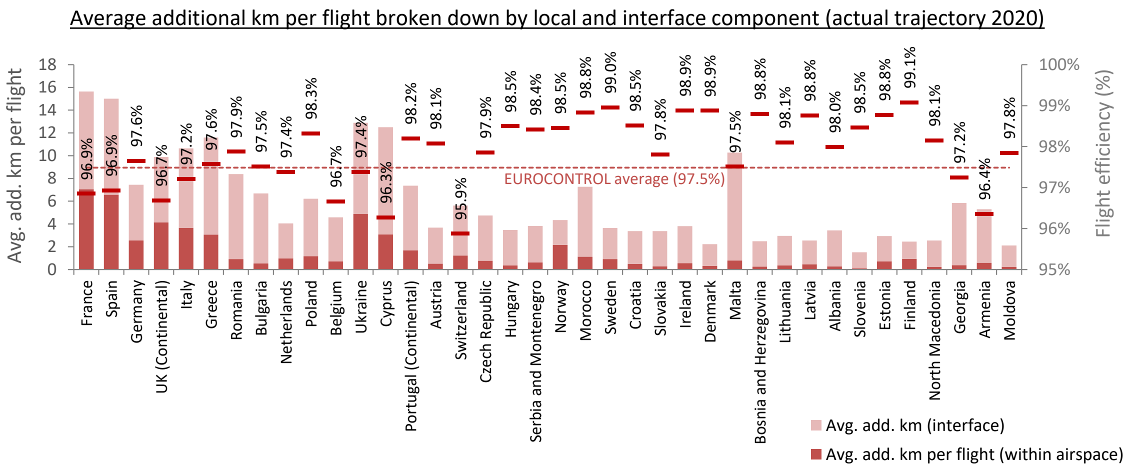


Figure 3-12: Horizontal en-route flight efficiency by local and interface component (actual– 2020)

Per definition, the interface component increases with the number of airspaces within a given area. With the EUROCONTROL area broken down at State level, more than two third (67.4%) of observed horizontal en-route flight inefficiency is related to the interface with adjacent States.

Larger States like France and Spain show a comparatively high share of local inefficiencies which suggests scope for further improvement to the national route network.

At the same time, 23 States included in the analysis had a network component greater than 80% in

2020 which suggests a high flight efficiency within the given States. In order to further improve flight efficiency in the European network those States might need to explore cross-border initiatives with their neighbouring States.

Figure 3-13 shows the changes in terms of average additional distance per flight by component (primary axis) and the changes in percentage points in terms of flight efficiency (secondary axis) compared to 2019 by State.

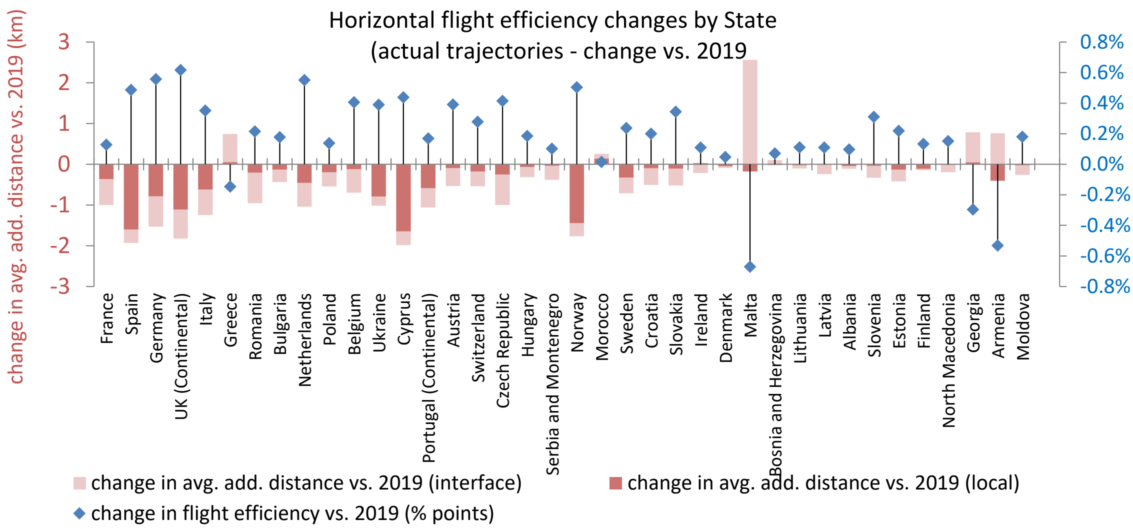


Figure 3-13: Horizontal en-route flight efficiency changes vs 2019 by component and State

The results confirm that the flight efficiency improvements in 5 largest States in 2020 were to a large extent driven by local improvements within the respective airspace (tactical or removal of constraints). For France, the improvement of the local component is comparatively small which could suggest that the French ATM system needed to be more flexible to adjust to the completely different situation.

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

In many States the local component is already small but the interface component can be further improved. In cases when States are located at the boundary of the EUROCONTROL area a certain level of interface inefficiency may result from the location of the entry and exit points where flights connect to the EUROCONTROL area.

As the expectations to improve flight efficiency will remain or become even more pressing on the way to recovery from the COVID-19 crisis, the dramatic drop in traffic offers an opportunity for ANS to progress on the implementation of FRA and to identify and remove route network constraints with a view to maintain the achieved performance as much as possible when traffic returns.

However, not all constraints are attributable to ANS. For example, military airspace activity may prevent the flying of an optimised trajectory whilst airline flight planning systems may not be optimised to enable the optimal FRA flight plan to be calculated.

Previous PRC research on the level of civil military cooperation and coordination [17] 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.

Clearly, the improvement of flight efficiency in the EUROCONTROL area will require a joint and collaborative effort which involves all stakeholders including the Network Manager.

Additional flight efficiency improvements will need to come from cross-border initiatives, improvements in airspace availability (Flexible Use of Airspace (FUA)), the avoidance of capacity shortfalls, less TMA entry/exit point–penalisation, and airlines making different route choices themselves.

3.3.2 Vertical en-route flight efficiency

The capacity crisis in 2018/19 and the implementation of air traffic flow measures to manage the significant en-route capacity shortfalls by removing traffic from congested areas, either by re-routing or level-capping flights put a specific focus on vertical en-route flight efficiency.

In this section, vertical en-route flight inefficiency (VFI) is expressed in feet per flight and calculated based on a methodology developed by the PRC [18]. More information on the methodology is available on the ANS performance data portal.

Figure 3-14 shows the evolution of VFI between 2016 and 2020 for all airport pairs (light red) and the top 20 airport pairs (turquoise) in terms of total vertical flight inefficiency (vertical inefficiency multiplied by the number of flights).

Before 2018, some smaller cyclical effects are visible in summer as a result of the higher traffic load during that time.

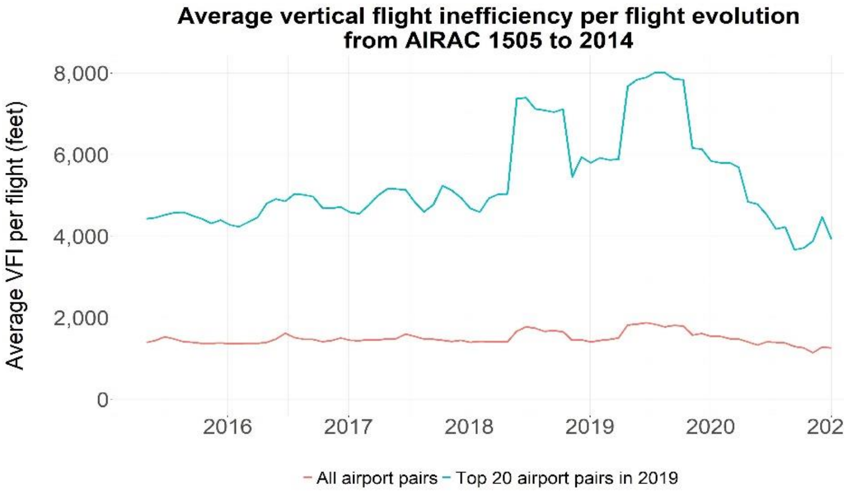


Figure 3-14: Evolution of average en-route vertical flight inefficiency (2016-2020)

In summer 2018 and 2019, the specific air traffic flow measures implemented to better manage the capacity crisis are clearly visible, mainly for the top 20 airport pairs which were almost all operating below en-route capacity constrained airspace (Maastricht and Karlsruhe Upper Area Control Centres (UAC)).

Figure 3-15 shows the lateral trajectories of the flights on the 20 airport pairs and the airspaces of Maastricht and Karlsruhe UAC.

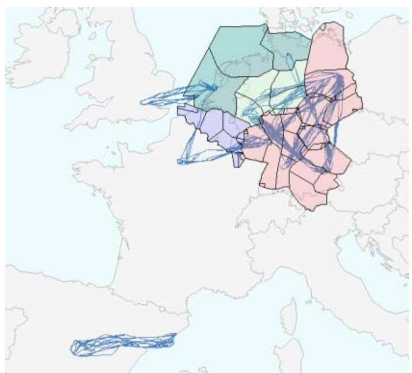
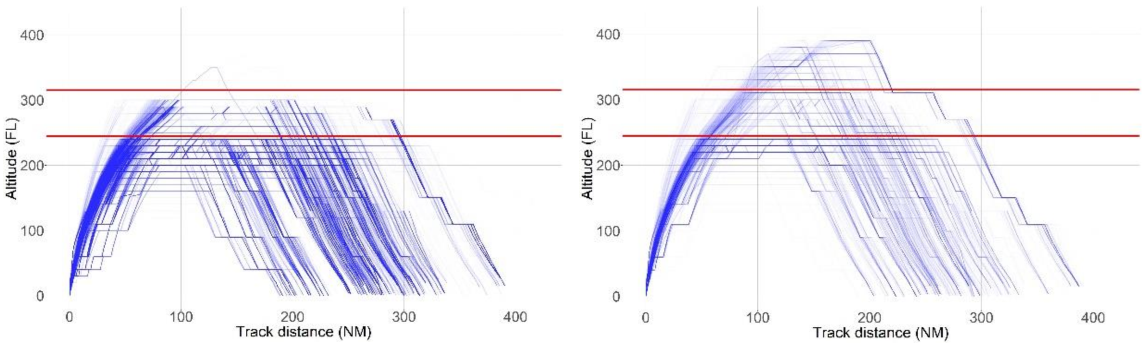


Figure 3-15: Top 20 airport pairs with the highest level of vertical inefficiency en-route (2019)

The COVID-19 outbreak at the end of the first quarter of 2020 and the subsequent dramatic drop in traffic removed the capacity shortages from one day to the next and hence the need to keep the constraining flow measures in place. As a consequence, the ANSPs in collaboration with the Network Manager removed a large number of Route Availability Document (RAD) measures in the ATM network. This resulted in a positive effect on vertical flight efficiency.



2019 (AIRAC 1907) | 2020 (AIRAC 2007)

The red lines in the figures indicate the lower limits of MUAC & Karlsruhe

Figure 3-16: Change in vertical profiles compared to 2019 (top 20 airports)

Figure 3-16 illustrates this effect for Maastricht and Karlsruhe UAC below which most of 20 most penalising airport pairs are located. The visualisation shows vertical flight profiles in summer 2019 (left side of Figure 3-16) and in summer 2020 (right side of Figure 3-16). The red lines in Figure 3-16 correspond to the lower vertical limits of Maastricht and Karlsruhe UAC. Whereas in 2019, the flights were unable to enter the two UACs due to (RAD) restrictions, the situation in 2020 changed entirely as a result of the lower traffic levels and the removal of the restrictions.

Once traffic returns to pre-COVID-19 levels, service providers are likely to face again a trade-off between capacity and efficiency as the optimum vertical trajectories on the 20 most penalising airport pairs enter Maastricht and Karlsruhe UAC for a comparatively short period of time but potentially increase vertical complexity (and reduce throughput) in the two UACs.

Despite the observed improvement in 2020 it is remarkable that the level of inefficiency on the top 20 most penalised airport pairs remained notably above the system average, considering the dramatic drop of traffic as a result of the COVID-19 crisis.

Overall it appears that there is still quite some vertical en-route flight inefficiency despite the low traffic numbers which suggests that there might be further scope for improvement. With traffic levels only recovering over the coming years, the COVID-19 crisis should be used as an opportunity to continue to review and remove constraints in the ATM system where possible with subsequent savings in terms of fuel and CO_2 emissions.

To enable stakeholders to get the en-route VFE results for an airport pair of their choice, an online report request tool is available 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.

3.4 Conclusions

The chapter on operational en-route ANS performance traditionally reviews the en-route capacity situation and en-route flight efficiency. With the COVID-19 pandemic hitting the aviation world in an unprecedented way in the first quarter of 2020 everything changed. As a result, air traffic in Europe dropped to the level of 1989 and the focus in Europe moved from capacity and ATCO staffing shortages in 2018/19 to downscaling of operations and funding to ensure business continuity.

At EUROCONTROL level, traffic dropped by 55.2% in 2020 which corresponds to 6.1 million lost flights compared to 2019. At ANSP level, the traffic reductions range from -41.9% (-49.5% Mar.-Dec.) for Avinor (Norway) to -69.2% (-80.4% Mar.-Dec.) for ARMATS (Armenia).

In absolute terms, DSNA (France), DFS (Germany), NATS (UK), ENAIRE (Spain), ENAV (Italy) and Maastricht UAC showed the highest year on year reduction with more than 1 million fewer flights than in 2019.

Following a first quarter with higher en-route ATFM delay levels than in 2019 there was virtually no en-route ATFM delay for the remainder of 2020, as a result of the unprecedented drop in traffic and the resulting capacity surplus. The virtual elimination of delays attributed to adverse weather (-99%) shows how capacity constraints stemming from weather are generally aggravated by other capacity constraints e.g. sector capacity and staffing availability.

Although it is unlikely that traffic will experience significant capacity problems in the immediate future, the traffic downturn provides an opportunity to review the “lessons learned” from the capacity crisis in 2018 & 19 to prepare for the time when the traffic returns.

The drop in demand combined with an uncertain recovery path forces the entire aviation value chain to downscale and to cut costs where possible. As a consequence, ANSPs are faced with the challenge to find and ensure sufficient funding while preparing the future in terms of capacity, staff planning & training; all without forgetting to invest in digitalisation and sustainability.

A number of ANSPs report plans to increase the numbers of ATCOs. Several of these ANSPs report that they are reviewing existing plans for additional controllers due to the pandemic even though it can take several years between initial recruitment and deployment in operations.

There is a risk that reducing or cancelling capacity improvement plans, including staffing, whilst potentially providing a short-term cost reduction for the ANSPs could result in capacity problems for many years ahead, with adverse financial consequences for airspace users of much greater magnitude than were 'saved' by the ANSP.

Several ANSPs plan to add capacity by redesigning airspace within their area of responsibility; one ANSP indicates that it is also seeking to work with adjacent ANSPs to add capacity through airspace redesign occurring beyond its boundaries.

In line with the performance improvement process outlined in this report, the PRC, working with ANSPs, will continue to report on capacity bottlenecks within the network, and on the efforts of ANSPs to resolve/mitigate the bottlenecks to improve capacity performance.

Another effect of the significantly lower traffic level in 2020 was the improvement of horizontal and vertical en-route flight efficiency, both with a high relevance for fuel efficiency and the environment.

Horizontal en-route flight efficiency at EUROCONTROL level improved from 97.2% in 2019 to 97.5% in 2020. The observed improvement was not distributed evenly across the network. In some areas where flight efficiency was already high, the scope for further substantial improvements was limited while in other areas the limited flexibility to adjust the route network to the completely different situation seems to have hindered higher improvements. Although the improvement seems small in terms of percentage, achieving the 2020 efficiency level with the traffic of 2019 would have saved a total of 29.7 million kilometre of additional distance and corresponding substantial reductions in fuel burn and CO_2 emissions.

The efficiency of the filed flight plans and the shortest constrained routes available to aircraft operators also improved but at a notably lesser rate than the actual trajectories which resulted in a further widening of the gap between flight plan and the actual flown trajectories.

It suggests that the actual trajectories were improved on a tactical basis whereas the flight planning and the route network showed a lower flexibility to adjust to the low traffic levels. In view of the dramatic drop in traffic there is a need to understand the remaining constraints in the ATM system that hinder a more substantial improvement of flight efficiency.

When looking at the changes in horizontal flight efficiency compared to 2019 by distance, it is interesting to note that the level of improvement was highest for shorter and domestic flights.

All but 4 States show an improved efficiency of the actual trajectory in their respective airspace. The changes compared to 2019 range from an improved flight efficiency of the actual trajectory of +0.6% points (UK) to a deterioration of -0.6% points (Malta). For a number of states the efficiency of the actual trajectory improved notably more than the filed or the shortest constraint trajectory which could indicate an insufficient flexibility to adjust processes and the route network to the new situation.

As highlighted in previous reports, a notable improvement in overall flight efficiency is expected with the implementation of Free Route Airspace (FRA) in those States in the core area where traffic density is highest. Although more challenging, FRA implementation in the dense European core area will have a notable positive effect on fuel burn and the environmental as even small improvements would have a higher impact because of the higher number of flights.

