EUROCONTROL

PRR 2024

Performance Review Report

An Assessment of Air Traffic Management in Europe

Performance Review Commission

March 2025

† This report is respectfully dedicated to the memory of Michael STEINFURTH, PRC Member, who passed away in January 2025.

Michael joined the PRC as Safety and Civil-Military focal point in 2023, building on his successful military career and his extensive experience as former EUROCONTROL Head of Civil Military Cooperation (CMC).

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

Notice

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The PRC has made every effort to ensure that the information and analysis contained in this document are as accurate and complete as possible. Despite these precautions, should you find any errors or inconsistencies we would be grateful if you could please bring them to the PRU's attention.

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

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

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FOREWORD

Dr Peter Whysall

Chairman

Performance Review Commission

As air traffic rebounds post-pandemic and is expected to continue growing, the performance of European Air Traffic Management (ATM) is a cause for concern and likely to get worse unless structural issues are addressed.

In 2024, ATM-related delays reached their worst level for decades (2.13 minutes per flight) and may get even worse in 2025. Delay costs borne by airspace users, approximately €2.8 billion, by far exceeded savings from pressure on unit costs.

Since 2014, the aggregated capacity plans agreed with Air Navigation Service Providers have not met the required level of service — either for the year of publication or for future years which calls for immediate action.

The PRC welcomes the forthcoming introduction of a new ATFM delay code to enhance transparency when additional ATC capacity could have been provided if more air traffic controllers had been available at the time of regulation. However, no progress has been made on a similar initiative to improve transparency regarding delays caused by adverse weather conditions.

Moreover, ATM environmental efficiency barely improved, being negatively impacted by airspace fragmentation and local congestion.

Growing Radio frequency interference also poses a threat to air traffic safety.

These issues must all be addressed.

The good news is that high delays arise from local capacity shortfalls. The marginal cost of allocating the right capacity where and when needed would by far be compensated by savings in delays, fuel burn and environmental costs. A total economic cost approach to decision making could help to prioritise the delivery of this capacity where needed through appropriate investment in people and technology.

In the longer term, without fundamental change, European ATM will struggle to handle the projected 50% increase in flights by 2050 while further improving cost, operational efficiency and environmental performance. What is required is a shift from the current local service centric model to a network-centric, trajectory-based approach.

To drive this transformation, which is supported by the PRC, innovative projects aligned with the ATM Masterplan priorities must be accelerated with sufficient funding and regulatory support. Without decisive action, Europe risks falling behind, compromising efficiency and sustainability.

While digitalisation and automation offer significant potential on this journey, the human element, growing cybersecurity risks and challenges from Global Navigation Satellite System radio frequency interference must also be addressed.

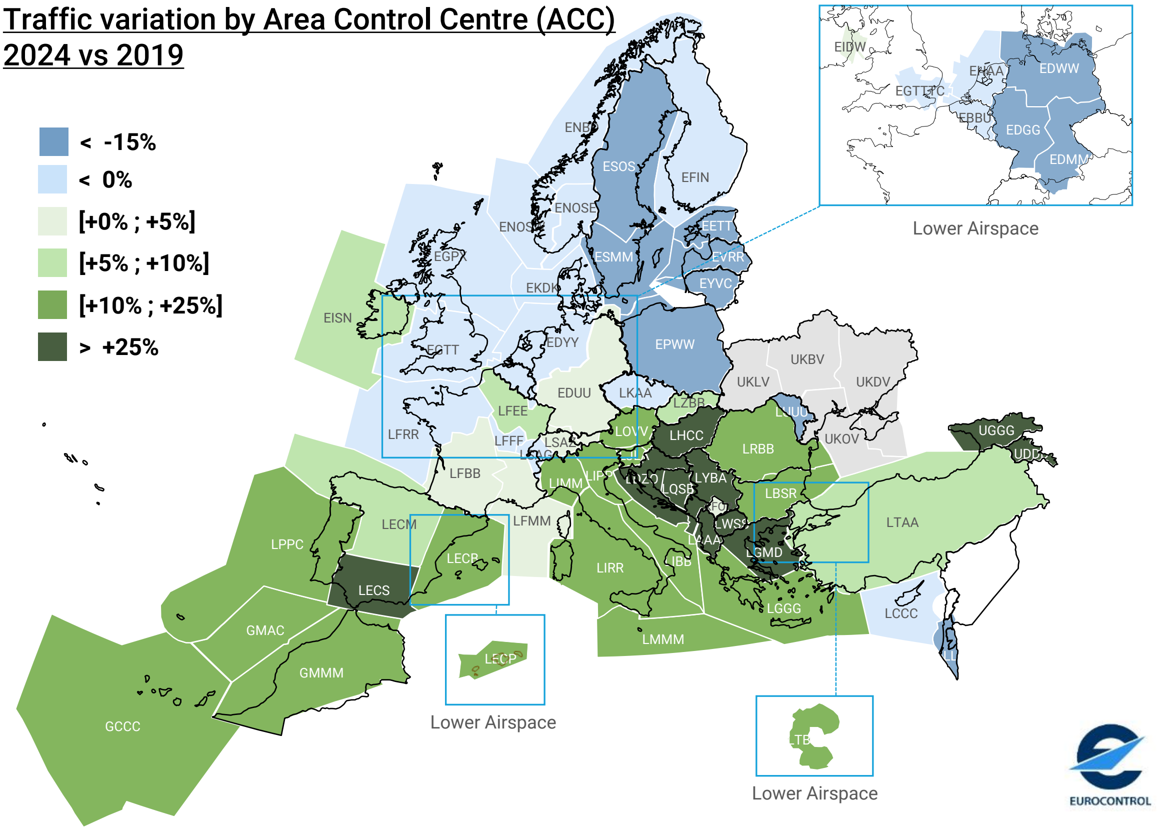
This Performance Review Report explores the current performance of European ATM, key challenges, and the potential path to a more integrated and resilient airspace in Europe.

More information on the PRC's work can be found on the Aviation Intelligence Portal @ http://ansperformance.eu.

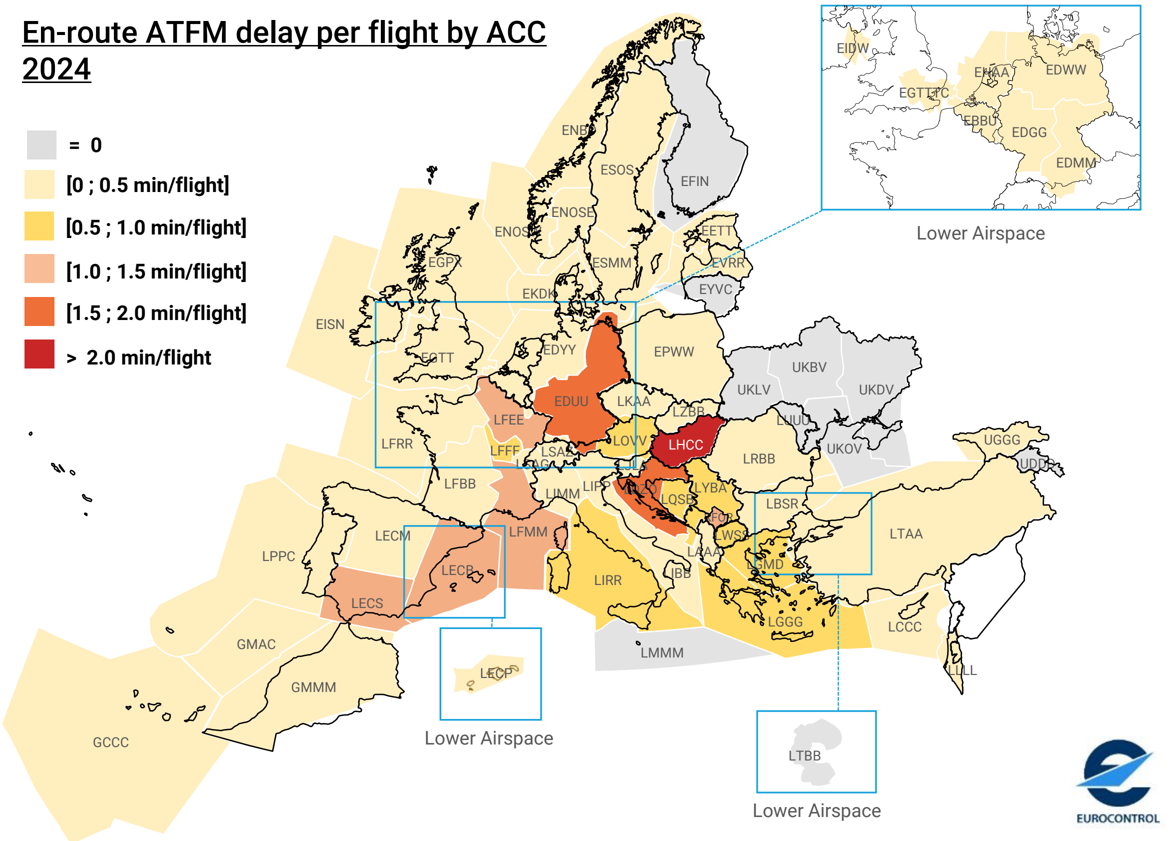
Should you wish to comment on any aspect of the PRC's work, or to make proposals for items you would like to be addressed by the PRC, please contact us @ pru-support@eurocontrol.int.

TRAFFIC AND EN-ROUTE ATFM DELAY OVERVIEW IN THE EUROCONTROL AREA

Traffic variation by Area Control Centre (ACC) 2024 vs 2019



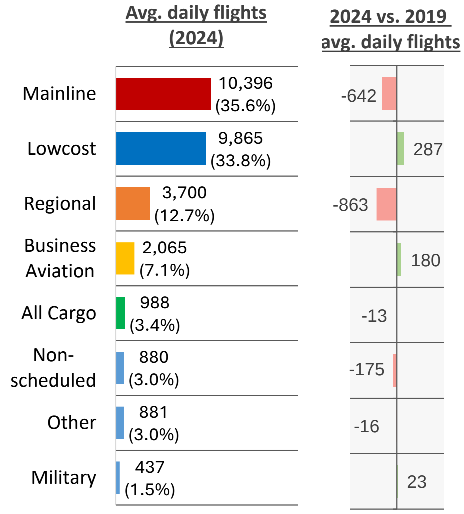
En-route ATFM delay per flight by ACC 2024



EXECUTIVE SUMMARY

TRAFFIC

- In 2024, **traffic in European airspace (ECAC area) increased by 4.5% on 2023 but remained 4.3% below pre-COVID levels**. Peak traffic day in 2024 was 14.06.2024 (35,171 flights) which was 4.6% below all-time peak (28.06.2019).
- The war in Ukraine and the conflict in the Middle East have led to a **reduction in available airspace** and **notable changes in traffic flows**, with **traffic levels in some regions exceeding 2019 levels**. A large part of the observed changes is driven by shifts in overflight patterns and increased travel to popular holiday destinations.
- Parts of Central, Southeast, and Southwest Europe significantly exceed 2019 traffic levels; the core area shows similar levels as in 2019 and Northern Europe shows considerably lower traffic.
- In 2024, **mainline and low-cost carriers (LCC) dominated network traffic**, followed by regional services and business aviation.
- Traditional mainline carriers - and regional services especially - continued to lag behind in their recovery to pre-pandemic levels.
- Both LCC and business aviation operated in 2024 more average daily flights than in 2019.
- **The growth of LCCs over the past years has reshaped traffic distribution among airports**. While mainline carriers focus on major hubs with regional services supporting their networks, LCCs operate point-to-point routes, driving up growth at smaller regional airports.

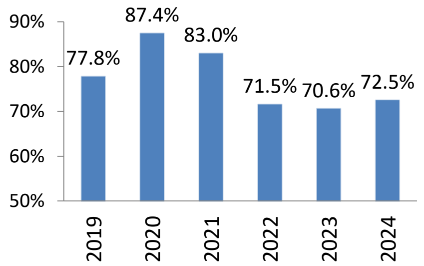


- **Two-thirds of the network's aircraft are now narrow-body**, with a growing share of fuel-efficient next-generation models and fewer regional and turboprop aircraft. **This shift in the aircraft mix increases the use of Europe's upper airspace**.
- According to the latest STATFOR forecast, **traffic is expected to grow to 12.2 million flights by 2031**, at an annual average growth rate of 2.0% (baseline).
- In the longer term, air traffic in Europe is expected to **increase to 15.4 million flights in 2050** in the most likely scenario, representing an increase of 52% vs. 2023 or an additional 5.3 million flights.

PUNCTUALITY

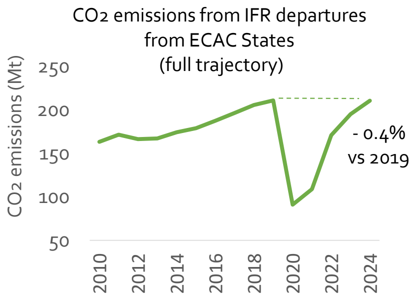
- Despite some progress in 2024, **punctuality in the EUROCONTROL area remained close to its lowest level in two decades**.
- On average, **only 72.5% of flights arrived within 15 minutes of their scheduled time** in 2024 (70.6% in 2023).
- **Average all cause departure delays also remained high in 2024** (18.0 minutes per flight in 2023, 17.7 minutes in 2024). Growing ATM delays were compensated by lower delays in most other categories.

Arrival punctuality in the EUROCONTROL area



Source: Network Manager

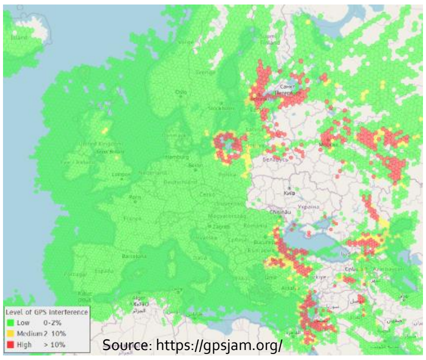
ENVIRONMENT



- After a temporary break during the pandemic, **total CO2 emissions from European aviation nearly reached the level of 2019** (-0.4% vs 2019), although there were some 5% fewer flights. **Emissions from longer and heavier flights outpaced savings from fewer and more fuel-efficient aircraft**.
- **Meeting the ambitious environmental targets set for 2050 will be an immense challenge**, requiring a substantial acceleration of current efforts, especially with air transport expected to continue to grow.
- **The decarbonisation of long-haul flights will remain one of the key challenges for aviation** as they have and will continue to have a disproportionate impact on CO_2 emissions.
- Regional services and business aviation accounted for 12.7% and 4.2% of flights in 2024 but contributed only 3% and 0.8% of total CO_2 emissions, respectively.
- Sustainable aviation fuel (SAF) can drive the path to net zero, but competition from other sectors for production capacity and renewable energy poses challenges. With SAF production lagging, significant investment, energy, and infrastructure are needed. **Accelerated efforts, funding, and incentives are crucial to scale up SAF production for timely, large-scale adoption**.
- Ultimately, achieving net-zero emissions in aviation will require significant time, resources, and financing, with a mix of technological, operational, and economic solutions. **While most initiatives will require time and take only real effect beyond 2030, improved ATM performance can already help now by addressing operational inefficiencies in the ATM system.**
- The PRC has developed a methodology to track CO2 emissions from a gate-to-gate perspective and to identify ATM-related environmental inefficiencies. **Based on a high-level estimate, the ATM-related benefit pool for flights within the EUROCONTROL area remains around 9% in 2024**. It is however important to stress that those inefficiencies cannot be reduced to zero.
- Given the uncertainties surrounding the climate impact of non-CO_2 emissions and the experimental nature of contrail avoidance technologies, future measures must strike a careful balance. **Further research is essential to deepen our understanding of non-CO_2 emissions**, the dynamics of contrail formation, and their interplay with CO_2-related climate effects.

SAFETY

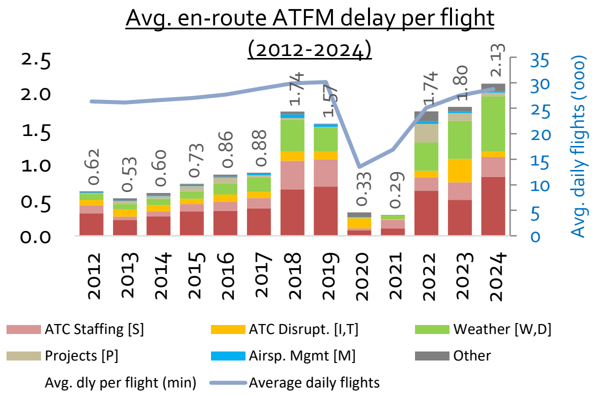
- **Overall safety levels in the EUROCONTROL area remain high,** with no accidents involving aircraft over 2,250 kg Maximum Take-off Weight that had a direct or indirect ATM contribution, reported between 2020 and 2023.
- The number of safety incidents increased in 2023, which is the latest year for which reported safety occurrences from the European Central Repository (ECR) is available.
- Complementary to incident reports from States, the PRC has begun **analysing safety performance by detecting operational risks directly from trajectory data**. Additionally, Traffic Alert and Collision Avoidance System (TCAS) Resolution Advisory (RA) events are being evaluated to get a more comprehensive perspective on potential operational safety risks.