However, it should also be noted that whilst FRA can provide efficiency improvements there are still further inefficiencies that may remain. For example, flight planning will be undertaken based on existing airspace entry / exit points which may not be optimised for all routes, military airspace activity may prevent the flying of an optimised trajectory whilst airline flight planning systems may not be optimised to enable the optimal FRA flight plan to be calculated. The full benefits of FRA will come from the inter-FAB and cross border implementation of FRA.

Also the vertical component of en-route flight efficiency has gained more attention over the past years, particularly following the implementation of additional flow measures to manage the capacity crisis in 2018/19. Although difficult to quantify at network level in terms of additional fuel burn and CO_2 emissions, the analysis shows a considerable reduction of altitude constrained flights in 2020, following the removal of a large number of Route Availability Document (RAD) measures in the ATM network.

The improvement of operational efficiency with subsequent savings in terms of fuel and CO_2 emissions was already a focus area before the COVID-19 crisis hit the industry and will remain important on the way to recovery over the coming years.

In this context the crisis also offers an opportunity to review and evaluate constraints imposed by ANS and to further improve existing procedures where possible.

4 Operational ANS Performance @ Airports

4.1 Introduction

The lack of sufficient airport capacity was seen as one of the key challenges for future air transport growth. The outbreak of the COVID-19 pandemic in March 2020 and the subsequent unprecedented decrease in traffic demand changed the situation and focus on capacity at airports for the next few years, depending on the rate of recovery.

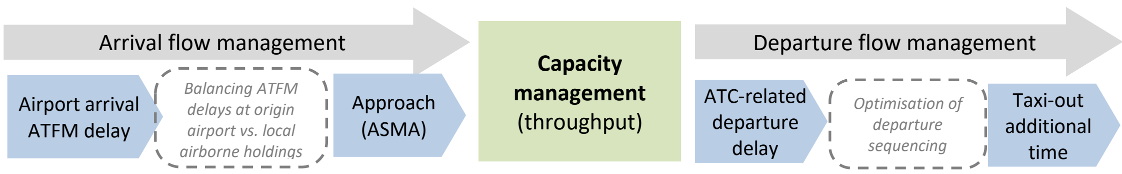
In the short term, airports will primarily focus on cost containment and funding but it will be important to gradually scale up capacity when traffic returns. In the meantime the focus on environmental sustainability will persist and airports will face the challenge to balance cost cutting measures with necessary future investments while working on improved procedures to further improve operational efficiency.

This chapter provides a review of operational ANS performance at the top 30 European airports in terms of movements in 2020 which have the strongest impact on network performance, and how the COVID-19 pandemic has impacted their operation. Together the top 30 airports accounted for 39.3% of all arrivals in the EUROCONTROL area in 2020. The evaluation of future airport capacity requirements (e.g. new runways, taxiways, etc.) is beyond the scope of this report.

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

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

Figure 4 2 shows the implementation status (end of 2020) of some of the initiatives listed in Figure 4-1.

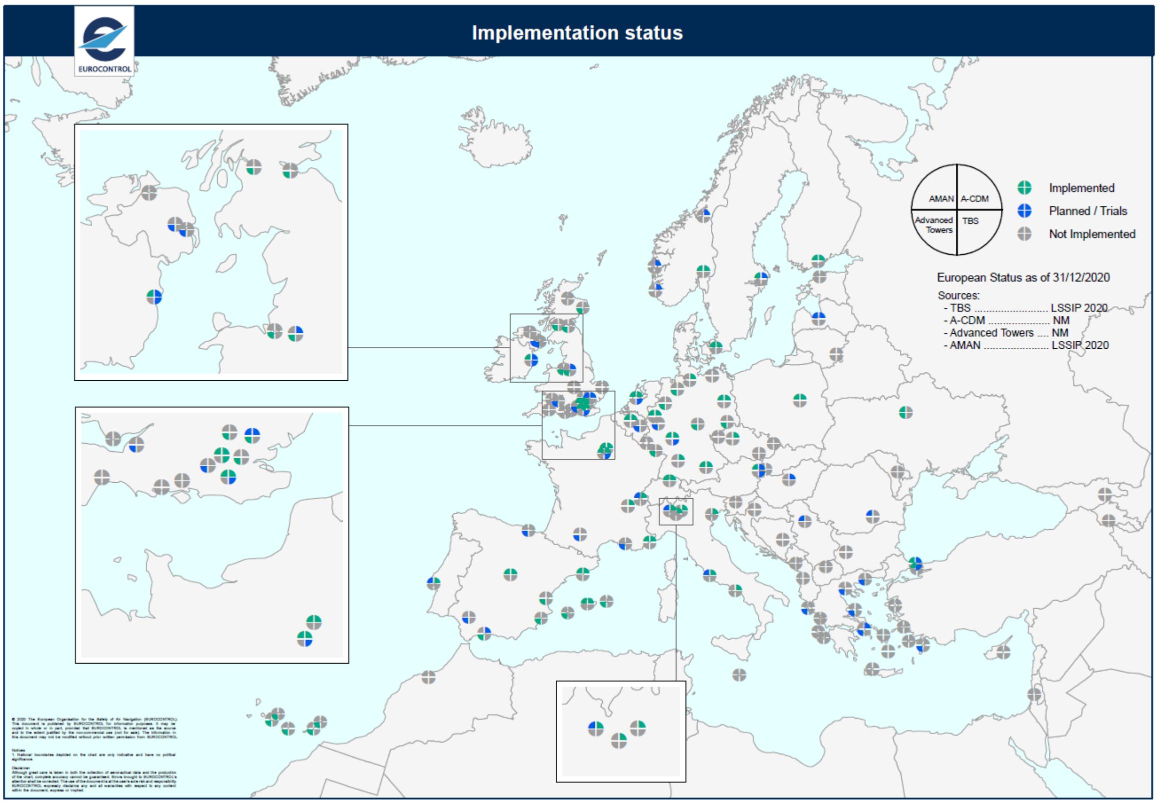


Figure 4-2: Airport initiatives implementation status (2020)

Several projects and initiatives 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 (APOC) implementation are expected to allow airport stakeholders to better handle their local capacity and bring local and network benefits in terms of predictability. 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 information between airports and the Network Manager, AOP-NOP integration should improve the operational performance of both airports and the network, through enhanced situational awareness which facilitates better decision making. In 2020, airports such as Frankfurt, Amsterdam, Madrid, Gatwick and Heathrow made progress towards 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.) This makes sometimes difficult a clear identification of underlying causes and the attribution to specific actors.

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 2020 have decreased by 59.3% compared to 2019. This corresponds to 13910 fewer movements each day. At the same time, the number of passengers at the top 30 airports in 2019 decreased by 72.3% compared to the previous year [19]. Figure 4-3 shows the evolution of average daily IFR movements at the top 30 airports in absolute and relative terms[10].

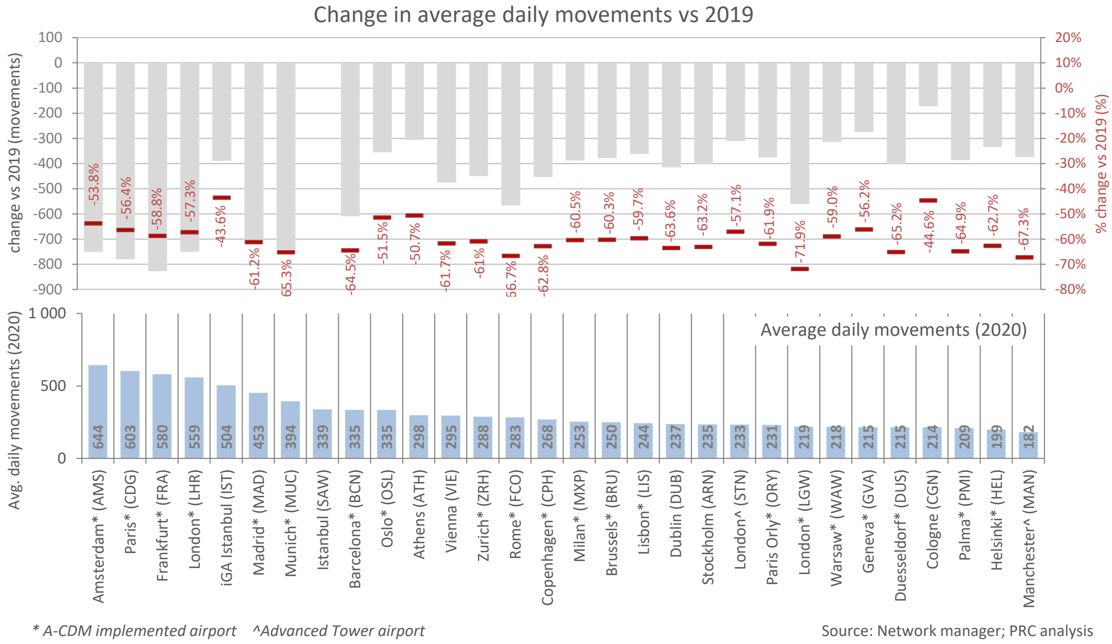


Figure 4-3: Traffic variation at the top 30 European airports (2020/2019)

London Gatwick had the highest drop in traffic (-71.9%), followed by Manchester (-67.3%) and Rome (-66.7%).

Cologne (CGN) enters the top 30, with the second lowest decrease (-44.6%) after iGA Istanbul (-43.6%). Geneva comes back to the top 30 (only -56.2%, thanks mainly to the lower decrease of business aviation).

Berlin Tegel (TXL), previously in the top 30, transferred all traffic to the new Berlin Brandenburg (BER) which opened at the end of October 2020, also replacing Berlin Schoenefeld. The new airport is expected to be the third busiest in Germany, after Frankfurt and Munich.

Liege (LGG) is the only airport in the Top200 that has increased its traffic in 2020 (+4.9%) thanks to its designation in April by the World Food Programme and the World Health Organization as a “Humanitarian Response Hub”, operating medical and humanitarian deliveries.

4.2.1 Impact of COVID @ the top 30 European airports

The COVID-19 crisis has impacted airports and the way they are operated in many different ways. The drop in traffic translated not only in fewer flights generating revenue, the number of passengers took an even greater hit due to much lower load factors.

Runways and terminals were closed to try to reduce the operating costs, and many airport staff were furloughed while at the same time the changing

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

COVID-19 measures (e.g. social distancing requirements, testing…) demanded extra effort to accommodate each passenger and imaginative solutions were required. These cost-containment measures might have an impact on the ability to scale back up when the demand requires, so adaptability to the changing scenarios is key.

Some of the busiest airports in Europe have seen their aprons and even taxiways and runways converted into longstanding parking, and in the midst of the need for longer term solutions, specialized storage facilities and aircraft boneyards have seen their business booming.

The airport slot utilization policy that requires airlines to use 80% of their airport slots in order to keep them the following year received a full waiver in 2020. Looking forward, the European Union will adopt an amendment of EU Slot Regulation 95/93 that set rules for a waiver on use-it or lose-it rules at EU airports and which will apply in Summer Seasons 2021 (S21) and possibly beyond. This amendment allows operators to hand back to airports up to 50% of their slots and reduces the required use rate to 50%.

4.2.1.1 COVID-19 impact on traffic @ the top 30 airports

In the first two months of 2020, average daily movements at the top 30 airports in 2020 was decreasing in general by 2.3%, with some airports showing more significant reductions (Rome -10.4%, Dusseldorf -8.3% and Stockholm -8.1%).

Figure 4-4 shows the traffic breakdown per market segment and area in 2020 since the beginning of the crisis in Europe (taking the 1st of March) for the set of top 30 airports and the comparison with the equivalent in 2019. Figure 4-5 shows the same analysis per airport.

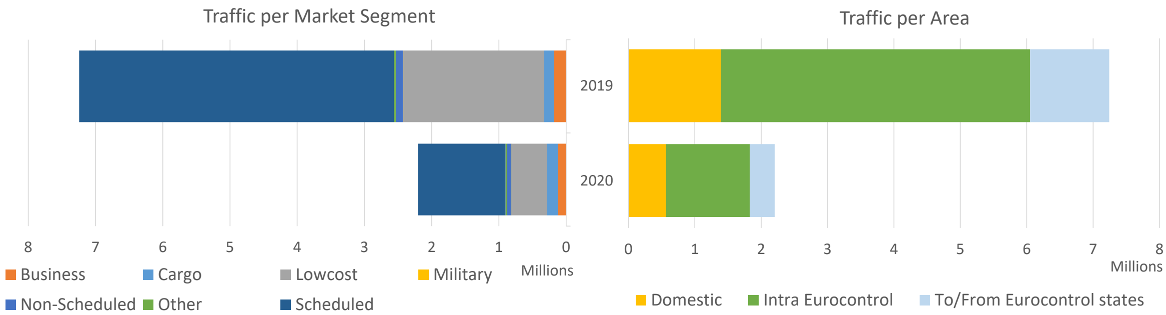


Figure 4-4: Traffic by market and area (overview of top 30 airports in Europe - 01-Mar to 31-Dec)

All market segments, except for cargo operations (+4.9%) suffered drastic reductions with uneven impact at different airports.

Traditional scheduled flights at the top 30 airports decreased by 72.2%. Of the airports with the most important scheduled operations in 2019 only Amsterdam (-61.5%) dropped less than 65%, while Munich decreased its scheduled operations by 79%.

Low-cost operations at the top 30 airports dropped even more than traditional scheduled flights, by 75.1%. Traffic at Gatwick, the second most important airport for low-cost flights in 2019, fell by nearly 80% in 2020. At some airports, such as Helsinki (-90.9%) and Istanbul IGA (-92.4%), this traffic segment almost disappeared in this period.

Non-scheduled flights decreased on average by 33.8%, which is much less than the previous categories. They increased at Heathrow (+650%), CDG (+38%) and Frankfurt (+27%), and at some other airports. Only half of the airports in the top 30 observed a decrease larger than 50% in this category.

Business flights, after cargo, represent the market segment that has held up better in this period, decreasing only by 30% on average at the top 30 airports. Geneva holds an important business operation, which has allowed them to re-enter the top 30, representing 35% of their traffic since February.

Cargo operations at the top 30 airports increased by almost 5%, but the situation varied depending on the airport. Istanbul IGA tripled its cargo flights, while CDG decreased by 9%. In addition, cargo flights operated by traditional scheduled airlines during the pandemic are still registered as scheduled, so the actual number of cargo flights might be higher.

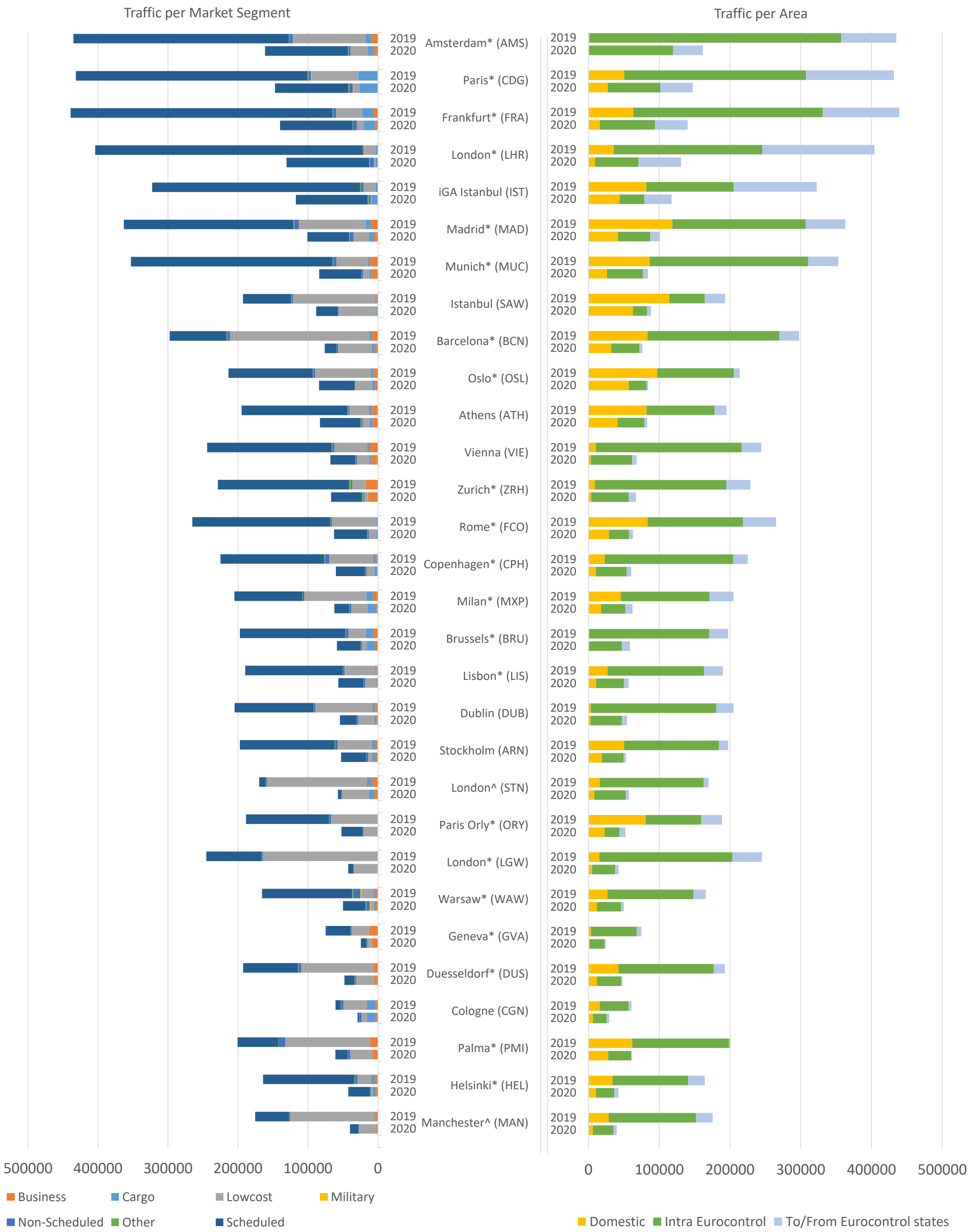


Figure 4-5: Traffic by market and area at the top 30 airports in Europe (01-Mar to 31-Dec)

Athens airport was, after Cologne and the Turkish airports, the airport with the lowest reduction in traffic during the crisis (-57.4% in total). The fact that Greece was one of the last “green” destinations in terms of COVID incidence helped maintain some of the scheduled and business traffic at Athens during the summer, mainly domestic and intra-EUROCONTROL.