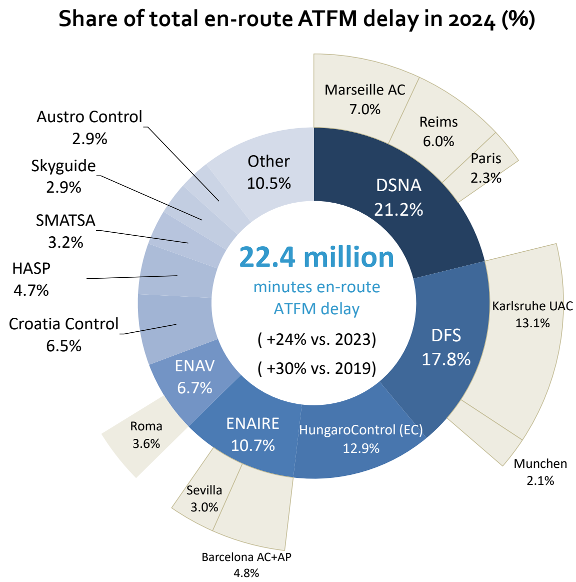
- Safety risks associated with GNSS (Global Navigation Satellite System) radio frequency interference and COMLOSS (Communication Loss) are critical issues in aviation that can compromise navigational accuracy, communication reliability, and ultimately flight safety.
- **Over the past years, a massive rise in GNSS Radio Frequency Interference (RFI) has been reported** with up to 38% of European en-route traffic operating through regions intermittently but regularly affected by RFI.
- Minimising risks from GNSS RFI requires maintaining traditional ground-based navigation aids and inertial navigation systems as backups, increasing monitoring of RFI, and raising awareness among pilots and ATC about its potential impact.

EN-ROUTE CAPACITY

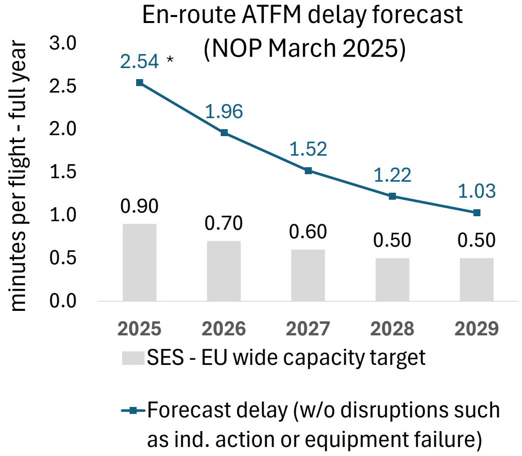
- **En-route ATFM delays in 2024 exceeded 2018/19 & 2022/23, reaching the worst level since 2001.**
- In 2024, **average en-route ATFM delay reached 2.13 minutes per flight** and 12.6% of all flights were en-route ATFM delayed.
- **Total en-route ATFM delays amounted to 22.4 million minutes** in 2024 (equivalent to 2.8 billion Euro delay costs).



- En-route **ATFM delays in 2024 were more concentrated during the summer** than in 2023, partly due to the absence of the 3 million minutes of delays caused by ATC industrial action in spring 2023 and high ATFM delays attributed to adverse weather in summer 2024.
- In 2024, **ATC capacity (38.8%) was attributed as the main reason for en-route ATFM delay, closely followed by adverse weather (36.2%),** ATC Staffing (13%), Other (5%), ATC disruptions (3.6%), and Special Events /Projects (2.5%).
- En-route ATFM delay in 2024 were mainly attributable to DSNA which generated 21.2% of all en-route ATFM delay, followed by DFS (17.8%), HungaroControl (12.9%), ENAIRE (10.7%), ENAV (6.7%), and Croatia Control (6.5%).
- The most delay generating individual Area Control Centre (ACCs) in 2024 were Karlsruhe UAC (13.1%), Budapest (12.9%), Marseille (7.0%), Zagreb (6.5%), and Reims (6%).
- **Together the 5 most penalising ACC (out of 65 ACCs) generated 45.5% of the total en-route ATFM delay in 2024** (10.6% of total controlled flight hours).



- The PRC analyses of constraining ACCs, both in 2023 and 2024, looks at three of the **main drivers of capacity performance: traffic demand; sector capacity, and the number of sectors deployed** to handle the traffic demand (sector hours).
- There is a significant **inverse relationship between changes in sector hours deployed and levels of ATFM delays**. Hard **staffing constraints are also evident** in situations where the Air Navigation Service Provider (ANSP) was unable to recruit and train sufficient Air Traffic Controller (ATCOs) to keep pace with high traffic growth.
- The PRC has previously raised **concerns about the lack of transparency in attributing ATFM delay causes**, particularly when staffing contributed to delays attributed to ATC capacity or adverse weather. The PRC welcomes that a new delay code will shortly be introduced to indicate when additional ATC capacity could have been provided if more ATCOs had been available at the time of regulation.
- However, the PRC **regrets that there has not yet been progress in a similar initiative to improve transparency regarding constraints attributed to adverse weather** and where the lack of available ATCOs was also a factor. ATFM delays attributed to "adverse weather" are the second largest category and they have been growing significantly over the last three years.
- The latest **delay forecasts** presented in the February 2025 version of the Network Operations Plan (NOP) 2025-2029 is **significantly different from** the 'binding' Union-wide **en-route capacity targets** from the SES Performance Scheme.

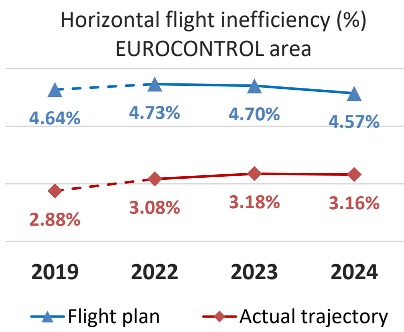


** Note that the NOP delay forecasts use the STATFOR High scenario for the first year and the Baseline scenario for subsequent years.*

- They predict **twice the level of en-route ATFM delays for 2025 & 2026 than were predicted in NOP 2024-2029,** published just last year. Forecast delays for 2025 **correspond to costs of €3.8 Billion for airspace users**.
- They include a statistical value of 0.49 minutes per flight just for adverse weather; practically equivalent to the entire union-wide target for en-route delay of 0.5 minutes per flight in 2014-2019, 2023-2024 and 2028-2029.
- The **PRC notes that many SES States have implemented incentive schemes that exclude all ATFM delays attributed to adverse weather,** even though such delays accounted for >40% of total network en-route ATFM delays in 2024.

FLIGHT EFFICIENCY

- **Horizontal en-route flight inefficiency in actual flown trajectories (red line) has steadily increased since 2019**, peaking in 2023 before showing a slight improvement to 3.16% in 2024.
- **Key factors driving this trend include the war in Ukraine, strikes in France, and a growing number of ATFM regulations** due to capacity constraints and adverse weather, especially during the summer months.



- Flight efficiency particularly worsened in those states affected by the changes in traffic flows because of the war in Ukraine and subsequent airspace closures.

- **Inefficiencies in filed flight plans (blue line) decreased between 2022 and 2024, indicating a reduction in network constraints**. This has allowed airspace users to take advantage of more optimal routings when filing their flight plans.
- Although the gap narrowed, there persists a **substantial difference between filed and flown trajectory in 2024**. Further reducing network constraints to better align flight planning with actual trajectories will deliver added benefits to all stakeholders.
- With the increased local implementation of local Free Route Airspace (FRA), the **network perspective and cross border become crucial to fully realise the benefits of FRA**.

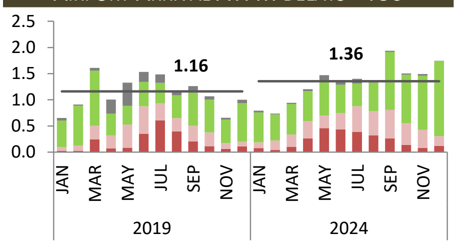
CIVIL/ MILITARY COORDINATION

- While notable progress has been made in civil-military coordination across Europe, **further optimisation is needed, particularly in processes and information flows**. Timely access to accurate airspace information is essential for optimising its use. Both local and network-wide awareness of reserved airspace status enable service providers and airlines to maximise available opportunities.
- States should **leverage available technologies to enhance the analysis, monitoring, and improvement of Flexible Use of Airspace (FUA) implementation**. Civil and military aviation authorities, ANSPs, and the network manager should collaborate to assess flexibility opportunities in the tactical Airspace Management (ASM) phase at the local level, optimising both strategic and tactical ASM processes.
- PRC analysis furthermore suggests that some states should **revise their ASM strategy for airspace reservations and Aeronautical Information Publication (AIP) publications to enhance flexibility in flight planning,** while ensuring sufficient access for military training. Additionally, difference in airspace availability between weekdays and weekends should be implemented.

ANS PERFORMANCE @ AIRPORTS

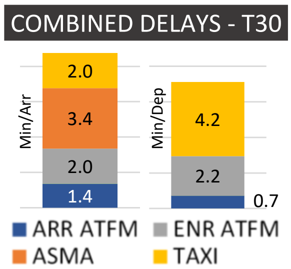
- At the Top30 airports, traffic in 2024 increased by 5.2% on 2024 and it is now only 0.8% below 2019 traffic. The list of airports in the Top30 remained unchanged with respect to 2023.
- **Holiday destinations continued to show the most significant traffic increases in 2024** (e.g. Malaga, Athens, Antalya, and Palma), while some business destinations and hubs are lagging behind (e.g. Munich Stockholm, and Frankfurt).
- **Average airport ATFM arrival delays increased again in 2024, surpassing 2019 levels, even though traffic has not yet fully recovered.** Weather-related ATFM delays saw a significant rise throughout the year, particularly from September onward. Airport capacity related ATFM arrival delays also experienced a notable increase.

AIRPORT ARRIVAL ATFM DELAYS - T30

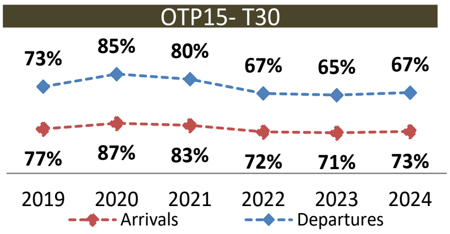


- The highest average arrival ATFM delays were recorded at Lisbon (4.20 min/arr), followed by Amsterdam (3.79 min/arr), Gatwick and Heathrow (both 3.60 min/arr), and Athens (3.46 min/arr).
- **Additional ASMA times at T30 in 2024 showed a slight increase compared to 2023** but remained below the levels recorded in 2019. The highest additional ASMA times were observed at the London airports with Heathrow averaging 7.48 min/arr and Gatwick at 6.02 min/arr. Lisbon followed showing a significant increase and reaching 4.87 min/arr (+1.41 min more than in 2023). This deterioration of the ASMA times was mostly observed since the implementation of the Point Merge procedure in mid-May 2024, alongside a reduction of the arrival ATFM delays at this airport.

- **Like the additional ASMA times, additional taxi-out times at T30 increased slightly in 2024,** but remained below 2019 levels.
- Additional taxi-out times at Rome increased substantially in 2024, reaching an average of 7.67 min/dep and surpassing Heathrow and Gatwick (6.82 and 6.99 min/dep respectively).



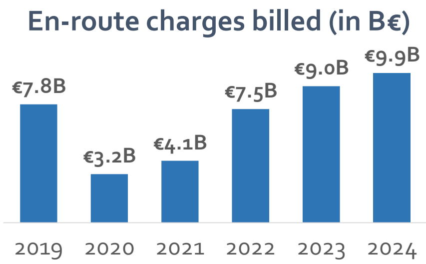
- Despite the **highest share of ATFM regulated departures on record at the T30 airports in 2024, ATFM slot adherence continued to improve** further**.**
- A comprehensive analysis of the various ATM-related inefficiencies for arrivals and departures underlines that **additional times in the approach and in the taxi phase had a more significant impact than all ATFM delays**.



- Regardless of a slight improvement in both arrival and departure punctuality at the T30 airports in 2024, performance remained significantly worse than in 2019. Similar to 2023, almost **one in three departures left more than 15 minutes late, with summer performance dropping to much lower punctuality levels**.
- The pre-departure delays were predominantly reactionary (due to late inbound) and airline-related, followed by ATFM enroute delays.
- Airport related pre-departure delays in 2024 have improved compared to the past three years, **suggesting that post-COVID issues like staff shortages and restrictions have largely been resolved**.

ANS COST EFFICIENCY PERFORMANCE AND ROUTE CHARGES

- In 2023 (which is the latest year for which financial data is available) average en-route unit costs decreased in real terms to €55.6 at pan-European level – the lowest level recorded since the creation of the Performance Review Commission.
- Total pan-European ANS costs grew by +3.2% in 2023, in real terms, following a similar increase in 2022 (+3.7%). The increase was mainly driven by growth in staff and other operating costs. Despite the increase between 2021 and 2023, pan-European ANS costs in 2023 remained some -1.3% below pre-COVID-19 levels mainly because of significant savings in depreciation costs.
- According to the planned figures submitted by the States in November 2024, traffic (measured in service units) is expected to grow at a faster rate (+3.5% p.a.) than the pan-European en-route ANS costs (+2.3% p.a.) between 2023 and 2029. If these projections materialise, en-route unit costs will reduce over the period (-7.3%).

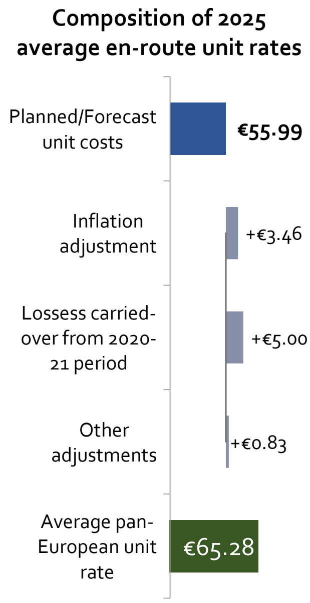


- En-route charges billed to airspace users grew by some 9% in 2024, reaching €9.9 B and surpassing pre-pandemic levels by some +€2.1 B (+26%). This growth reflects, higher unit rates on average charged to airspace users and an increase in service units. However, this trend, has not been uniform across the pan-European system with some charging zones still billing below 2019 levels.
- The average pan-European en-route unit rate for 2025 – which is subject to change pending the adoption of National Performance Plans for the 4th Reference Period for the States subject to Single European Sky legislation – amounted to €65.28, reflecting a +11% increase compared to 2024 and

exceeding the planned unit costs for 2025. Like last year, this difference is primarily due to the inflation adjustment included in the unit rates of States subject to economic regulation (some €623M) as well as the portion of losses incurred by these States in the 2020-21 period (some €899M) to be recovered from airspace users in 2025.

- Detailed benchmarking analysis of pan-European ANSPs shows that the net book value of fixed assets reduced in 2022 and 2023, mainly reflecting lower capital expenditures since 2020. On the liabilities side, the level of ANSPs indebtedness continued to reduce in 2023 but still remains significantly higher than before the COVID-19 crisis.

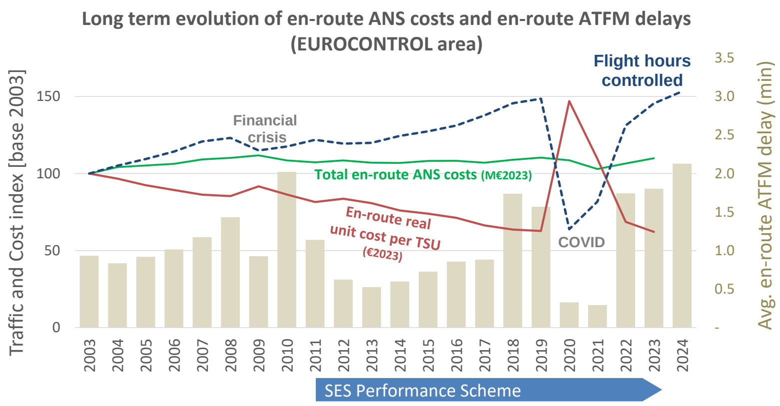
- The pan-European system's free cash flow, one of the indicators used to monitor the financial impact of the COVID-19 crisis on ANSPs, turned positive for the first time since 2019. This change in trend may indicate an improvement in the financial strength of ANSPs following three years of deterioration.



THE BIGGER PICTURE

- The role of Air Traffic Management (ATM) is to accommodate airspace users' needs in a safe, efficient, and cost-effective manner. Safety lies at the heart of ATM and is assessed independently.

- A more **holistic assessment of ANS performance accounts for both the direct ANS provision costs and indirect costs of delay** incurred by airspace users. The analysis reveals clear trends and cycles over the past two decades.

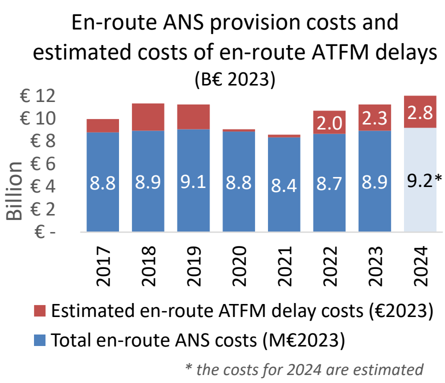


- A steady growth in flight hours (dotted line), coupled with a relatively stable en-route cost-base in real terms (green line), led to a consistent decline in en-route unit costs until the pandemic in 2020 (red line). After the pandemic unit costs declined to their lowest level since monitoring began.

- **While cost efficiency improved, en-route ATFM delays started rising gradually in 2014, surged in 2018 and 2019**, and continued to climb as traffic rebounded between 2022 and 2024, reaching historically high levels.

- **Capacity shortfalls can quickly cancel direct cost-efficiency gains because of the disproportionally high delays and associated costs**. A high-level estimate suggests that en-route ATFM delay costs to airspace users in 2024 were €2.8 billion which is equivalent to some 30% of the total en-route ANS provision costs.

- Insufficient capacity plans, reduced ATCO recruitment, and the delay of planned projects generated cost savings for some ANSPs but are likely to have contributed to the widening capacity gap since 2013.



- **The planning and deployment of adequate capacity levels may entail a cost but failing to deploy sufficient staffing levels results in disproportionally higher costs to airspace users** and passengers which are in most cases sufficiently high to justify for example adding extra ATCOs.
- **There is a critical need for robust monitoring, increased transparency, and a strengthened network planning process.** This will ensure that future capacity plans are fully aligned with performance expectations and that they are effectively delivered.
- **The long lead times for recruitment and capacity improvements highlight the importance of** proactive planning, the need for flexibility and some buffers in capacity development, and **a balanced approach that accounts for the broader economic context**.
- This underscores the need for an **approach that considers the "total economic costs", which includes not only the direct ATM provision costs but also the indirect costs arising from inefficiencies**, such as delays and additional fuel burn.