In terms of flight area for these top 30 European airports, domestic flights dropped by 60%, in comparison with the intra-EUROCONTROL (-73.1%) or the To/From EUROCONTROL (-68.7%).

The picture of domestic traffic is quite different depending on the airport. The most important domestic operations in 2019 were at Madrid airport (representing almost a third of the flights in the period Feb-Dec) and in 2020 it suffered a 65% reduction. Istanbul Sabiha, on the other hand, which had the second most important domestic operations in 2019 after Madrid airport, decreased by 45% in 2020. It is also worth noting that Oslo airport, where domestic traffic represented 45% of the operations in 2019, only reduced by 41.5%, becoming almost 70% of the total flights during the crisis. This need to ensure connectivity in Norway has helped Oslo to be one of the airports with the lowest total traffic reduction in 2020 (-60.5%).

Intra-EUROCONTROL flights decreased at most of these airports by between 70% and 85%, with the biggest hit taken by Gatwick (-82.8%)

Traffic to/from EUROCONTROL States during the crisis seems to be more concentrated at the bigger airports, where 5 of them (Heathrow, Frankfurt, CDG, Amsterdam and Istanbul iGA) cover 59% of the out-of-area flights in Europe. Furthermore, while half of the top 30 airports show a drop in international flights around 75% or above, Amsterdam stands out with only a 46.2% decrease.

4.2.1.2 Adapting to lower demand: closure of runways and terminals

Airport operators and ATC services had to adapt quickly to the drastic drop of flights and passengers, reducing costs but ensuring the minimum required services were available, both airside and landside.

This translated in closure of runways and terminals across airports in Europe, implementation of COVID related measures (social distancing, COVID test points,…) and limited staffing (ATC, ground handling), operating in many cases on minimum resource levels with the consequent impact on capacity (both in passengers and in aircraft movements). In a few cases it resulted in the temporary closure of the airports for commercial traffic (Paris Orly, London City).

Airports were constantly monitoring the situation, with all partners ready to increase capacity as soon as demand required it. That was the case for the summer season when traffic partially recovered, and many of the closed runways and terminals reopened.

Most of the top 30 airports closed at least 1 runway, permanently or alternatively for a certain period of time (April and May mostly, but some also in the third trimester), applying temporarily single runway operations. Amsterdam converted runway 18L/36R into long term parking for grounded aircraft during April and May.

Along the same lines, the vast majority of the top 30 airports closed between April and mid-June some passenger terminals totally or partially (satellites, piers, sections) even if the capacity of the remaining open terminals was reduced due to “social distancing” measures. Some terminals remain closed to date.

4.2.1.3 Grounded aircraft

Figure 4-6 shows the situation on the ground at the top 30 European airports at the end of 2020, with up to 129 grounded aircraft (inactive for more than 7 days) at Madrid airport. These aircraft that could not fly due to the pandemic have during these months saturated aprons and even runways (like in Amsterdam airport), in some cases creating bottlenecks in taxiways or closing entire areas for normal operation.

As can be observed, most of the grounded aircraft at these airports are narrow bodies, but there is also a significant number of wide bodies and very large aircraft, with the obvious impact on the required space on the aprons.

At the height of the crisis, there were almost 7000 grounded aircraft in Europe and, notwithstanding the partial recovery in the second trimester, there are still more than 4000 aircraft parked on airport tarmacs all across Europe.

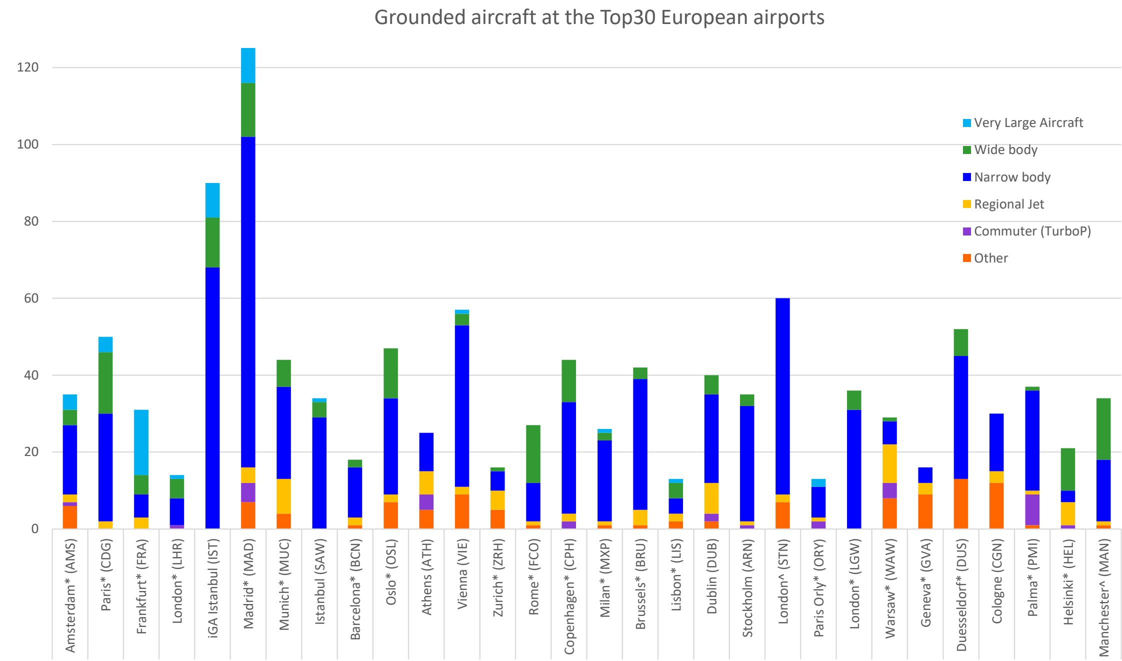


Figure 4-6: Grounded aircraft by category at the top 30 airports in Europe (as of 31-12-2020)

Storage facilities – Aircraft boneyards

With no clear view of an immediate recovery and lack of parking space at the main airports, together with some airlines' previous plans to retire part of their older fleet, the aircraft storage companies and facilities have considerably increased their business during the pandemic.

Some airports like Teruel were conceived as long term storage and dismantling facilities and have during the crisis reached their maximum capacity. Some other airports that were handling little or no traffic (like Ciudad Real airport) have now a second life, quickly adapting their services to provide the required maintenance for these aircraft, or the dismantling and storage of engines and parts.

Figure 4-7 shows the current situation (as of 31-12-2020) at the most important storage facilities in Europe (more than 30 grounded aircraft and virtually no other operation) with the breakdown per aircraft type.

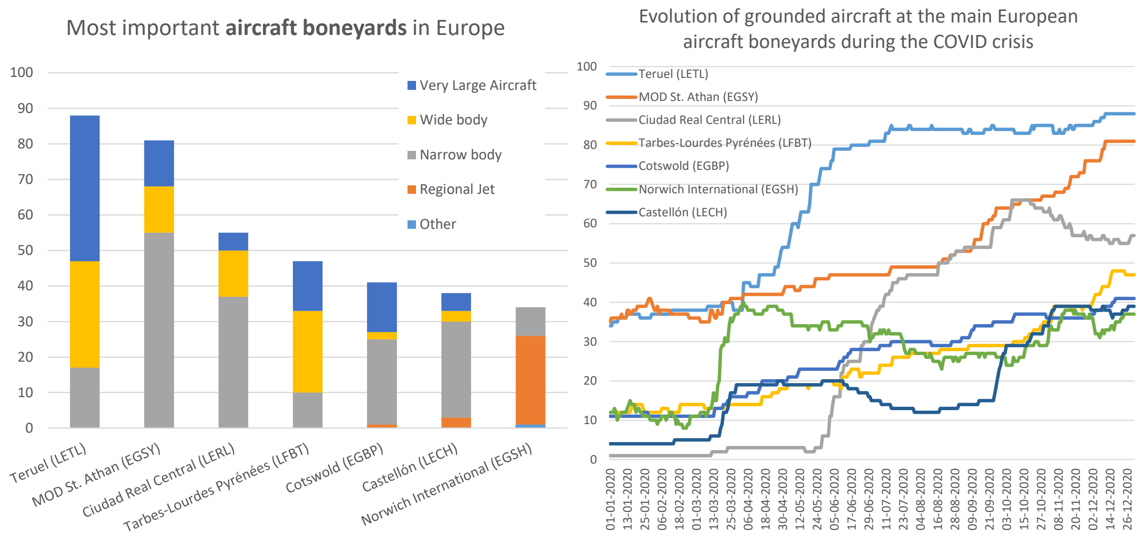


Figure 4-7: Aircraft storage facilities situation at 31-12-2020 and evolution during 2020

Some aircraft that were initially parked at main airports awaiting a faster traffic recovery, were then progressively moved to these storage facilities, freeing aprons and runways at their original parking location.

More detail on grounded aircraft, including breakdown per location and operators can be found in https://ansperformance.eu/covid/acft_ground/ .

4.3 Capacity management (airports)

Regardless of the current and extraordinary circumstances due to the COVID crisis, airport capacity is one of the major constraints to future traffic growth in Europe. Some major European airports were already operating close to their maximum capacity throughout most of the day before the crisis. 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.

The usual analysis in this section, providing a high-level indication of operations at the top 30 airports, seeks to give an overview on the level of saturation and capacity utilization at these airports. For this, the hourly throughput distribution for each airport is analysed and compared with the declared capacity. Unfortunately the hourly throughput in 2020 has little to do with the normal operating conditions, with demand well below capacity at all these airports.

Figure 4-8 shows the historic evolution of the total hourly throughputs between 2010 and 2020 (median and peak service rate).

The "peak service rate[11]" is used as a proxy to evaluate the peak throughput that can be achieved in ideal conditions and with a sufficient supply of demand. This year, however, this 99th percentile will be taken from the demand in January and February, but that would normally not be the highest in a normal year.

The gap between peak and median throughput, which in general had narrowed down in the last years, is now strongly impacted by the low throughput during the crisis, resulting in a very low median hourly throughput for the year and drastically widening this gap.

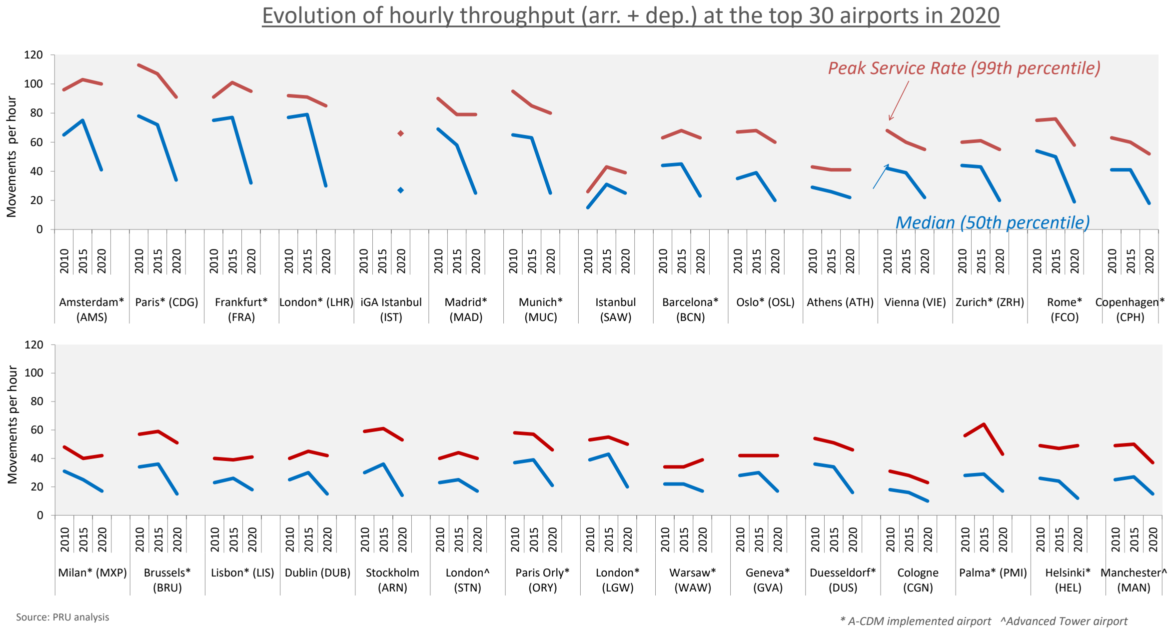


Figure 4-8: Evolution of hourly movements at the top 30 airports (2010-2020)

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11 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.

Airport capacity imbalance

Available runways at a given airport, together with their relative disposition, length, navigational aids, environmental constraints and local meteorological conditions (wind rose, visibility,…) can result in very different operating circumstances, with a direct impact on the capacity of the airport and the operational performance. This factor might become even more significant when considering the closure of runways during the crisis and the consequent potential unavailability of the optimal runway configuration, and should be taken into account when demand comes back.

The PRC carried out a study to evaluate this impact, through the identification of runway configurations and corresponding capacity and performance, based on 2019 data for 90 European airports.

The results of the study were presented in a Technical Note for stakeholder consultation and the final paper was published in October 2020.

The PRC held a webinar on the 25th March 2021 to raise the awareness on this matter and share the different stakeholders' points of view. More than 300 participants from 52 countries joined the webinar which presented the concept, methodology and results of the PRC study, followed by an expert panel providing the airlines, airports and airport coordinator's perspective.

The presentations and recording of the webinar are available on the EUROCONTROL event webpage: https://www.eurocontrol.int/event/addressing-airport-capacity-imbalance

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.

Figure 4-9 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 2020. It also shows at the top of the figure the monthly evolution of the global indicator for the top 30 airports in the last 5 years.

There is an obvious "before" and "after" the beginning of the crisis in the observed delays. Airport arrival regulations, which caused high delays in January and February mainly due to weather, virtually disappeared in April May and June, with only 24 arrivals affected in those months (versus nearly 83000 in the same period of 2019). Only minor arrival ATFM delays were registered during the rest of the year.

The heavy storms in February (Dennis and Ciara) had an important effect in the additional ASMA times at airports across UK, Ireland and Central Europe, with Heathrow reaching more than 10 minutes delay on average per flight that month. These were however followed by nearly zero delays at most airports in the top 30 in the month of April and, with a few exceptions, delays remained close to zero throughout the summer. In the last quarter of 2020, the additional ASMA times increased slightly, and in Cologne and Athens they resulted in even higher average additional times than in 2019.

To illustrate this difference before and after the beginning of the crisis in the additional ASMA times but still providing the annual values, Figure 4-9 shows also the average in the March to December period and its comparison with the same period in 2019. It can be observed how the lack of congestion has reduced drastically the need for holdings and vectoring in the approach phase.

The average additional ASMA time at the top 30 airports since the crisis started is 0.70 min/arr., versus 2.18 min/arr. in 2019. This performance would represent, for the traffic levels of 2019, a reduction of more than six million minutes of flying time at these top 30 airports with the associated fuel burn, noise and emissions.