THE NEED FOR TRANSFORMATION

- Despite numerous successful local and regional improvements which greatly enhanced the operational, economic and safety performance of ATM in Europe, **the operational concept, processes and technology remained essentially the same over the past 20 years**.
- The stakeholder workshops carried out as part of **the PRC Transformation Support Strategy (TSS) highlighted the significant potential of innovative projects and services, as well as the challenges hindering their widespread deployment**.

- Major concerns included the **lack of regulatory support at local and European levels**, which increases time and costs and discourages innovation in the ANS community. Other factors hindering transformation were a **lack of incentives and industry commitment**, **reliance on operational budgets for significant investments**, **difficulties in integrating legacy systems** with new technologies, and poor coordination and standardisation of initiatives.
- **Without fundamental change, the PRC believes that European ATM will be unable to accommodate the projected 50% increase in flights by 2050**, while also improving cost and operational efficiency.
- **Addressing future challenges and leveraging network effects will require rethinking current operations** and effectively deploying strategic priorities based on the European ATM Master Plan. This includes **shifting from a local, service provider-centric model to a trajectory-based approach**.
- A more comprehensive approach to airspace design is essential—one that aligns operations with traffic flows rather than rigid national borders. **The fragmentation of ATM provision across Europe still presents challenges across operational, technological, and institutional dimensions**. Despite visible local performance improvements, there is a pressing need to adopt a true network-oriented approach to maximise performance benefits across airspace interfaces, capacity planning and deployment, and information flows.
- The PRC is committed to supporting the necessary European transformation process by independently monitoring the performance improvements achieved by selected flagship initiatives and by assisting in the removal of any obstacles hindering enhanced performance.

RECOMMENDATIONS 2024

The recommendations from the Performance Review Commission (PRC) to the EUROCONTROL Provisional Council build on the information and analyses in this report. Several recommendations in this report closely mirror previous ones, as their relevance and importance have only grown over time. Until they are properly addressed, they remain just as critical - if not more so - than before.

Recommendation	Rationale
The Provisional Council is invited to advise the Permanent Commission:	
a. to recommend a review and strengthening of the annual capacity planning process to prevent inadequate capacity planning at ACC and network level;	Analysis shows that the output of the capacity planning process in the Network Operations Plan (NOP) consistently fails to meet the binding network targets set by the SES performance scheme. Since 2014, the aggregated capacity plans agreed with ANSPs have not met the required level of service — either for the year of publication or for future years. In most years, actual delays exceeded the forecasted level, indicating that some ANSPs not only provided insufficient plans but also failed to even deploy those plans and the associated committed capacity effectively. The revised delay forecast for 2025 has more than doubled compared to last year's NOP projection, highlighting an urgent need to improve the capacity planning process if the targeted service levels are ever to be met in a growing traffic scenario.
b. to recommend to Member States to ensure that ANSPs deploy adequate numbers of qualified ATCOs to meet traffic demand and train sufficient ATCOs to prepare for future demand;	En-route ATFM delays started rising gradually in 2014, surged in 2018 and 2019, and continued to climb as traffic rebounded between 2022 and 2024, reaching historically high levels. Reduced recruitment, sub optimal deployment of available ATCOs, and the delay of planned projects, may have generated initial cost savings but, with a constant medium-term traffic growth forecast, have led to a widening capacity gap and so ultimately resulted in disproportionally higher costs to airspace users. Closing the gap between actual and required ATCO deployment would significantly reduce existing staffing-related delays at a fraction of the estimated €2.8 billion incurred due to delays in 2024. For the necessary transformational change, innovative projects aligned with the ATM Masterplan priorities must be accelerated with sufficient funding and regulatory support.

c. to recommend to Member States and the Network Manager to work with ANSPs to further improve transparency in the attribution of ATFM delays related to adverse weather when the lack of available ATCOs was also a contributing factor.	While the PRC welcomes the forthcoming introduction of a new delay code to provide transparency, where additional ATC capacity could have been provided if more ATCOs had been available at the time of regulation, there has been no progress in a similar initiative to improve transparency regarding constraints attributed to adverse weather. ATFM delays attributed to "adverse weather" are the second largest category in 2024 and have grown significantly over the past three years. Objective and accurate identification of the underlying causes of ATFM regulations are essential prerequisites for selecting the most effective mitigation measures.
d. to recommend the use of total economic costs as a key driver of performance management considering both service costs and the cost of delays instead of delay minutes only.	Additional costs to airspace users caused by en-route ATFM delays were already substantial in 2018 and 2019 and continued to rise between 2022 and 2024, representing 30% of ANS costs by 2024. Due to the disproportionate increase in delays and associated costs, capacity shortfalls can quickly cancel direct cost-efficiency gains. Given the long lead times for recruitment and investment, this underscores the importance of proactive planning, the need for flexibility and buffers in capacity development, and a balanced approach that accounts for the broader economic context. The goal should be to prioritise total economic costs as a key factor in performance management, taking into account both service provision and delay costs, rather than focusing solely on delay minutes.

CONTENTS

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1 Introduction

This Performance Review Report (PRR 2024) has been produced by the independent Performance Review Commission (PRC) of EUROCONTROL, together with its supporting unit the Performance Review Unit (PRU).

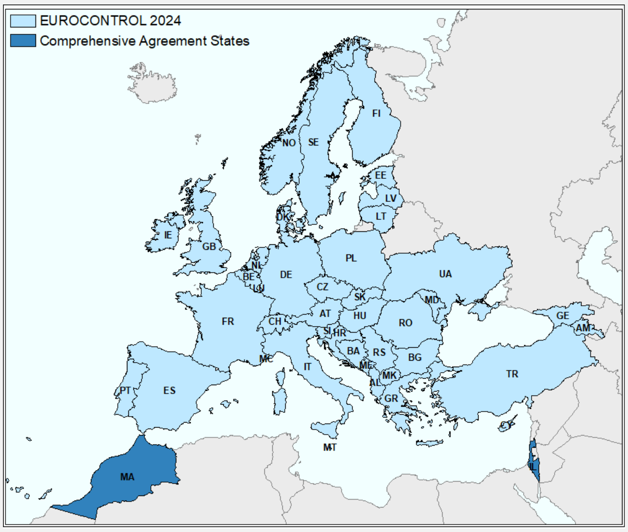
PRR 2024 gives an independent holistic view of Air Navigation Services (ANS) performance in all EUROCONTROL Member States across all key performance areas. The goal is to provide policy makers and ANS stakeholders with objective information and independent advice concerning the performance of European ANS, based on analysis, consultation and information provided by relevant parties. The spirit of the PRC's work is neither to praise nor to criticise, but to help everyone involved in effectively improving performance in the future.

The PRC and the EUROCONTROL Agency also have a long-standing relationship and history of cooperation with the European Union (EU) in Air Traffic Management (ATM) and in the implementation of the Single European Sky (SES) and other related policies. The PRU helps the European Commission (EC) in performance monitoring, target setting and the assessment of performance plans in support of the SES Performance Scheme (SES-PS). The PRC has established a dialogue with the Performance Review Body (PRB) to support each other's work and to avoid duplication or overlaps with the PRB's work in assisting the EC in the implementation of the SES-PS.

Report Scope

Unless otherwise indicated, PRR 2024 refers to ANS performance in the airspace controlled by the 41 EUROCONTROL Member States and the two Comprehensive Agreement States – Israel and Morocco. Iceland became EUROCONTROL's 42 Member State on 1 January 2025.

The geographical scope of the report is therefore wider than the scope of the SES-PS, but includes all the "SES States", consisting of the 27 EU Member States plus Switzerland and Norway.



Except for actual 2024 ANS costs and Safety occurrence data from EASA (which were not yet available at the time of writing this report) all data in this report refer to the calendar year 2024.

The designations employed do not imply the expression of any opinion whatsoever on the part of EUROCONTROL concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

More information about the PRC and its work can be found on the Aviation Intelligence Portal (www.ansperformance.eu) which also provides a variety of interactive dashboards for more detailed analysis and offers monthly updates of performance information covering all EUROCONTROL Member States.

2 ANS in European Air Transport

This chapter situates ATM performance within the broader context of European air transport, offering background on key trends to support the detailed analyses of environment (Chapter 3), safety (Chapter 4), operational ANS performance (Chapters 5,6), and ANS cost efficiency (Chapter 7) in the report's second part.

The second part of this chapter reviews the long-term evolution of ANS performance over the past two decades, adopting an economic perspective that combines service provision costs with expenses from operational inefficiencies. Finally, it provides an update on the PRC's transformation support strategy (TSS) designed to support the European ANS system toward higher performance standards.