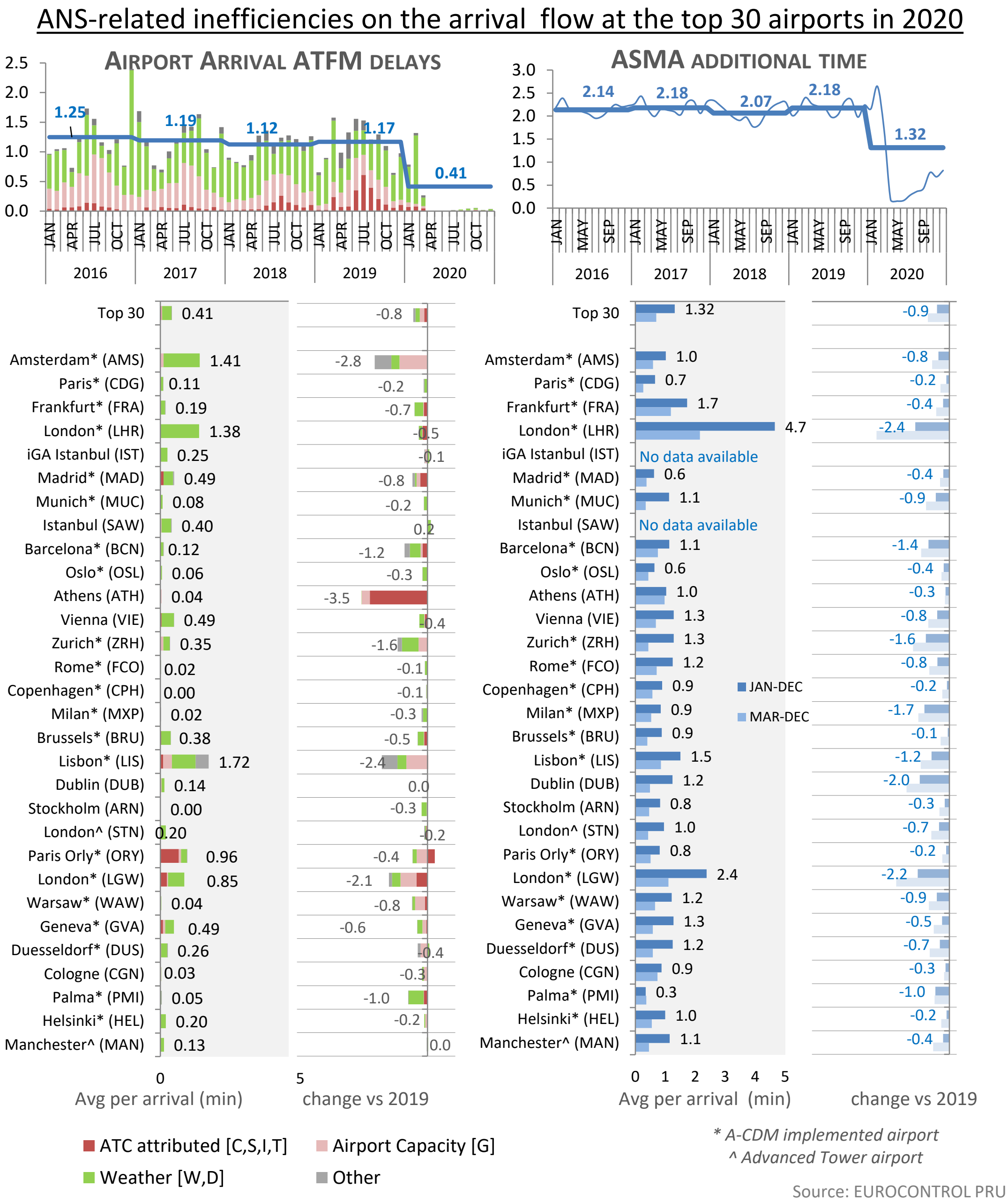


Figure 4-9: ANS-related inefficiencies on the arrival flow at the top 30 airports in 2020

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.

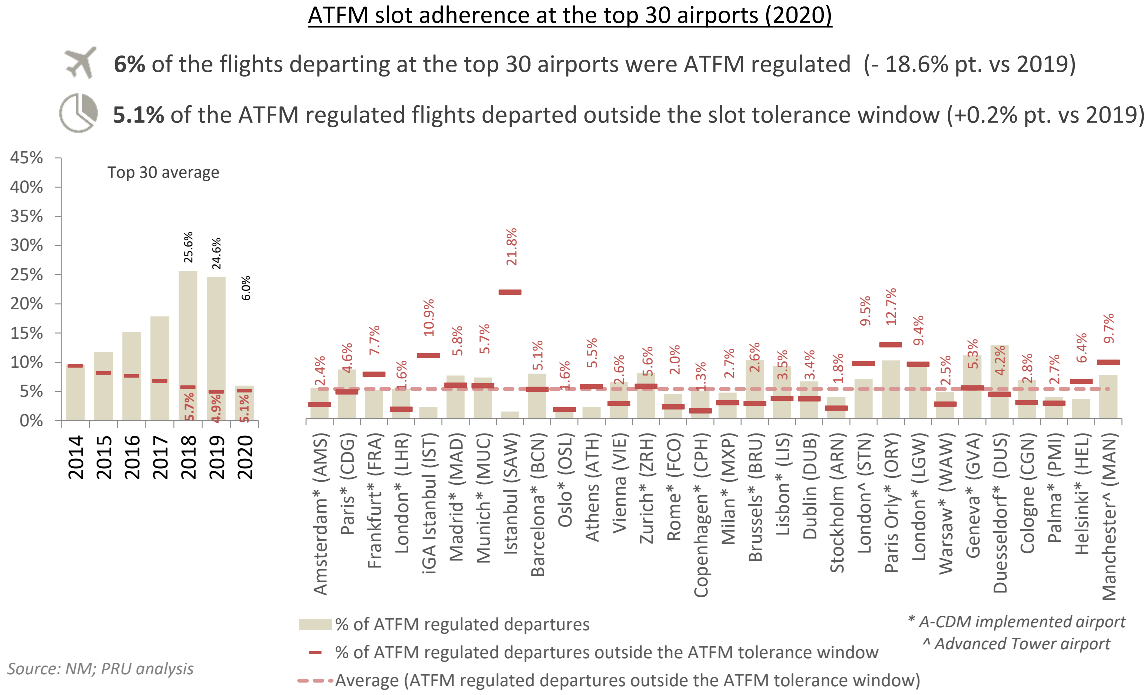


Figure 4-10: ATFM slot adherence at the top 30 airports in 2020

The almost total disappearance of arrival regulations since March 2020 has resulted in the lowest share of regulated departures in the last 7 years at the top 30 airports. 5.1% of those regulated departures, a similar proportion compared to the last two years, take off outside of their slot tolerance window (STW). In view of the low traffic levels in 2020 this however corresponds to only a few flights mostly departing ahead of their STW.

4.4.2.2 ANS-related inefficiencies on the departure flow

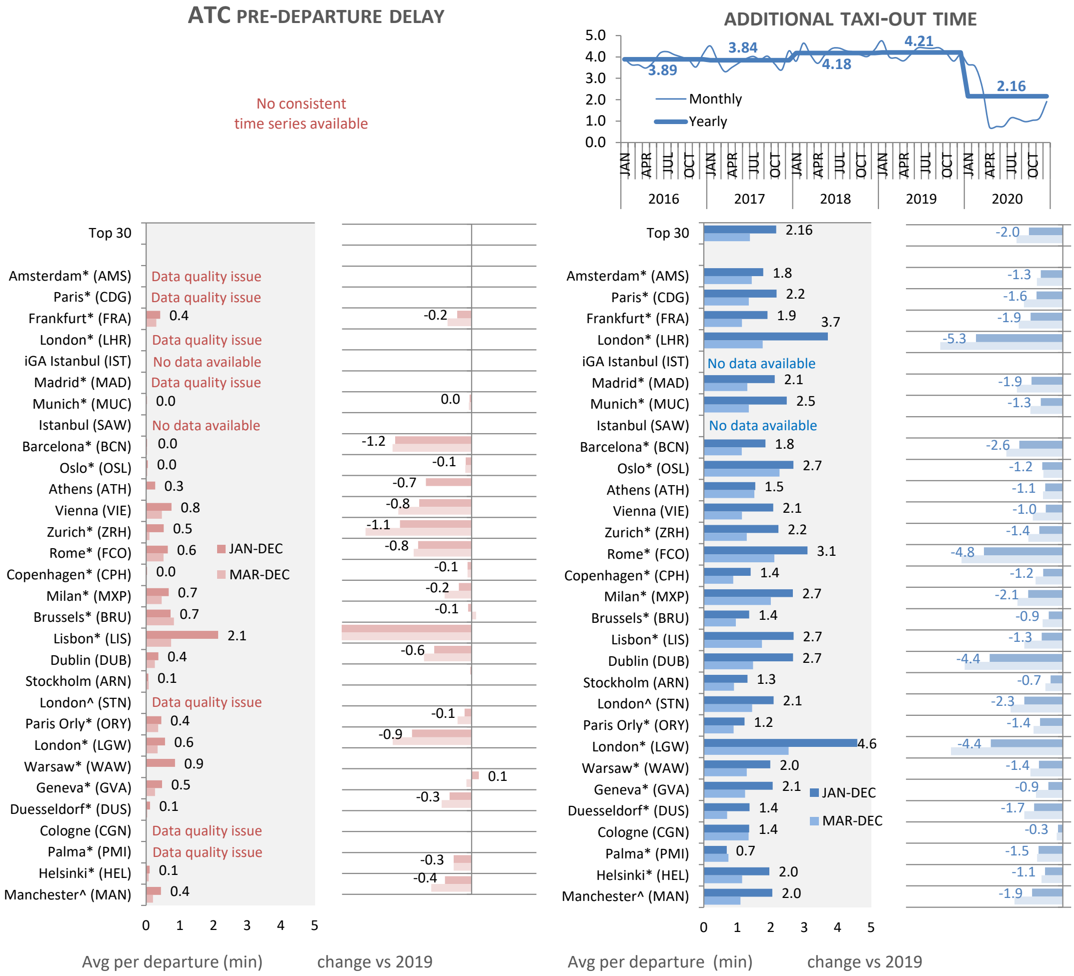
Figure 4-11 shows the local ATC departure delays and the taxi-out additional time at the top 30 airports in 2020. The average additional taxi-out time decreased by 2 minutes per departure in 2020 (excluding the Turkish airports for which no data was available), resulting in 2.16 min per departure. Just like the rest of indicators, this reduction is the combination of the normal circumstances in January- February with the unprecedented drop of traffic and therefore congestion at these airports as of March. To illustrate the actual impact after the beginning of the crisis, Figure 4-11 shows as well the average in the March to December period and its comparison with the same period in 2019 for both ATC pre-departure delay and additional taxi-out times.

The additional taxi-out times show a similar evolution to the additional ASMA times for arrivals, with almost zero delays at many of the top 30 airports in the second trimester of the year. Airports like Gatwick, Heathrow, Rome Fiumicino and Dublin, that showed the highest additional taxi-out times in 2019, have reduced their delays between 73% and 81% per departure. If this performance could have been achieved in 2019, with departures benefiting from these lower delays in the taxi-out phase, the aircraft would have taxied around 12 million minutes less, with the associated savings in fuel, noise and emissions. At the end of the year there was a notable increase in the additional times at some airports, mainly associated with remote de-icing procedures.

The taxi out phase might look different in the future though. Amsterdam Schiphol airport tested in 2020 a new taxiing procedure, using “Taxibots” (semi-robotic, pilot-controlled towing system) that tow the aircraft from the parking to the runway, including the pushback. The aircraft therefore does not need to run engines during the taxi procedure, helping save fuel and emissions. Nevertheless, this gain might be nugatory if the aircraft then spends a long time in the departure queue with running engines.

The reporting on the reasons for the delays in the off-block, used for the calculation of the ATC pre-departure delay, has been impacted as well since March showing lower data quality at most airports. Nevertheless, where the indicator could be calculated, a clear reduction of these delays was observed, notably at Lisbon, Zurich and Barcelona.

<u>ANS-related inefficiencies on the departure flow at the top 30 airports in 2020</u>



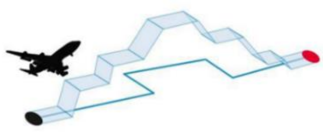
** A-CDM implemented airport*
^ Advanced Tower airport

Source: EUROCONTROL PRU

Figure 4-11: ANS-related inefficiencies on the departure flow at the top 30 airports in 2020

4.4.3 Vertical flight efficiency during climb and descent

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



The dramatic reduction of traffic as a result of the COVID-19 pandemic in 2020 (-55.2% vs. 2019) has had a clear impact on the time in level flight at airports in the EUROCONTROL area.

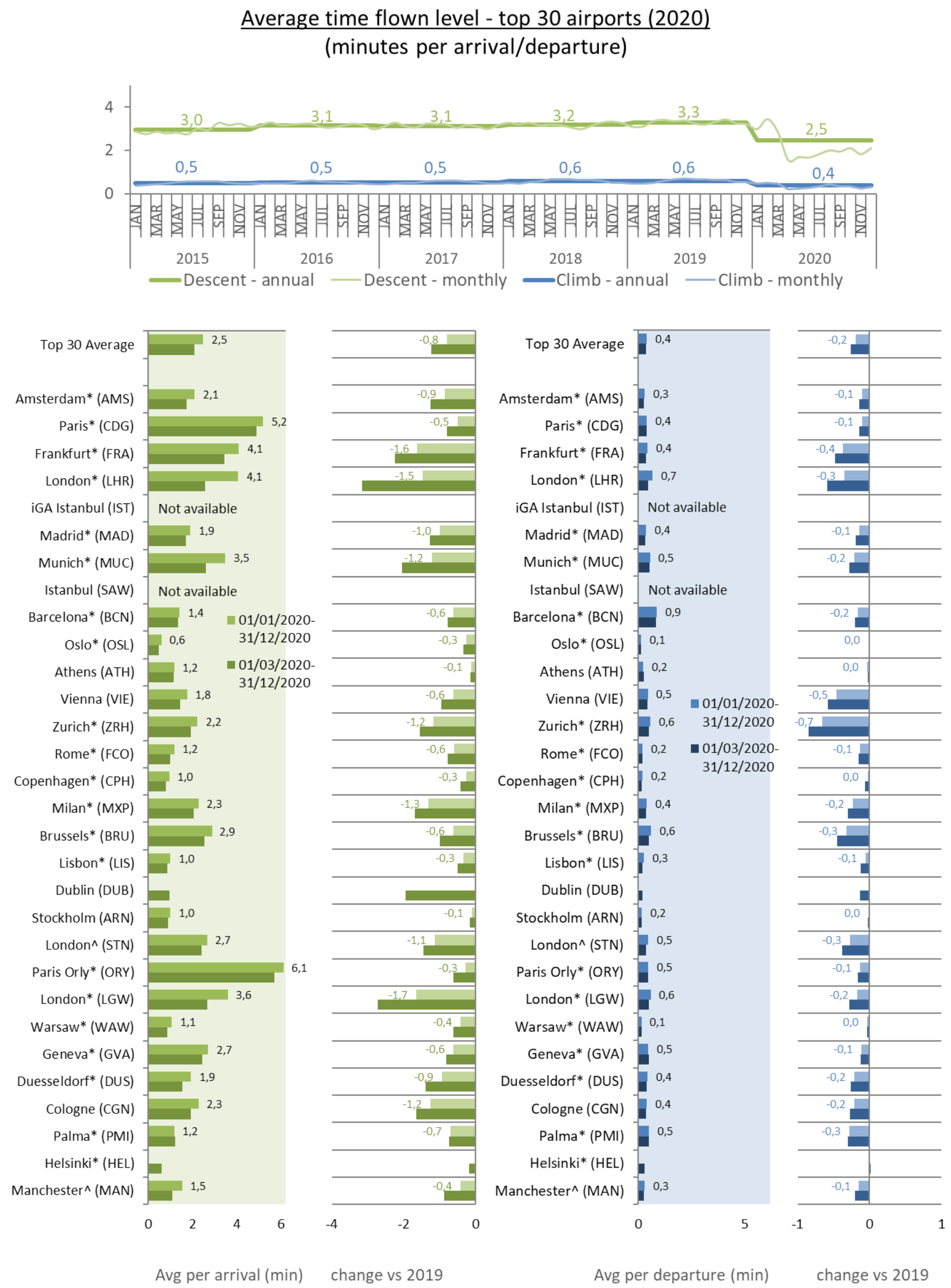
Figure 4-12 shows the average time flown level per flight within a 200NM radius at the top 30 airports. Generally, climb-outs (right side) were less subject to level-offs than descents (left side).

The time flown level during descent is on average around five-six times higher than the time flown level during climb. At system level the average time flown level decreased slightly to 2.5 minutes per arrival compared to 0.4 minutes per climb out.

Environmental impact

Reducing intermediate level-offs and diversions during climb and descent can save substantial amounts of fuel and CO_2 and also reduce noise levels in the vicinity of airports.

The lower the level segment, the higher the additional fuel consumption.



Source: EUROCONTROL PRU

Figure 4-12: Average time flown level in descent/climb at the top 30 airports

On average, arrivals were operating 48 seconds less in level flight at the top 30 airports in 2020, but with notable variations across States and airports. Achieving this performance with the traffic level of 2019 would have saved 3.2 million minutes (6.1 years) in level flight with the corresponding savings in terms of fuel and CO_2 emissions.

Most airports have a substantial reduction in average time flown level, especially during the descent. However, Paris Charles de Gaulle and Paris Orly do not show a comparable level of improvement and still have an average time flown level of more than 5 minutes per flight during the descent.

Figure 4-13 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 base of each arrow indicates the 2019 values while the arrowhead indicates the 2020 values. Airports with good vertical flight efficiency results are located in the top left corner while efficiency deteriorates towards the bottom right corner.