2.1 Traffic evolution and outlook

Controlled flights EUROCONTROL area in 2024	**Controlled airspace** EUROCONTROL area in 2024	**Peak traffic day** EUROCONTROL area in 2024	**Forecast growth** EUROCONTROL area by 2031
10.5 million Flights + 4.5% vs. 2023 - 4.3% vs. 2019	**12.5 million square km** - 6% vs. 2019 (Ukraine airspace)	**14.06.2024** - 4.6% below the all-time peak on 28.06.2019	**12.2 million flights** + 14.9% vs. 2024 + 1.6m vs. 2024

2.1.1 KEY INDUSTRY INDICATORS

Figure 2-1 provides an overview of the evolution of the European key air traffic indicators[1].

The trends observed in previous years continued in 2024. The average flight distance and aircraft mass increased at a higher rate than the number of flights. While the number of flights remained below 2019 levels, both distance and average aircraft mass exceeded those of 2019.

The combination of longer and heavier flights also drove a disproportionately higher growth in en-route service units[2] and total CO_2 emissions in 2024.

Although efficiency improved with an increasing number of fuel-efficient flights, total CO_2 emissions still rose due to the overall increase in flights, longer distances, and heavier aircraft.

Passenger numbers continued to grow strongly in 2024, surpassing pre-pandemic levels from 2019.

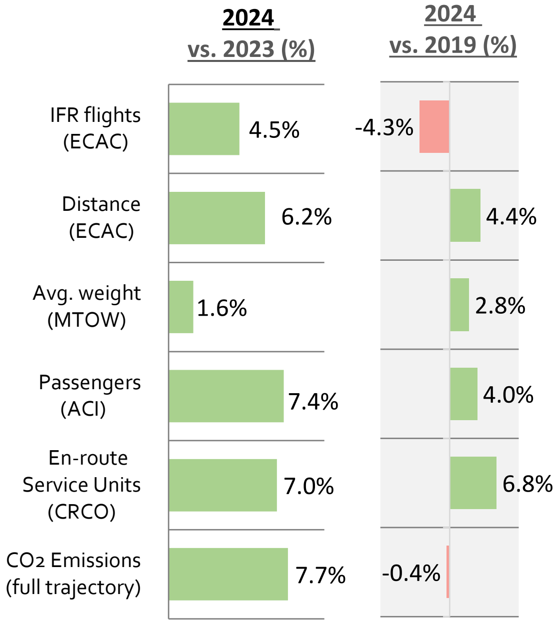


Figure 2-1: European air traffic indicators

2.1.2 TRAFFIC EVOLUTION

In 2024, controlled flights in the EUROCONTROL area rose by 4.5% compared to 2023, reaching 10.5 million flights but remained 4.3% below 2019 levels.

Traffic in 2024 peaked on 14.06.2024 with 35,171 flights, which was 4.6% below the all-time peak on 28.06.2019.

In this context it is important to point out that available airspace in the EUROCONTROL area in 2024 was approximately 6% less than in 2019 due to the closure of Ukrainian airspace following Russia's invasion in February 2022.

Subsequent reciprocal airspace bans on Russian and Western operators, coupled with escalating tensions in the Middle East after the October 2023 terror attack on Israel, further impacted airspace availability and reshaped traffic flows, resulting in significant shifts in traffic load across various parts of the network.

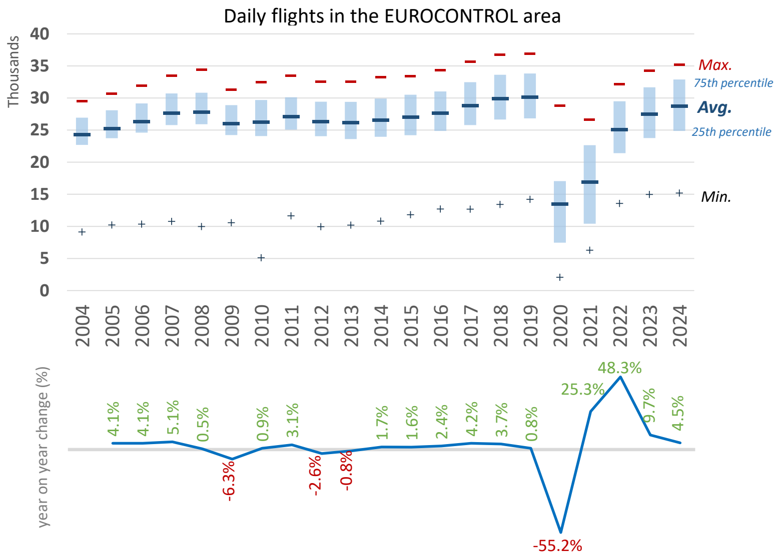


Figure 2-2: Evolution of IFR traffic in the EUROCONTROL area

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

[2] Used for charging purposes based on aircraft weight factor and distance factor.

Fewer flights and less airspace than in 2019 with notable shifts in traffic distribution

Figure 2-3 and Figure 2-4 show the change in average daily flights in 2024 compared to 2019 (right) and 2023 (left) respectively.

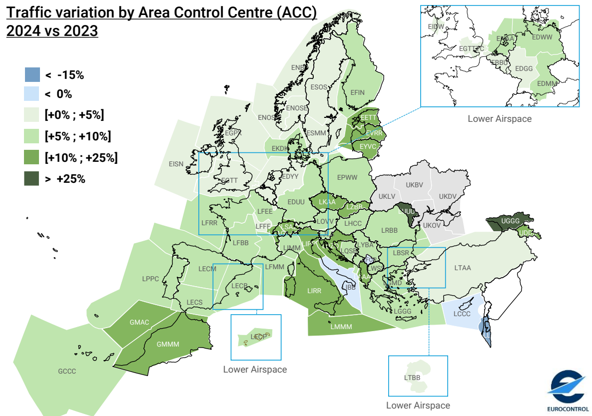


Figure 2-3: Change in average daily flights (2024 vs 2023)

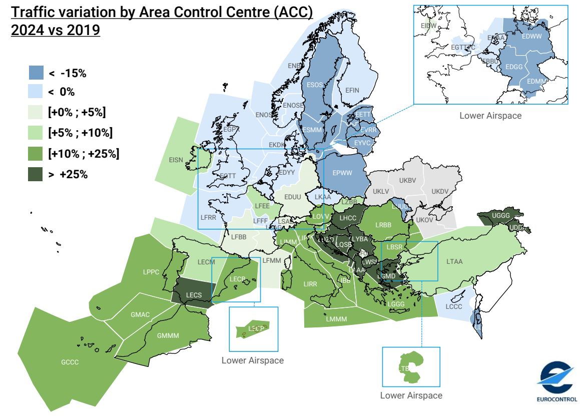


Figure 2-4: Change in average daily flights (2024 vs 2019)

The designations employed do not imply the expression of any opinion whatsoever on the part of EUROCONTROL concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Even though overall traffic was still below 2019 levels, parts of Central, Southeast, and Southwest Europe saw traffic levels notably surpass those of 2019, driven partly by a rise in travel to popular holiday destinations and significant shifts in overflight patterns (see Figure 2-4).

The European core area managed traffic volumes similar to 2019, while Northern Europe—especially the Baltic States—but also Israel and Cyprus, managed considerably less traffic compared to pre-pandemic levels.

Peak week traffic in some ACCs surges to over 50% above average

Traffic variability (seasonal, daily, hourly) can be challenging and impact performance if not properly managed. Limited flexibility to align capacity with demand may result in high delays or resource underutilisation.

The comparison of traffic between peak and average week in Figure 2-5 provides an indication of the level of seasonality in each area control centre (ACC) in 2024.

During peak times, some ACCs handle traffic exceeding 50% above the weekly average, typically those serving popular holiday destinations.

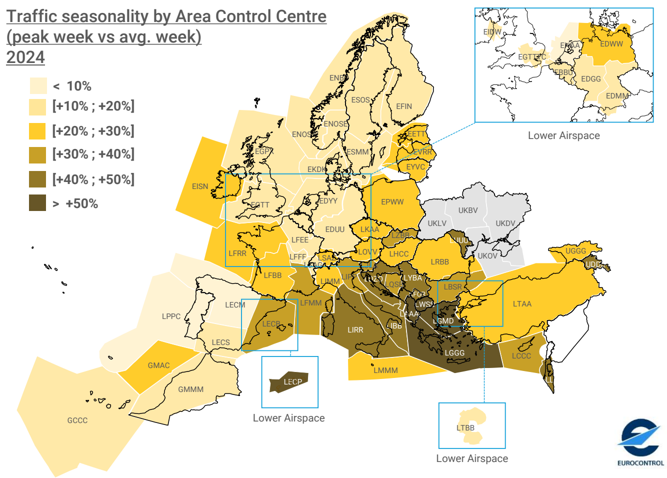


Figure 2-5: Traffic variability between peak and average week

Figure 2-6 displays the average daily flights in 2024 (brown bar at the bottom), along with the percentage change relative to 2019 and the breakdown of changes in average daily flights by flight type. The analysis is sorted by the relative growth in 2024, with Georgia on the left showing the highest growth versus 2019.