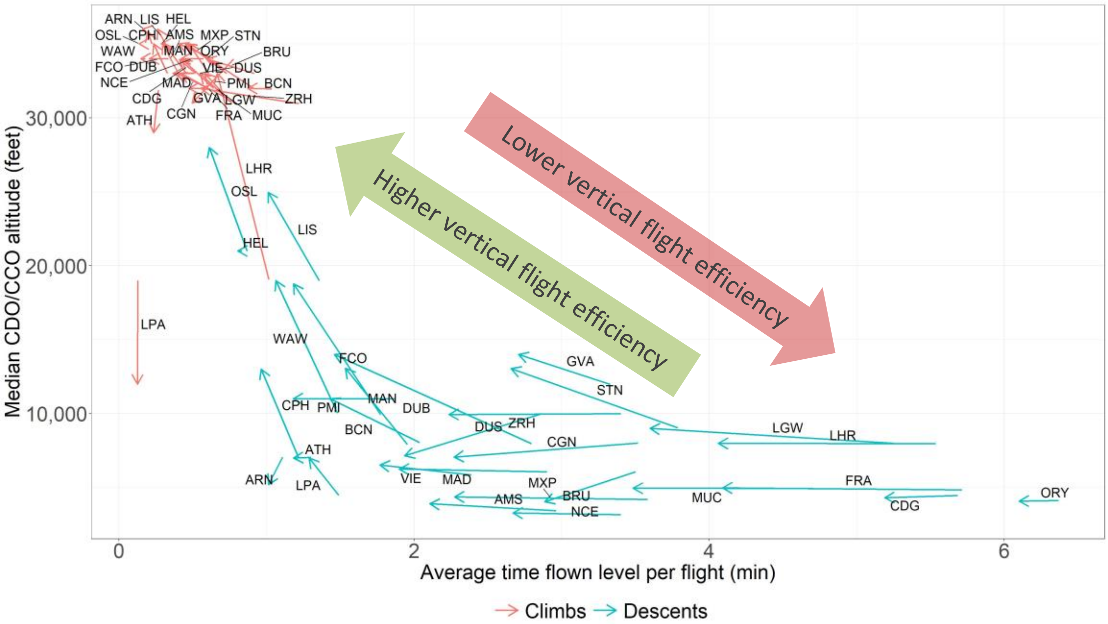


Figure 4-13: Median CDO/CCO altitude vs. Average time flown level per flight (2019 vs. 2020)

The climb results (red in the top left corner of Figure 4-13) haven't changed significantly from 2019 to 2020, except for the median CCO altitude for London Heathrow. This can be explained by the lower number of flights, which resulted in the departing traffic being able more often to climb through the airspace allocated to the holding stacks.

For the descents, there are two main effects:

- a reduction of mainly the average time flown level per flight for flights to airports which had a relatively high average level time, and
- a reduction of mainly the median CDO altitude for flights to airports which had a relatively low average level time.

The comparatively small improvement of the two Paris airports despite the substantial decline in traffic in 2020 is again visible at the bottom right side of Figure 4-13.

Despite the dramatic drop in traffic as a result of the COVID-19 pandemic, there appears to be still quite some vertical flight inefficiency during climb and descent at European airports. This suggests that traffic levels alone are not the explanatory factor but there is also a need to review and improve inherent processes and procedures which may contribute to lower vertical flight efficiency at airports.

Figure 4-14 shows the change of the number of arrivals (y-axis) and the average time flown level during descent (x-axis) from 2019 to 2020. It is clear that the reduction of the average time flown level is less pronounced for the Paris airports compared to the other airports.

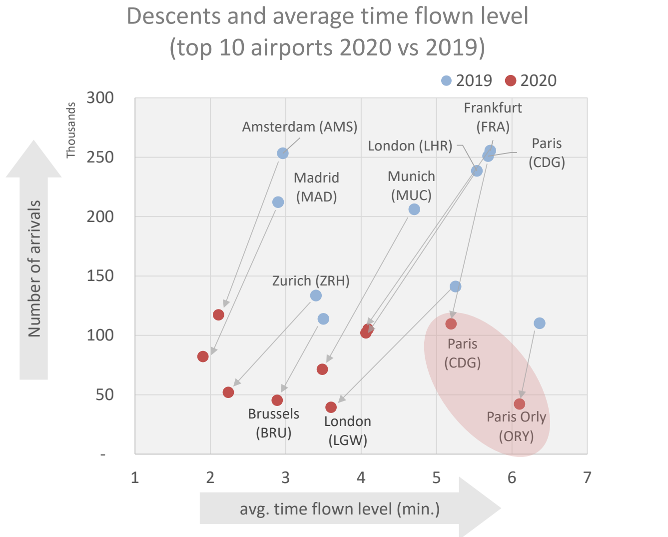


Figure 4-14: Number of descents and average time flown level at the top 10 airports

The arrival procedures into the Paris airports contain level flight by default. Most of the airspace design and the

Letters of Agreement are hardcoded in the ATC system, so adaptations would require important development efforts or even safety issues.

This is the reason why a lot of level flight is detected for Paris airports despite the low traffic numbers.

Air France and DSNA were invited to comment on these observations. Essentially, Air France in collaboration with DSNA is trying some temporary procedures which lead to some significant improvements on specific flights (later Tops of Descent less level flight). This is done for a limited number of flights so it doesn't appear in the overall results.

The low traffic levels provide an opportunity to further reduce vertical inefficiencies around airports where possible to maintain improved performance levels when traffic recovers over the coming years.

The PRC is aware that DSNA plans to implement a new system in the next years, which should allow for a more flexible approach with subsequent benefits in terms of vertical flight efficiency.

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

4.5 Conclusions

The lack of sufficient airport capacity was seen as one of the key challenges for future air transport growth but with the outbreak of the COVID-19 pandemic in Europe in March 2020 and the unprecedented decrease in traffic changed the immediate focus to cost containment, downscaling of operations and financial survival.

As a result of the COVID-19 crisis, airports in the EUROCONTROL area lost more than 55% of their traffic. At the top 30 airports the drop in traffic was even higher, reaching -59% compared to the level in 2019. According to ACI, European airports lost 1.72 billion passengers (-70.4% vs 2019) compared to 2019 due to the COVID-19 pandemic.

The impact of the crisis on individual airports depends to some extent on the market segments and type of traffic they serve (share of international and cargo traffic) which reshaped the list of top 30 airports in 2020 (e.g. Cologne moved from number 37 in 2019 to 27 in 2020).

Although all cargo flights accounted for a comparatively small share of total traffic, the continued demand of goods (also for equipment to fight the pandemic) is visible at airports specialised in cargo operations (Cologne, Liege, Leipzig).

International traffic is heavily affected by the measures implemented by States to contain the pandemic and the subsequent reduced demand for air travel in Europe. As a result, traffic at airports with a comparatively high share of domestic traffic such as Oslo Gardermoen declined less than airports with a higher share of international traffic and airlines consolidated their remaining long haul operations at their respective hubs. Hence, more than half of the international traffic to or from the EUROCONTROL area took place at the top 5 airports in Europe (AMS, CDG, FRA, LHR, IST).

Overall, airports have adjusted their operations to the dramatic drop in traffic in various ways. Runways and terminals have been closed to contain costs, with some of these runways reconverted into long term parking for grounded aircraft for some period of time. Terminals had to be readapted to ensure the "social distancing" requirements and host COVID-test facilities, all while having to furlough many of their staff.

The grounding of 7000 aircraft in the peak of the crisis also posed a challenge in terms of parking and storage on the ground. Some existing storage facilities have reached their maximum capacity, while other underutilised airports have quickly reacted to these new business possibilities offering their aprons, under the uncertainty on how long the storage will be required and if it is worth investing in the required facilities for proper maintenance of the grounded aircraft.

The unprecedented drop in traffic at the end of the first quarter of 2020 removed the capacity problems at congested airports and created in fact a capacity surplus with virtually no airport arrival

ATFM delays for the remainder of 2020. Although not an issue in the immediate future, airport capacity will be back on the agenda when traffic returns and the PRC's study on Airport Capacity Imbalance can support stakeholders in preparing the gradual increase of capacity throughout the recovery phase.

As a result of the significantly reduced traffic levels all indicators measuring operational efficiency at the top 30 airports improved in 2020.

For example, at the top 30 airports in Europe the additional taxi-out time dropped by 2 minutes on average while airport holdings decreased by almost 1 minute in 2020. Vertical efficiency at the top 30 airports during approach, measured as average time flown level, decreased by 48 seconds compared to 2019. Achieving this performance with the traffic level of 2019 would have saved 3.2 million minutes (6.1 years) in level flight with the corresponding savings in terms of fuel and CO_2 emissions.

Although the COVID-19 crisis will keep the focus of airports on operational downscaling and financial survival for a while, the reduced traffic levels provide also an opportunity to review and improve operational processes in the absence of traffic congestion in order to deliver those improved performance levels also when traffic returns.

5 ANS Cost-efficiency (2019)

SYSTEM TREND	2019	Trend	change vs. 2018
En-route ANS cost-efficiency performance (38 charging zones)			
Total en-route ANS costs (M€$_{2019}$)	7 720	↑	+1.4%
En-route service units (M)	161	↑	+2.9%
En-route ANS costs per service unit (€$_{2019}$)	47.8	↓	-1.4%
Terminal ANS cost-efficiency performance (36 charging zones)			
Total terminal ANS costs (M€$_{2019}$)	1 303	↑	+2.1%
Terminal service units (M)	7.4	↑	+2.3%
Terminal ANS costs per terminal service unit (€$_{2019}$)	176.5	↓	-0.2%
Air Navigation Service Provider gate-to-gate economic performance (38 ANSPs)			
Gate-to-gate ATM/CNS provision costs (M€$_{2019}$)	8 711	↑	+1.8%
Composite flight-hours (M)	22.0	↑	+1.7%
Gate-to-gate ATM/CNS provision costs per composite flight-hour (€$_{2019}$)	396	↑	+0.1%
Gate-to-gate unit costs of ATFM delays (€$_{2019}$)	112	↓	-7.4%
Gate-to-gate economic costs per composite flight-hour (€$_{2019}$)	508	↓	-1.6%

5.1 Introduction

This chapter analyses ANS cost-efficiency performance in 2019 (i.e. the latest year for which actual financial data are available) and presents a performance outlook for 2020 based on available preliminary figures.

It provides a pan-European view, covering 39 States[12] operating 38 en-route charging zones[13] that are part of the Multilateral Agreement for Route Charges. This includes the 30 States which in 2019 were 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 2019 has already been scrutinised in accordance with the SES Regulations and the results have been reflected in the Performance Review Body (PRB) 2019 monitoring report[14]. 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 monitoring 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.

Section 5.2 presents a detailed analysis of en-route cost-efficiency performance at pan-European

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12 This is different from the 41 EUROCONTROL Member States in 2019 since: (1) Ukraine is a EUROCONTROL Member State which is not yet technically integrated into the Multilateral Agreement relating to Route Charges, and (2) Monaco en-route costs are included in the French cost-base.

13 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).

14 2019 Annual Monitoring Report is available online on EU SES Performance website

system level. Section 5.3 gives an evaluation of terminal ANS costs-efficiency within the SES area.

Section 5.4 provides an analysis of the impact of COVID-19 on the pan-European ANS. Since the actual cost figures for 2020 will not be available until the second-half of 2021, the analysis instead focusses on the trends in total en-route service units (TSU), the estimated losses of en-route revenues in 2020 and the measures implemented by the pan-European ANSPs in response to this crisis.

Finally, section 5.5 provides a factual benchmarking analysis of ANSPs' 2019 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 2019, the financial indicators presented in sections 5.2, 5.3, 5.4 and 5.5 are expressed in Euro 2019[15].

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 2019 (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) in 2019, plus Switzerland and Norway. These States operate under the "determined costs" method which includes specific risk-sharing arrangements, defined in the Charging Regulation [21] aiming at incentivising economic performance and driving cost-efficiency improvements.

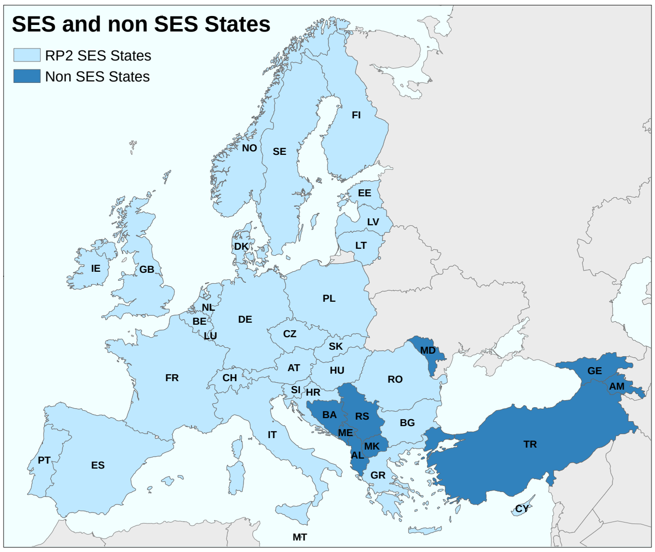

Figure 5-1: SES and non-SES States

The "non-SES States" refer to nine States which are not bound by the SES regulations but which were part of the EUROCONTROL Multilateral Route Charges System in 2019 (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 2019.

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 38 en-route charging zones that consistently provided en-route costs data over the 2014-2019 period[16].

Figure 5-2 shows that in 2019, at pan-European level, en-route ANS costs increased by +1.4%. This cost increase was compensated by +2.9% growth in TSUs, resulting in a reduction of en-route unit costs (- 1.4%) compared to 2018. This marks the seventh consecutive year of reducing en-route unit costs at system level (-23.9% overall compared to 2012).

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15 More information on the treatment and presentation of financial values for the purpose of this Report is available on p. 56 of PRR 2018 [25].

16 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 [23].

	2014	2015	2016	2017	2018	2019	2019 vs 2018	2014-19 CAGR
Total en-route ANS costs (M€2019)	**7 389**	**7 490**	**7 510**	**7 472**	**7 612**	**7 720**	**1.4%**	**0.9%**
SES States (EU-28+2)	6 940	7 017	6 998	6 935	7 022	7 099	1.1%	0.5%
Other 9 States in the Route Charges System	450	473	512	537	590	621	5.3%	6.7%
Total en-route service units (M TSUs)	**129**	**134**	**139**	**148**	**157**	**161**	**2.9%**	**4.6%**
SES States (EU-28+2)	112	115	120	127	134	138	2.8%	4.3%
Other 9 States in the Route Charges System	17	19	19	21	23	24	3.0%	6.8%
En-route ANS costs per TSU (€2019)	**57.4**	**56.0**	**54.0**	**50.6**	**48.5**	**47.8**	**-1.4%**	**-3.6%**
SES States (EU-28+2)	62.2	61.0	58.2	54.7	52.4	51.5	-1.7%	-3.7%
Other 9 States in the Route Charges System	26.3	25.2	26.9	25.6	25.7	26.2	2.3%	-0.1%

Figure 5-2: Real en-route ANS cost per TSU for EUROCONTROL Area (€$_{2019}$)

Between 2014 and 2019, en-route unit costs for pan-European system reduced by -3.6% per annum, on average. This is a result of an increasing en-route ANS costs (+0.9% p.a.), in the context of continuous robust TSU growth over the entire period (+4.6% p.a.).

These aggregated trends, however, mask the different performance dynamics observed for SES and non-SES States over the same period. The analysis provided below highlights these observed differences in en-route cost-efficiency performance.

Figure 5-3 and Figure 5-4 present an aggregated trends in TSUs, costs and en-route unit costs over this period for SES and non-SES.

Figure 5-3 shows that, for SES States, en-route unit costs decreased continuously between 2014 and 2019, at an average rate of -3.7% p.a. This cost-efficiency improvement was achieved by maintaining en-route costs mostly stable (+0.5% p.a.) in the context of significant TSU growth (+4.3% p.a.).

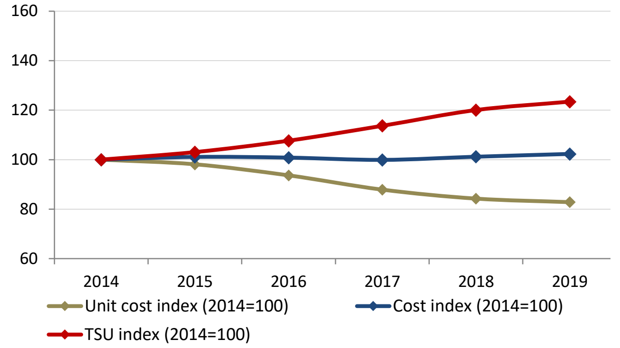


Figure 5-3: Trends in en-route costs, TSUs and unit costs for SES States

Detailed analysis shows that the growth in TSUs over this period was mainly driven by six States, which, taken together, account for more than half of the observed increase in volume. These include Spain Continental (+5.6% p.a.), Greece (+5.4% p.a.), United Kingdom (+4.8% p.a.), Italy (+3.9% p.a.), Germany (+3.4% p.a.) and France (+3.3% p.a.). It should also be noted, that most of these States have managed to absorb the increases in TSUs while also reducing their en-route ANS cost-bases. On the other hand, France recorded an increase in en-route ANS costs (+1.4% p.a.) over this period.

On the other hand, unit costs increased for five States, including Estonia (+5.2% p.a.), Belgium-Luxembourg (+1.3% p.a.), Malta (+1.0% p.a.), Sweden (+1.0% p.a.) and the Netherlands (+0.7% p.a.). For these charging zones the growth in TSUs over this period was not sufficient to compensate for the increases in en-route costs.

Figure 5-4 indicates that, for non-SES States, the en-route unit costs remained mostly stable (-0.1% p.a.) over the 2014-2019 period. This is the result of a substantial TSU growth over the period (+6.8% p.a.), while the en-route ANS costs also increased by +6.7% p.a.

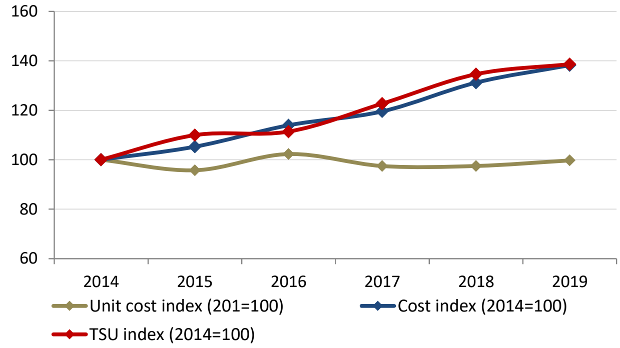


Figure 5-4: Trends in en-route costs, TSUs and unit costs for non-SES States

It should be recognised that these results are heavily influenced by trends for Turkey, which represents some 67% of total costs and 76% of TSUs recorded for non-SES States.

Over this period, the TSUs grew for all, but two of the non-SES States included in this analysis. This is the case for Georgia (-2.2% p.a.), while for Moldova (-7.9% p.a.) the decrease reflects ongoing slow recovery from the significant traffic downturn recorded between in 2013 and 2016 (-75.1% overall over this period).

Detailed changes in the en-route unit costs are analysed in the sub-section below.

5.2.2 Breakdown of en-route costs by type

As shown in Figure 5-5, en-route costs in 2019 can be broken down into the following main components:

- Staff costs: the largest category representing some 60% of the en-route cost-base;
- The second largest category, other operating costs account for 23% of the total;
- Capital-related costs which represent 17% of total en-route costs can be further broken down into depreciation (12%) and cost of capital (5%);
- Finally, exceptional costs recorded in 2019 are negative and represent less than 0.1% of total costs.

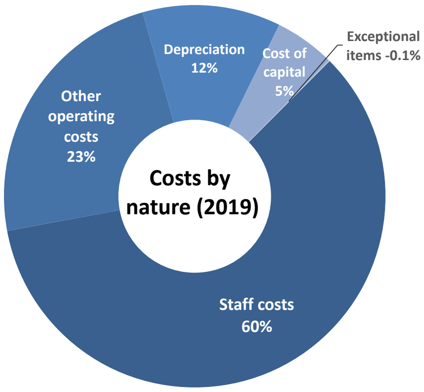


Figure 5-5: Breakdown of en-route costs by type

Figure 5-6 presents the breakdown of en-route ANS costs into main components as well as the changes in these cost categories over 2014-2019 period for SES and non-SES States.

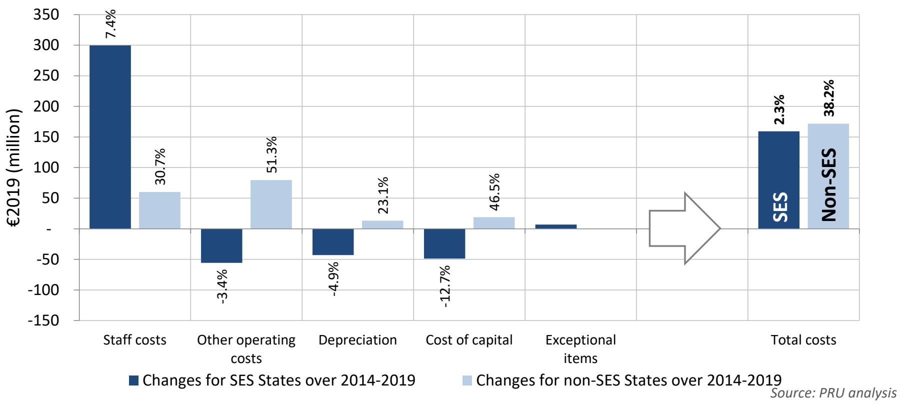


Figure 5-6: Changes in en-route cost categories over 2014-2019 for SES & non-SES States (€2019)

Figure 5-6 shows that, over this period, en-route costs for non-SES States grew by +38.2% (+€171.7M) reflecting increases across all cost categories: staff costs (+€60.1M), other operating costs (+€79.6M), depreciation costs (+€13.3M) and the cost of capital (+€19.0M).

For SES States, the increase in en-route ANS costs (+€159.2M) is driven almost entirely by a substantial growth in staff costs (+€299.7M), which was slightly compensated by reductions in other operating costs (-€55.7M), depreciation costs (-€43.0M) and cost of capital (-€48.7M).

When interpreting the results for SES States, it is important to recall that Germany reported negative components in its en-route cost-base between 2015 and 2019 (some -€50M annually), mostly reflecting a contribution of the German State in DFS equity. Additionally, it should be noted that as of 2017, part of the administrative and regulatory costs, including EUROCONTROL contribution to Part I of the budget (some €32M in 2019), are now financed by the Ministry of Transport and no longer included in the en-route cost-base for Germany. While these two elements allow to significantly reduce the unit rate charged to airspace users, they affect the trend analysis of Germany's cost-efficiency performance at pan-European system level. Should these two items be taken into account, the 2019 en-route costs for the SES States would be some +4.1% higher than in 2014 (instead of +2.3% as currently shown). Similarly, at pan-European system level, the en-route costs would be +6.1% higher instead of +4.5% as presented.

5.2.3 Actual en-route unit costs at charging zone level

The bottom part of Figure 5-7 presents the level of en-route unit costs[17] for each individual charging zone in 2019. En-route unit costs ranged from €83.0 for Switzerland to €23.0 for Malta, 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 CZs which are outside the Euro zone. Substantial changes of the national currency against the Euro may significantly affect the level of en-route unit costs when expressed in Euros[18].

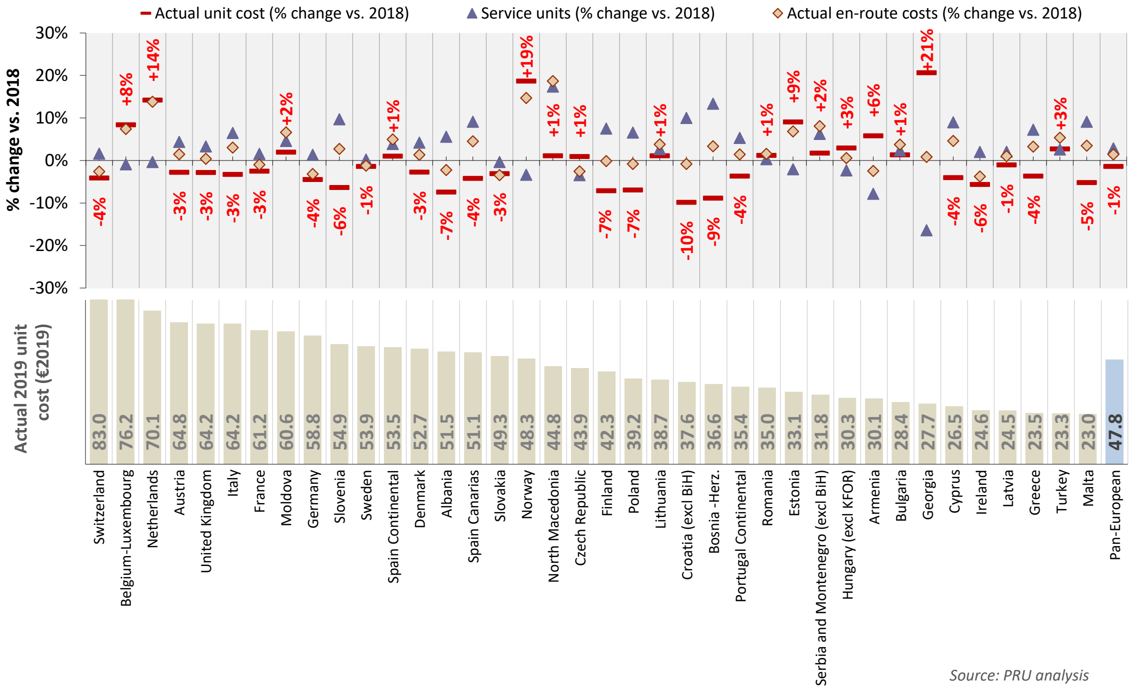


Figure 5-7: 2019 real en-route ANS costs per TSU by charging zone (€$_{2019}$)

Figure 5-7 also presents the changes in en-route unit costs, TSUs and costs compared to 2018 (upper part). It indicates that in 2019, en-route unit costs increased for 16 en-route CZs out of the 38 included in the analysis. For three charging zones, the unit costs rose by more than +10% in 2019, including Georgia (+20.6%), Norway (+18.7%) and the Netherlands (+14.2%). For most of these States, the increase in unit costs is mainly due to a significant increase in en-route costs:

- For Norway (+€15.1M), this is stemming from a significant increase in staff costs (+28.3%) which is understood to reflect i) an increase in employer contributions to staff pensions following changes in national legislation, and ii) an increase in severance payments resulting from implementation of cost-efficiency programs.
- For the Netherlands (+€28.7M), this is driven by increases across all cost categories: staff costs (+12.1%), other operating costs (+13.0%), depreciation (+35.9%) and the cost of capital (+29.7%). The observed increase in staff costs is understood to reflect the application of the collective agreements and agreed wage increases as well as increase in pension costs. At the same time, the increases in depreciation costs and the cost of capital are driven by growth in en-route asset-base resulting from application of IFRS 16 on reporting of leased assets as well as completion of several investment projects.

Differently from above, the significant increase in en-route unit costs for Georgia (+20.6%) primarily

[17] The actual unit costs reflected in Figure 5-7 refer to the ratio of actual en-route costs and TSUs recorded for 2019 and should not be confused with the chargeable unit rate.

[18] 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 €58.5 in 2019 (instead of €23.3), 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 2019 Report [24].

reflects a significant reduction in TSUs (-16.4%) while the costs remained mostly stable (+0.8%).

On the other hand, Figure 5-7 indicates that for eight CZs, en-route unit costs decreased by more than -5% in 2019, with substantial unit costs reductions observed for Croatia (-9.8%), Bosnia-Herzegovina (- 8.8%), Albania (-7.4%), Finland (-7.1%), Poland (-6.9%), Slovenia (-6.4%), Ireland (-5.6%) and Malta (- 5.2%). 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 Bosnia-Herzegovina, Malta and Slovenia, for which the growth in TSUs more than compensated the increases in en-route costs.

5.3 Terminal ANS cost-efficiency performance

The analysis of terminal ANS cost-efficiency in this section refers to the SES States (see Figure 5-8) which are required to provide terminal ANS costs and unit rates information in accordance with EU legislation [21] in 2019. As detailed in Section 5.1, the financial figures are expressed in Euro 2019 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.

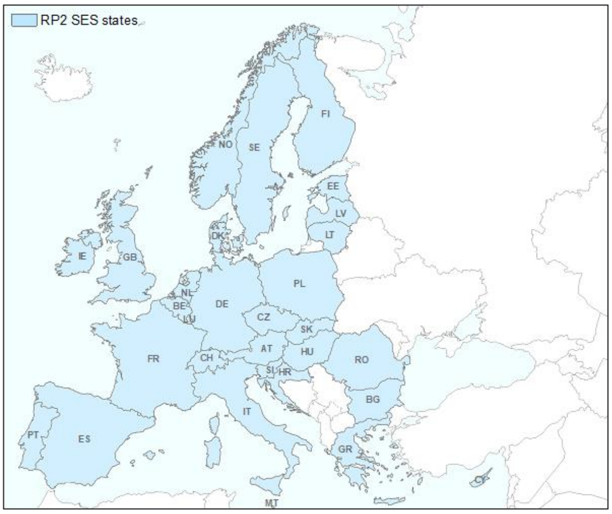


Figure 5-8: Geographical scope of terminal ANS cost-efficiency analysis

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

TNSUs are computed as a function of aircraft maximum take-off weight ($(MTOW/50)^{\alpha}$). Since 2015, in accordance with the Charging Scheme Regulation [22], all SES States use a common formula $(MTOW/50)^{0.7}$ to compute TNSUs. This allows for a better comparison of the level of unit terminal costs per TNSU reached 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 air navigation services.

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

Figure 5-9 below provides a summary of actual terminal ANS performance at European system level for the period 2015-2019. As explained in PRR 2016 [23], 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 at the start of the second reference period. As a result, the data recorded prior to 2015 for both terminal ANS costs and terminal navigation service units is not directly comparable at charging zone and European system level.

Figure 5-9 shows the changes in terminal ANS costs, TNSUs and unit costs between 2015 and 2019 at European system level.

	2015	2016	2017	2018	2019	2019 vs 2018	2015-19 CAGR
Total terminal ANS costs (M€2019)	1 251	1 265	1 259	1 275	1 303	2.1%	1.0%
Total terminal service units ('000 TNSUs)	6 319	6 622	6 891	7 215	7 382	2.3%	4.0%
Real terminal unit cost per TNSU (€2019)	**198.0**	**191.0**	**182.8**	**176.7**	**176.5**	**-0.2%**	**-2.8%**

Source: PRU analysis

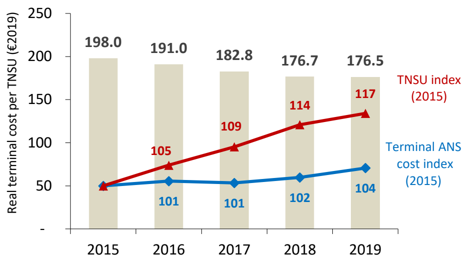


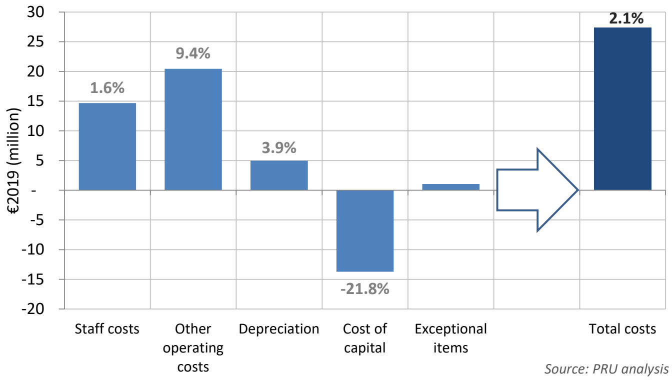
Figure 5-9: Real terminal ANS cost per TNSU at European System level ($€_{2019}$)

In 2019, terminal ANS costs increased (+2.1%) in the context of TNSU growth (+2.3%), as a result, the terminal costs per TNSU reduced slightly (-0.2%) compared to 2018. This is the fourth consecutive year of decreasing terminal unit costs at European level (-2.8% p.a. over the period covering 2015 to 2019).

As already detailed earlier in this chapter, these results are affected by the negative exceptional items reported by Germany in its terminal ANS cost-base for the years 2016-2019. Excluding the amounts arising from the German State intervention (some €57M for 2019), the actual terminal ANS costs in 2019 for European system would be +7.8% above those in 2015 (instead of +4.1% as currently shown).

Figure 5-10 below shows how the main components of terminal ANS costs changed between 2018 and 2019.

An increase in terminal ANS costs observed in 2019 (+2.1%, or +€27.4M) results mainly from increases in most of the cost categories: staff costs (+1.6%, or +€14.7M), other operating costs (+9.4%, or +€20.4M), depreciation (+3.9%, or +€5.0M) and exceptional item costs (+€1.0M). At the same time, the cost of capital reduced by -21.8%, or -€13.7M.