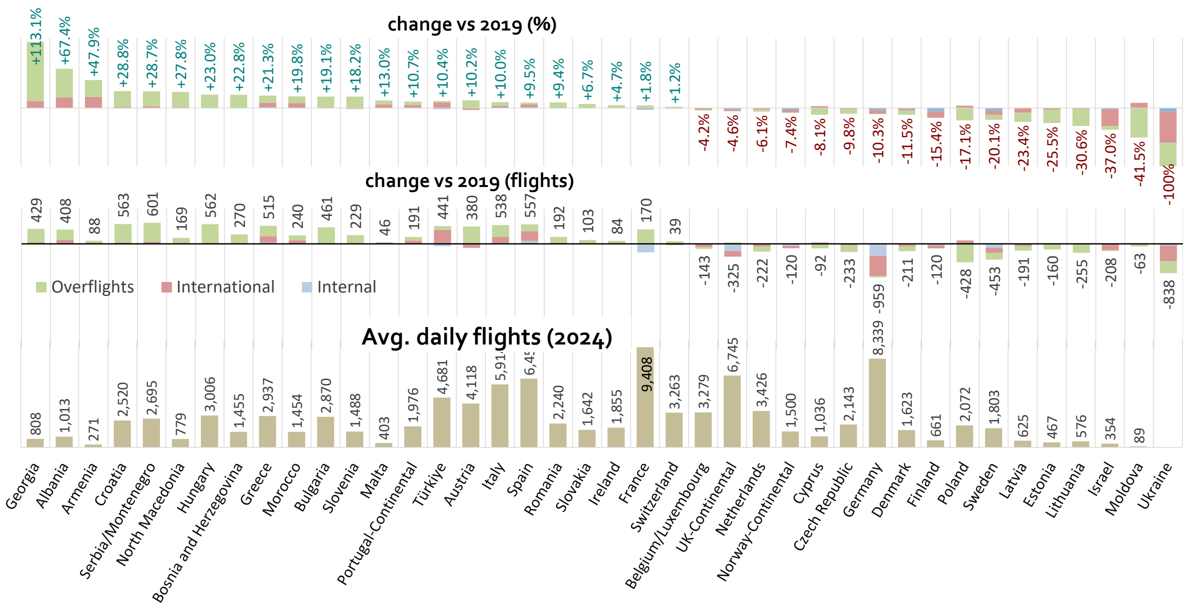


Figure 2-6: Average daily flights by traffic zone (2024)

The analysis shows that a **large part of the traffic load changes compared to 2019 was related to changes in overflights** (green bars). The loss of heavier long-haul overflights to and from Asia in northern Europe had an even stronger economic impact when analysing charged Service Units.

Compared to 2019, international traffic increased primarily in traditional holiday destinations like Spain, Greece, Türkiye, and Italy, while traffic in Scandinavia, Germany, and the UK declined. **In terms of domestic traffic, Germany, France, the UK, and Sweden saw significant decreases** in traffic relative to 2019 levels.

Low-cost carriers rise as regional and non-scheduled services struggle

In 2024, mainline and low-cost carriers (LCCs) dominated network traffic, followed by regional services and business aviation.

Although nearly all market segments [1] experienced growth in 2024, only low-cost carriers, business aviation and military flights surpassed 2019 levels.

Traditional mainline carriers—and regional services especially—continued to lag behind in their recovery to pre-pandemic volumes.

LCC increased their market share from virtually zero 20 years ago to 34% in 2024 which corresponds to close to 10k daily flights.

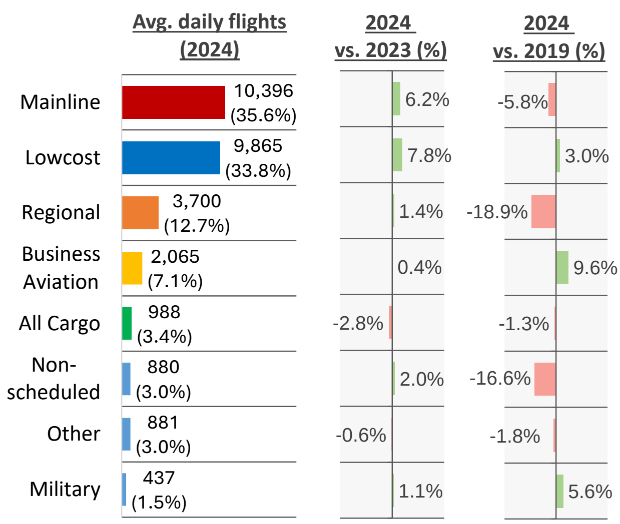


Figure 2-7: Network traffic by market segment

Low-cost carrier growth reshapes airport traffic distribution

The growth of LCCs over the past years has also reshaped traffic distribution among airports between 2019 and 2024 (see Figure 2-8).

While mainline carriers focus on major hub airports with reduced services at mid-sized and regional airports supporting their networks (red and orange bars), LCCs increased their point-to-point services, driving up the growth at smaller regional airports (blue bars).

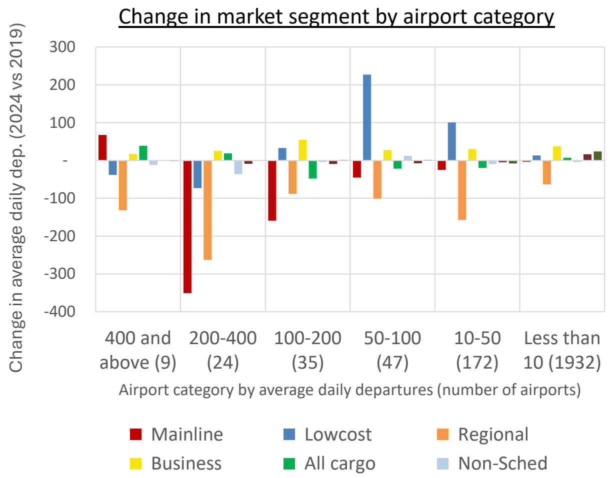


Figure 2-8: Change in market segment by airport category

Narrow-body fleet grows while regional jets and turboprops decline

In 2024, two third of the flights in the EUROCONTROL area are operated by narrow-body aircraft (66%), an aircraft type that has seen significant growth in recent years.

This expansion is largely fuelled by the rise of LCCs, which typically operate a single aircraft model, such as the Boeing 737 or Airbus A320 to optimise operating costs per passenger and maximise aircraft productivity.

Meanwhile, smaller regional jets and turboprop (commuter) aircraft have seen a decline in use, with reductions of 33% and 28% respectively between 2019 and 2024. This trend aligns with the decrease of the regional market segment in Figure 2-7.

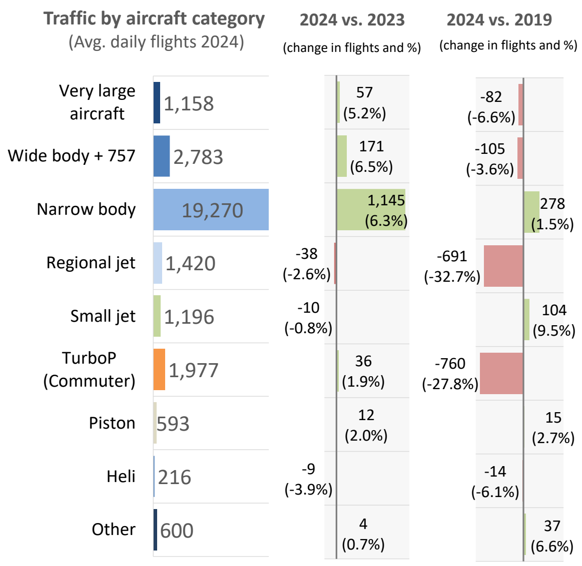


Figure 2-9: Aircraft types operating in the EUROCONTROL area

Fleet evolution increases utilisation of upper airspace

The changes in the composition of the aircraft mix also impacts on the requested flight levels in the European ATM network.

With higher altitudes offering greater fuel efficiency and speed, it is not surprising that most flights are concentrated in the upper airspace (see Figure 2-10).

The decline in turboprop aircraft over the past years, coupled with a surge in modern, fuel-efficient narrow-body planes, has further intensified demand for upper flight levels.

This trend, alongside with traffic growth and shifts in traffic flows, has added pressure on Europe's upper airspace which is already congested in some areas.

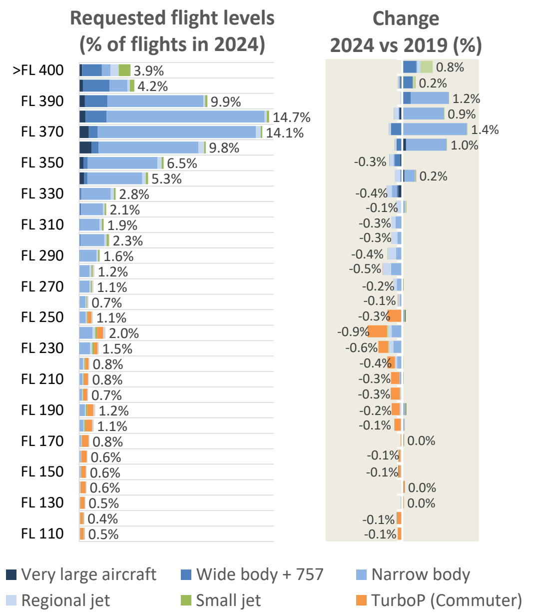


Figure 2-10: Requested flight levels in filed flight plans

Ryanair remains the dominating airline – and even expands operations further

The analysis of the top 30 aircraft operators[3] in 2024 in Figure 2-11 shows that for the 10th consecutive year, Ryanair was with 3,044 average daily flights in 2024 by far the airline with the most flights in the network, followed by EasyJet, Turkish Airlines, Lufthansa, and the Air France Group.