Source: PRU analysis

Figure 5-10: Breakdown of changes in terminal cost categories between 2018-2019 ($€_{2019}$)

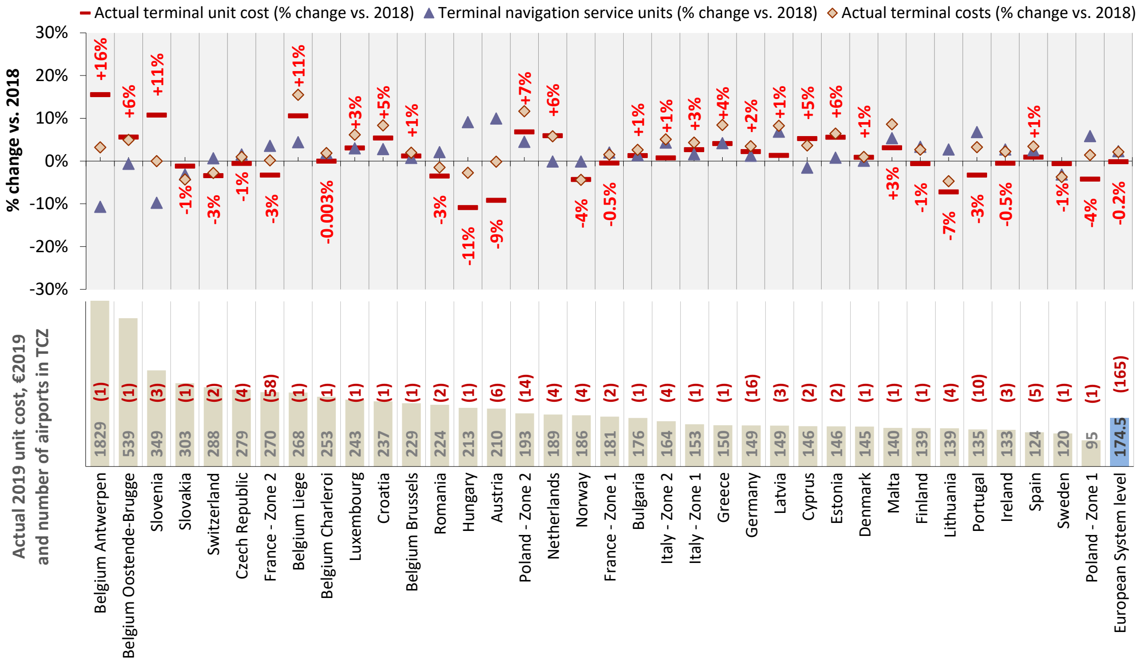
5.3.2 Terminal ANS 2019 cost-efficiency performance at terminal charging zone level

Figure 5-11 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 2018 and 2019, while the lower part provides information on the level of terminal ANS unit costs in 2019. For the sake of completeness, the bottom chart of Figure 5-11 also shows the number of airports included in each of the charging zone (see number in brackets).

Figure 5-11 indicates that in 2019, the average terminal ANS costs per TNSU amounted to €176.5 at system level. Figure 5-11 also shows that the terminal unit costs ranged from €1 829 for Belgium Antwerpen TCZ, to €95 for Poland TCZ 1, a factor of more than 18.

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 5-11 shows that the two Belgian TCZs (Belgium Antwerpen and Oostende-Brugge) with the highest unit terminal costs in 2019 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.



Source: PRU analysis

Figure 5-11: 2019 real terminal ANS costs per TNSU by charging zone (€2019)

The upper half of Figure 5-11 indicates that terminal unit costs reduced for 16 TCZs. Three of these TCZs managed to reduce unit costs by more than -5% in 2019: Hungary (-10.9%), Austria (-9.2%) and Lithuania (-7.2%). Detailed analysis indicates that the cost-efficiency improvements observed for these TCZs in 2019 reflect a reduction in terminal ANS costs in the context of TNSU growth.

On the other hand, Figure 5-11 also indicates that, in 2019, terminal unit costs increased for 20 TCZs, with unit costs growing by more than +10% for Belgium Antwerpen (+15.6%), Slovenia (+10.8%) and Belgium Liege (+10.6%). Detailed analysis shows that for most of these TCZs, the increases reflect substantial decreases in TNSUs in 2019, with the exception of Belgium Liege, since for this TCZ the increase in terminal unit costs reflects significant growth in terminal ANS costs.

5.4 Estimated impact of COVID-19 on pan-European ANS

The COVID-19 outbreak in 2020 has sparked an unprecedented crisis in Europe and elsewhere with its effects particularly felt in the entire aviation industry as already discussed in Chapter 1 of this report.

While the actual ANS cost figures for 2020 will not be available until the second-half of 2021, it is already possible to provide an overview of the impact COVID-19 crisis on the en-route TSUs and anticipated revenues from en-route charges in 2020. It also provides an estimate of the revenue losses to be borne by the ANSPs and the airspace users under the charging schemes[19] currently in place.

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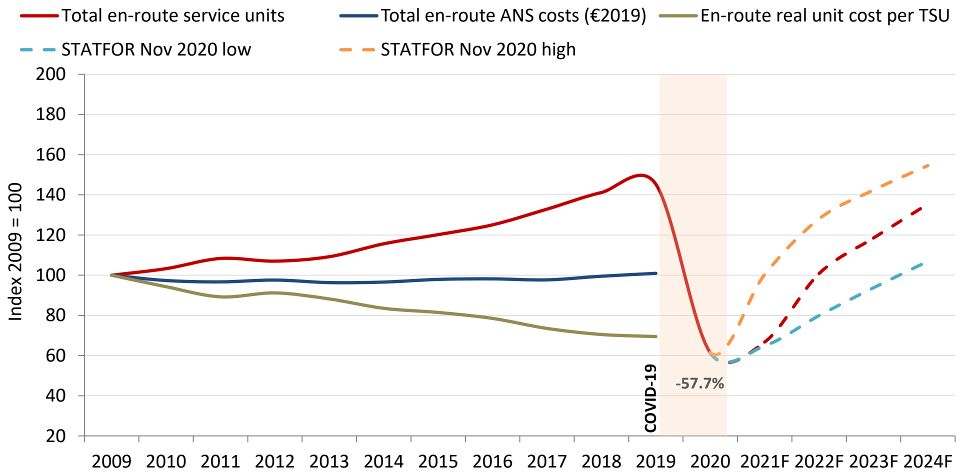
19 More information on the charging schemes can be found in the "Principles for Establishing the Cost-Base for En-Route Charges and the Calculation of the Unit Rates" and Commission Implementing Regulation (EU) 2019/317 of 11 February 2019 laying down a performance and charging scheme in the single European sky and repealing

It is important to recognise that the analysis presented in this section **does not refer to actual collection or disbursement of cash** and only provides indicative information on the estimated loss of en-route revenues. It should also be noted that this analysis only considers revenues from en-route charges for the 38 individual en-route charging zones included in this analysis. Revenues from terminal activity as well as from provision of other ANS and non-ANS services are not considered.

The extraordinary impact of the COVID-19 pandemic is shown in Figure 5-12 depicting the long-term trends in en-route costs, TSUs and unit costs between 2009 and 2019 for a consistent set of 37 en-route charging zones[20] as well as forecast TSU figures for 2020 to 2024 as provided by STATFOR [8]. It shows that over the 2009-2019 period TSUs grew by +3.8% annually, on average, while costs remained fairly constant (+0.1% p.a.). As a result, the en-route costs per TSU decreased by -3.6% annually throughout this period, with an overall reduction of -30.5%.



Source: PRU analysis

Figure 5-12: Long-term trends in en-route ANS cost-efficiency (€$_{2019}$)

The effect of a global financial crisis on the aviation industry in 2009 resulted in a -5.3% drop in TSUs, this impact, however, is not even comparable to the disastrous effects of the COVID-19 crisis in 2020, with the recorded actual TSUs amounting to less than half of those in 2019 (a reduction of -57.7%). According to the latest STATFOR forecast, recovery back to 2019 levels is not expected before 2024, even in the most optimistic scenario.

Figure 5-13 provides a more detailed view of the TSU evolution in 2020 by comparing 2019 actual figures with those planned[21] and recorded in 2020 on a monthly basis. Labels in the figure indicate the difference between 2019 and 2020 actual TSUs.

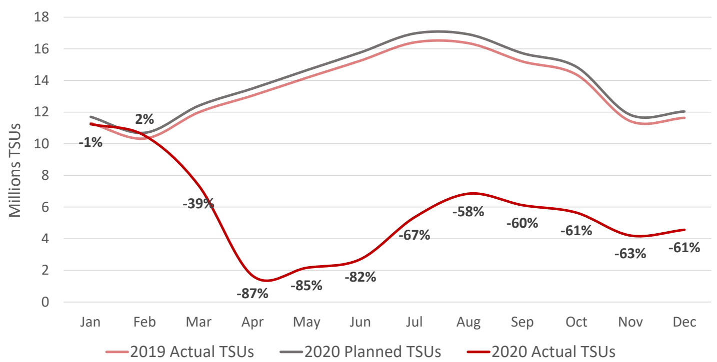


Figure 5-13: 2019/2020 actual and 2020 planned TSUs, monthly comparison

Although COVID-19 started impacting air traffic at the start of 2020, the most dramatic fall in traffic was seen in April, with the TSUs dropping by -87% (compared to previous year) as the national

Implementing Regulations (EU) No 390/2013 and (EU) No 391/2013 (Text with EEA relevance.) C/2019/785 OJ L 56, 25.2.2019, p. 1–67.

[20] Data for Georgian en-route charging zone is not available prior to 2014, therefore it is excluded from Figure 5-12.

[21] The 2020 'planned' TSUs used in this analysis are based on the data submitted by States in November 2019 en-route Reporting Tables for the determination of the national en-route unit rates for 2020. The monthly distribution of planned TSUs is in line with that of 2019 actual figures.

lockdowns and travel restrictions were implemented across Europe in response to the first wave of the pandemic.

Between April and June -a period characterised by the implementation of national lock-down measures in Europe- the traffic was mostly limited to cargo flights and the TSUs remained at around -85%. While the traffic slightly rebounded over the summer period with 67% less TSUs recorded in July and 58% in August compared to 2019.

This partial recovery diminished from September to December, with a 61% less TSUs overall over this period, as countries began re-introducing travel restrictions and measures in response to the second wave of COVID-19.

Overall, the actual TSUs at pan-European system level, actual TSUs in 2020 were -57.7% below the figures recorded in 2019.

This dramatic reduction in TSUs for 2020 directly affects the level of en-route revenues and therefore has a severe impact on the ANS service providers. Indeed, at system level, ANSPs represented some 90% of the en-route cost-bases in 2019.

5.4.1 Impact of COVID-19 on estimated en-route revenues in 2020

Figure 5-14 shows the estimated losses in en-route revenues at pan-European system and for the 38 en-route charging zones by comparing planned to the projected actual revenues[22].

The resulting estimated shortfall or "loss" in en-route revenues amounts to €4 827M at system-level in 2020. According to the charging regime currently in place, the majority of these estimated losses will result in under-recoveries to be charged to the airspace users in the coming years. Due to the traffic risk-sharing mechanism (see grey box), the ANSPs operating in the States operating in the SES States[23] are estimated to retain a loss of some €308M, while the remaining amount of €4 519M will be carried over to future years.

Figure 5-14 shows that the revenue losses for individual charging zones ranged from €822.9M for the French charging zone to some €3.8M for Moldovan charging zone.

It also shows that the revenue losses for the five largest charging zones accounted for some 55% of the overall losses at system level (€2 648M out of €4 827M). Since these CZs are all subject to SES Regulations, the ANSPs operating in these zones are estimated to bear a loss of €183M.

While, as foreseen in the ANS cost recovery systems, the majority of these losses are expected to be recovered in the coming years,

Differences in ANS charging schemes

States not subject to SES Regulations apply a method of full cost recovery. In this mechanism, the full amount of gains (over-recovery)/losses (under-recovery) with respect to the planned costs and traffic, are borne by airspace users through an adjustment of future unit rates (typically N+2, but can be spread over longer period). Under this arrangement, the risk resulting from variations in traffic and costs is entirely borne by the airspace users.

States subject to SES Regulations operate under the "determined costs" method, which includes specific risk-sharing arrangements. In particular, the traffic risk-sharing mechanism (applicable only to ANSP costs, while MET, NSA and other State costs are not subject to traffic-risk sharing), through which the risks of revenue changes due to deviations between planned and actual TSUs in the year are shared between air navigation service providers and the airspace users based on a specific formula. Under this arrangement, the losses/gains attributable to the airspace users are carried over and reimbursed/charged in the future years (typically N+2, but can be spread over a longer period subject to certain conditions). As explained in footnote 23, the traffic-risk sharing and carry-over arrangements described here are subject to change following the application of the exceptional RP3 measures proposed by the European Commission and the adoption of RP3 performance plans.

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[22] The planned revenues are calculated on the basis of planned TSUs submitted by the States in November 2019 (see also footnote 20 for details), multiplied by the chargeable en-route unit rate for 2020. Hence the revenue losses depicted here reflect the difference between these planned and estimated actual en-route revenue figures.

[23] The estimated losses for SES ANSPs were calculated using the traffic risk sharing arrangements defined in Regulation 2019/317 (see footnote 19). These figures are therefore subject to change following the application of the exceptional RP3 measures proposed by the European Commission and the adoption of RP3 performance plans.

the timing of these revenues (i.e. when they are recovered from airspace users) may result in significant challenges for ANSPs in the short term, especially in terms of their ability to meet various payment obligations (for staff, suppliers, etc.).

The magnitude of the revenue shortfall in 2020 (€4.8 Billion) and the risk this might present to ANSPs' resilience can be put into perspective by comparing it with ANSPs' cash reserves (i.e. cash in hand or at bank) reported at the end of 2019.

At pan-European System level, cash and reserves at the end of 2019 stood at an estimated €2.9 Billion[24], which suggests that in the short and medium-terms, ANSPs might face significant liquidity issues (shortage of cash to finance operations). This will be particularly the case if airlines are not in a position to pay for ANS charges (i.e. bankruptcies, payment default).

In the view of these short and medium term financial pressures, several ANSPs already undertook a range of measures to mitigate the impact of the traffic reduction on their activity but also to address potential cash shortages. A high-level presentation of some of these measures is provided in the sub-section below.

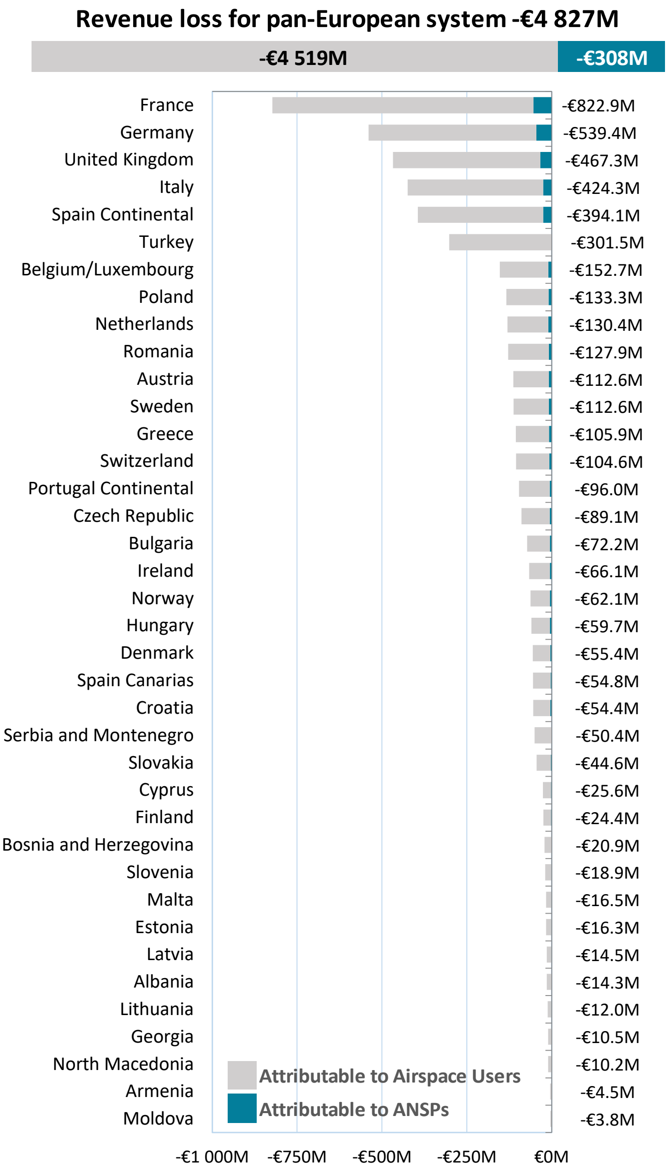

Figure 5-14: Estimated loss of 2020 en-route revenues

5.4.2 Measures implemented by ANSPs in order to mitigate the impact of the COVID-19 pandemic

It is important to note that the figures in this sub-section is based on information provided by ANSPs as part of the data collection process for the ACE 2019 benchmarking report.

Based on the information collected, the range of implemented measures can be broadly grouped into three categories:

- Aid from national governments;
- Loans; and
- Cost-containment measures.

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[24] This figure reflects the cash and cash equivalents held by ANSPs at the end of 2019 based on the information reported in ACE data submissions. Although the €4.8 Billion losses in revenue presented in Figure 5-14 refer only to en-route ANS, the comparison of these two figures nevertheless provides a good indication of the liquidity issue that might be faced by ANSPs in the short and medium terms.

The aid from national governments in the form of State subsidies and loans are predominantly aimed at safeguarding ANSPs' liquidity and ongoing operations. Some subsidies or State-backed loans may come with certain conditions attached that require longer-term restructuring or cost-containment measures to be implemented, which is, for example, the case for skyguide. By comparison, cost containment measures involve a broad range of changes (from tactical adjustments to more structural measures) at ANSPs which should also contribute towards slightly reducing the impact of the crisis on airspace users in future years.

It should also be noted that some supranational financing initiatives have also been made available. For instance, in order to alleviate the cash shortage in the ANS industry, EUROCONTROL contracted a loan of €272M on behalf of the Members States participating to the EUROCONTROL Route Charges System. Ten States have opted in to the facility, with the loans scheduled to be repaid by end March 2022.

Figure 5-15 shows that 27 ANSPs contracted loans and twelve received aid from national governments. Amongst those having contracted loans, eight made use of the loan facility negotiated by EUROCONTROL detailed above either as a main financing vehicle or as a complement to other loans.

Figure 5-15 also shows that all 38 ANSPs have reported the implementation of cost containment measures targeting, in almost all cases, a combination of operating and capital-related costs.

<table>
<tr><th rowspan="2">Aid from national government</th><th rowspan="2">Loans</th><th colspan="3">Cost-containment measures</th></tr>
<tr><th>Staff</th><th>Non-staff</th><th>Capital expenditure</th></tr>
<tr><td colspan="5">ANS CR, ANS Finland, Austro Control, DFS[b], LGS[a,b], LPS[b], NATS[a], NAVIAIR, skeyes[a], Slovenia Control</td></tr>
<tr><td colspan="2"></td><td colspan="3">Albcontrol, ARMATS, Avinor, BULATSA, Croatia Control, DCAC Cyprus, DSNA, EANS, ENAIRE, HungaroControl, IAA, LFV, LVNL, M-NAV, MUAC, NAV Portugal, PANSA, ROMATSA, Skyguide, SMATSA, UkSATSE</td></tr>
<tr><td>Skyguide [b]
Avinor[b]</td><td>Albcontrol[a], ARMATS, Croatia Control, DHMI[a], DSNA, EANS[a], HungaroControl, IAA, LVNL[c], MATS[a], NAV Portugal, Oro Navigacija[a], PANSA, ROMATSA, Sakaeronavigatsia, SMATSA, UkSATSE</td><td>ENAV
HCAA
MATS
MOLDATSA</td><td>DHMI
ENAV
MOLDATSA</td><td>DHMI
HCAA
MATS
Sakaeronavigatsia</td></tr>
</table>

(a) EUROCONTROL Loan. (b) Increase in equity. In the case of Avinor from the parent company, which is a State-owned enterprise.
(c) LVNL operates in a specific environment where the balance in its current accounts is ensured by Treasury banking.

Figure 5-15: Mitigation measures implemented by pan-European ANSPs in 2020 or planned in 2021

The cost-containment measures applied cover reductions in staff through temporary layoffs, the suspension of bonuses and overtime, reduced working hours, postponement of promotions and associated salary increases, freezing of recruitment and non-essential training activities. Non-staff measures reported include completing only essential maintenance, and reduced travel, external (e.g. consultancy) support and utilities costs. Some ANSPs also cancelled or deferred non-essential investments.

While it remains to be seen how ANSPs will be able to adjust their costs in view of the many uncertainties, the PRC will continue monitoring these efforts in the future PRR reports.

More details on the measures implemented by the pan-European ANSPs in response to COVID-19 crisis are available in the PRC Performance Insight #2 on the economic impact of COVID-19 on the ANS system [1] and the ACE 2019 Benchmarking Report [24].

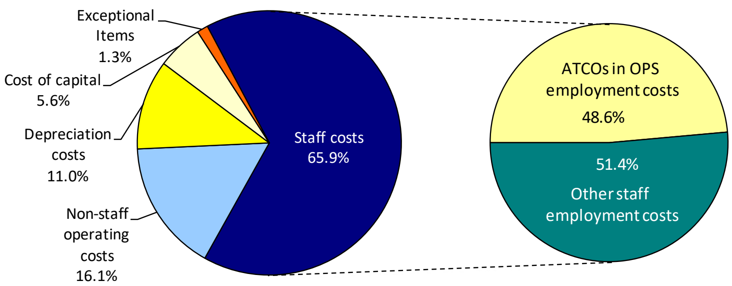
5.5 ANSPs gate-to-gate economic performance

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 2019 part of the SES, and hence subject to relevant SES regulations and obligations. Detailed analysis is given in the ACE 2019 Benchmarking Report [24].

The ACE 2019 data analysis presents information on performance indicators relating to the benchmarking of cost-effectiveness and productivity performance for the year 2019, and shows how these indicators changed over time (2014-2019). 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 (2019) is the latest year for which actual financial data are currently available[25].

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.



Total ATM/CNS provision costs: € 8 711 M

	En-route		Terminal		Gate-to-gate	
	€ M	%	€ M	%	€ M	%
Staff costs	4 439	65.2%	1 302	68.3%	5 740	65.9%
ATCOs in OPS employment costs	2 143	n/appl	646	n/appl	2 789	n/appl
Other staff employment costs	2 296	n/appl	656	n/appl	2 952	n/appl
Non-staff operating costs	1 089	16.0%	318	16.7%	1 407	16.1%
Depreciation costs	789	11.6%	167	8.8%	956	11.0%
Cost of capital	395	5.8%	95	5.0%	490	5.6%
Exceptional Items	92	1.3%	26	1.3%	117	1.3%
Total ATM/CNS provision costs	6 804	100.0%	1 907	100.0%	8 711	100.0%

Figure 5-16: Breakdown of gate-to-gate ATM/CNS provision costs 2019 ($€_{2019}$)

Figure 5-16 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 5-16 indicates that in 2019, at pan-European system level, gate-to-gate ATM/CNS provision

[25] As indicated in Section 5.1, the indicators analysed in this section are presented in Euro 2019. 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 6 of the ACE 2019 Benchmarking Report [24].

costs amount to some €8.7 Billion. Operating costs (including staff costs, non-staff operating costs and exceptional cost items) account for some 83% of total ATM/CNS provision costs, and capital-related costs (cost of capital and depreciation) amount to some 17%.

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

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

The quality of service provided by ANSPs has an impact on the efficiency of aircraft operations, which carry with them additional costs that need to be taken into consideration for a full economic assessment of ANSP performance. The quality of service associated with ATM/CNS provision by ANSPs is, for the time being, assessed only in terms of ATFM delays[26], 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 2019 Benchmarking Report [24].

5.5.1 Economic cost-effectiveness performance (2014-2019)

Figure 5-17 shows the comparison of ANSPs gate-to-gate economic cost per composite flight-hour ("unit economic costs" thereafter) in 2019. The economic cost-effectiveness indicator at pan-European level amounts to €508 per composite flight-hour in 2019, and, on average, cost of ATFM delays represent 22% of the total economic costs.

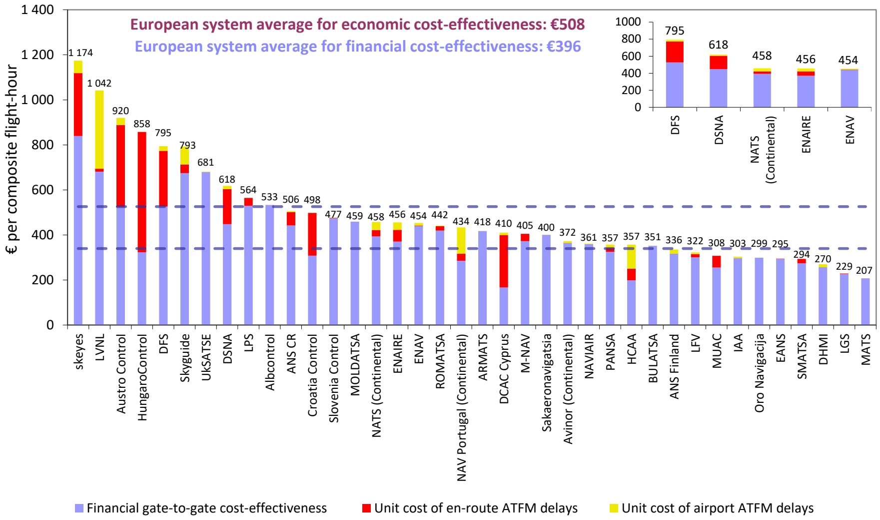


Figure 5-17: Economic gate-to-gate cost-effectiveness indicator, 2019

Figure 5-17 indicates that in 2019 unit economic costs ranged from €1 174 for skeyes to €207 for MATS, a factor of more than four. Figure 5-17 also indicates that DFS had the highest unit economic costs amongst the five largest ANSPs.

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26 ATFM delays used in this analysis are calculated after post-ops and eNM adjustments, which entail a re-allocation of ATFM delays across ACCs in order to account for the initiatives taken to improve performance at network level. Further details on these adjustments can be found in Annex II of the ACE 2019 Benchmarking Report [24].

Figure 5-18 displays the trend at pan-European level of the unit economic costs between 2014 and 2019. The upper part of the Figure 5-18 shows the changes in unit economic costs, while the lower part provides complementary information on the year-on-year changes in ATM/CNS provision costs, composite flight-hours and unit costs of ATFM delays.

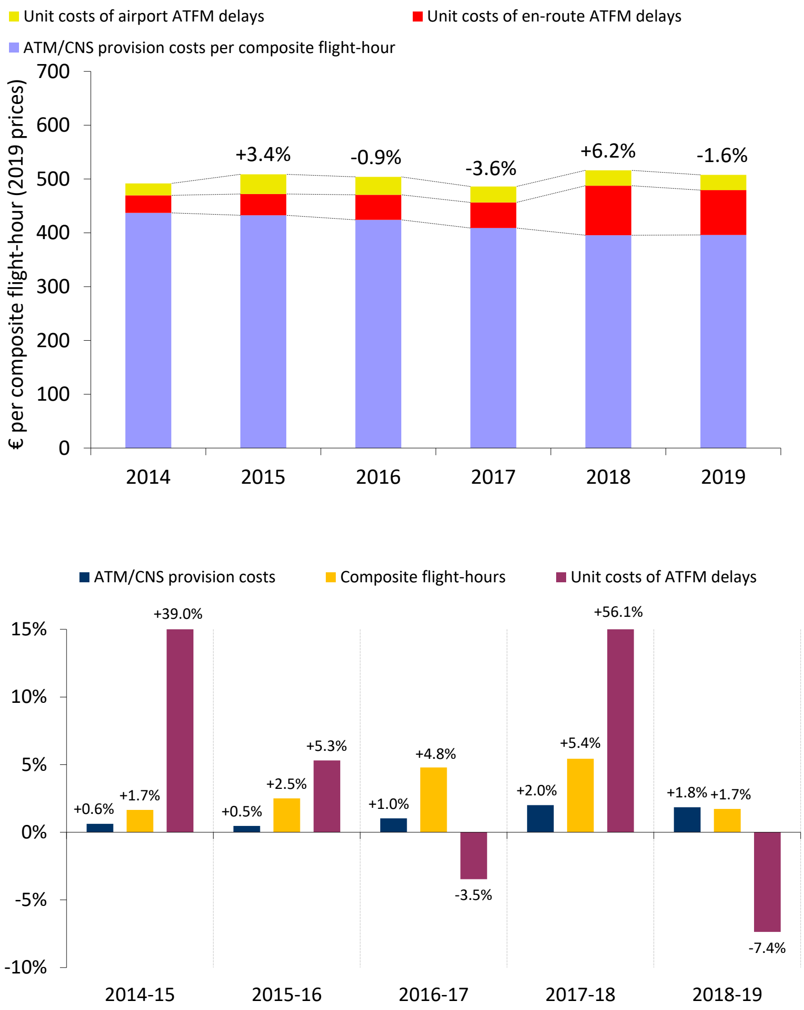

Figure 5-18: Changes in economic cost-effectiveness, 2014-2019 (€$_{2019}$)

Between 2014 and 2019, economic costs per composite flight-hour increased by +0.6% p.a. in real terms. Over this period, ATM/CNS provision costs grew by +1.2% p.a. while the number of composite flight-hours also increased (+3.2% p.a.). At the same time, the unit costs of ATFM delays increased by +20.7% p.a., on average, over the period, primarily due to the significant increases recorded in 2015 (+39.0%) and 2018 (+56.1%).

In 2019, ATM/CNS provision costs rose slightly faster (+1.8%) than composite flight-hours (+1.7%). As a result, unit ATM/CNS provision costs grew by +0.1% in 2019. In the meantime, the unit costs of ATFM delays decreased by -7.4% and therefore unit economic costs reduced by -1.6% compared to 2018.

Figure 5-19 shows how the unit ATM/CNS provision costs (see blue part of the bar in Figure 5-19) 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 5-19 also shows how these various components contributed to the overall change in cost-effectiveness between 2018 and 2019.

Figure 5-19 indicates that in 2019, ATCO employment costs per ATCO-hour rose at a slightly faster rate (+1.3%) than ATCO-hour productivity (+1.1%). As a result, ATCO employment costs per composite flight-hour slightly increased (+0.2%). In the meantime, unit support costs remained fairly stable (+0.1%) since the support costs grew at a slightly higher rate (+1.8%) than the number of composite flight-hours (+1.7%). As a result, in 2019 unit ATM/CNS provision costs grew by +0.1% at pan-European system level.

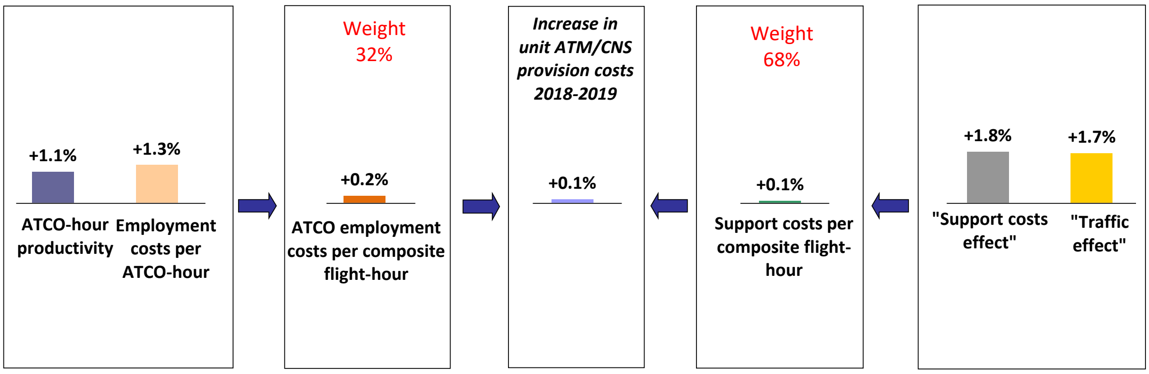

Figure 5-19: Breakdown of changes in cost-effectiveness, 2018-2019 (€$_{2019}$)

More details on the changes in unit ATM/CNS provision costs at ANSP and pan-European system levels are available in the ACE 2019 Benchmarking Report [24].

In addition, time-series of ANSPs cost-effectiveness performance data for the period 2002-2019 are available online in the ATM cost-effectiveness dashboard.

5.6 Conclusions

PRR 2020 analyses performance in 2020 in all key performance areas, except for cost-efficiency, which focuses on performance in 2019 as it is the latest year for which actual financial data are available. PRR 2020 also presents an outlook on TSU evolution and estimated en-route revenue losses in 2020.

In 2019, the **en-route ANS cost-efficiency performance** of the pan-European system improved for the seventh consecutive year, since real en-route unit cost per service unit (TSU) reduced by -1.4% to reach an amount of €47.8. This performance improvement is driven by a robust growth in TSUs (+2.9%), which more than compensated the increase in en-route ANS costs (+1.4%).

Over the six year period covering 2014-2019, en-route unit costs reduced continuously at an average rate of -3.6% annually, reflecting cost-efficiency performance improvements achieved by SES States (- 3.7% p.a.). The decrease in unit costs observed for SES States over this period was achieved by maintaining ANS costs mostly stable (+0.5% p.a.) in the context of robust TSU growth (+4.3% p.a.). This is different for non-SES States, for the TSUs (+6.8% p.a.) and en-route ANS costs (+6.7% p.a.) grew at a similar rate.

Real **terminal ANS costs** per terminal navigation service unit (TNSU) decreased by -0.2% compared to 2018 and amounted to €176.5. The drivers for this improvement are similar to those observed for en-route ANS, since TNSUs increased at a slightly higher rate (+2.3%) than terminal ANS costs (+2.1%).

Detailed benchmarking analysis focusing on ANSPs cost-efficiency shows that in 2019 the **gate-to-gate unit costs** of the pan-European system increased slightly (+0.1%) since the ATM/CNS provision costs increased at a slightly faster pace (+1.8%) than traffic (+1.7% in terms of composite flight-hours). In the meantime, the unit costs of en-route and airport ATFM delays generated by the ANSPs decreased (- 7.4%). As a result, the unit economic cost-effectiveness indicator for pan-European system reduced by -1.6% in 2019.

Preliminary figures show that in 2020, as a result of the **COVID-19 pandemic**, the en-route TSUs decreased by -57.7% compared to 2019. It is estimated that, as a result of this collapse in traffic, the shortfall or “loss” of en-route revenues at pan-European system level amount to some €4 827M. While majority of these estimated revenue losses are expected to be recovered from the airspace users in the coming years in line with the ANS cost recovery methods currently in place, some €308M will be borne by the ANSPs operating in the SES States as a result of the application of the traffic risk sharing mechanism (based on the application of EC Regulation 2019/317 [19]). However, the timing of the recovery of these losses from airspace users may result in significant challenges for the ANSPs in the short term, in particular in terms of their ability to meet various payment obligations. Depending on the situation of individual ANSPs, these potential cash shortages could become a significant issue which should be monitored in the coming years.

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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".

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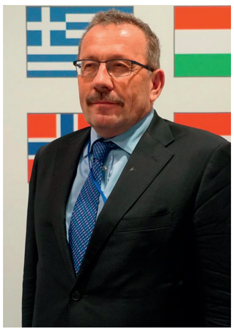
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