Except for Turkish Airlines, SAS, TAP, Widerøe, and DHL, all operators in the top 30 showed an increase in the number of flights in 2024.

Several traditional mainline airlines such as Lufthansa, Air France, and SAS **still operated in 2024 significantly less flights than in 2019**.

In contrast, the Ryanair and Wizz Air have substantially increased their flights in 2024 compared to 2019.

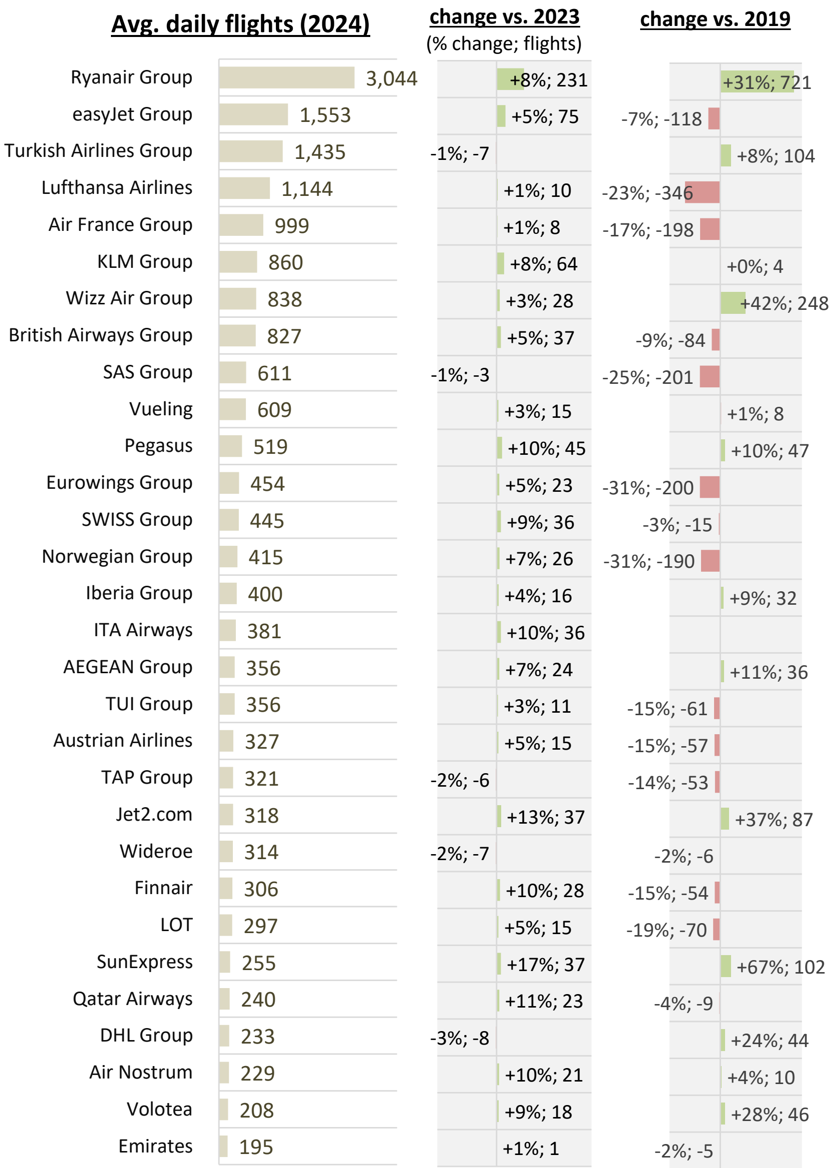


Figure 2-11: Top aircraft operators in 2024 (EUROCONTROL area)

[3] Groups refer to Level 1 grouping as defined here: https://www.eurocontrol.int/directory/airline-groups-lookup

2.1.3 TRAFFIC OUTLOOK

The latest seven-year forecast [2] published in February 2025, incorporates flight trends and route patterns up to Summer 2025 and updated economic projections. Routing patterns from 2024, along with recent trends in state overflights, have served as the foundation for forecasting future overflight activity. **Due to uncertainty surrounding the reopening of Ukrainian airspace, the forecast uses the current situation as its baseline**. A quicker resolution to the conflict in Ukraine could present significant upside potential for future projections.

Although it is difficult to foresee the exact timing, there is a need to prepare for the reopening of Ukraine's airspace and the resulting significant shift of traffic flows in adjacent States.

The three forecast scenarios—high, base, and low—factor in uncertainties such as potential geopolitical disruptions, economic shocks, and persistent challenges within the aviation industry, providing a strategic tool for managing business risks.

European flight numbers have steadily recovered, with significant traffic volumes reported over the summer. Several states have already notably exceeded their 2019 traffic levels.

However, the network is still affected by the ongoing Russian invasion of Ukraine, which disrupts airspace usage and forces rerouted traffic flows.

Figure 2-10 shows the actual traffic up to 2024 and the three scenarios up to 2031 for the ECAC area.

In the most likely (baseline) scenario, annual traffic is expected to 12.2 million flights in 2031 which corresponds to 1.6 million more flights compared to 2024 (+15%). This corresponds to an annual average growth rate (AAGR) of +2.0% between 2025 and 2031.

Forecast growth ECAC area by 2031	**Annual avg. growth rate** 2025 - 2032
12.2 million flights	**+ 2.0 %** ↑ **base scenario**
+ 14.9% vs. 2024	High: + 3.5% ↑
+ 1.6m ✈ vs. 2024	Low: + 0.3% ↑

In the high growth scenario, the average annual growth rate (AAGR) is projected at 3.5%, which would add approximately 2.9 million flights by 2031 compared to 2024 levels, resulting in a total of 13.5 million flights (+27.3% vs. 2024).

In contrast, the low scenario would result in a total of 10.9 million flights by 2031 which is some 2.1% higher than in 2024.

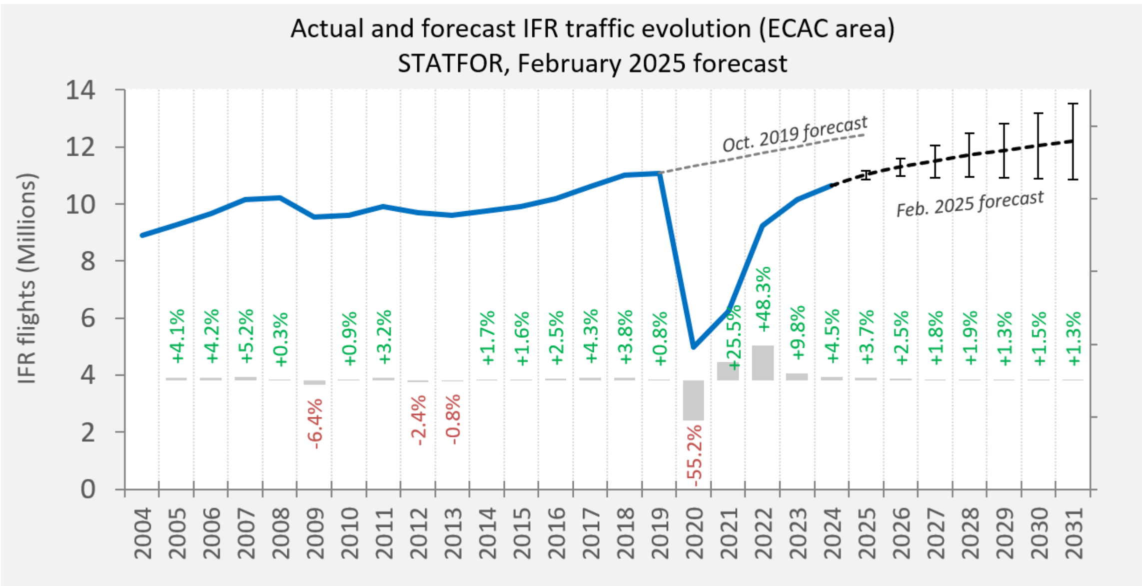


Figure 2-12: STATFOR seven-year forecast (2025-2031)

European flights projected to increase by 52% by 2050

In the longer term, the EUROCONTROL Outlook 2025 [3] expects air traffic in Europe to increase to 15.4 million flights in 2050 in the most likely scenario. This represents an increase of 52% or an additional 5.3 million flights compared to 2023.

As illustrated in Figure 2-13, growth across Europe between 2024 and 2050 is expected to vary. North-East and South-East Europe are likely to grow faster than Western Europe. In the most likely scenario, growth will range from 1% annually in the Netherlands and the Canary Islands to over 3% in the Caucasus states of Armenia, Azerbaijan, and Georgia.

Generally, the fastest growth will occur in Eastern European countries, with annual rates above 2%, particularly in Türkiye, due to higher traffic growth potential in these regions.

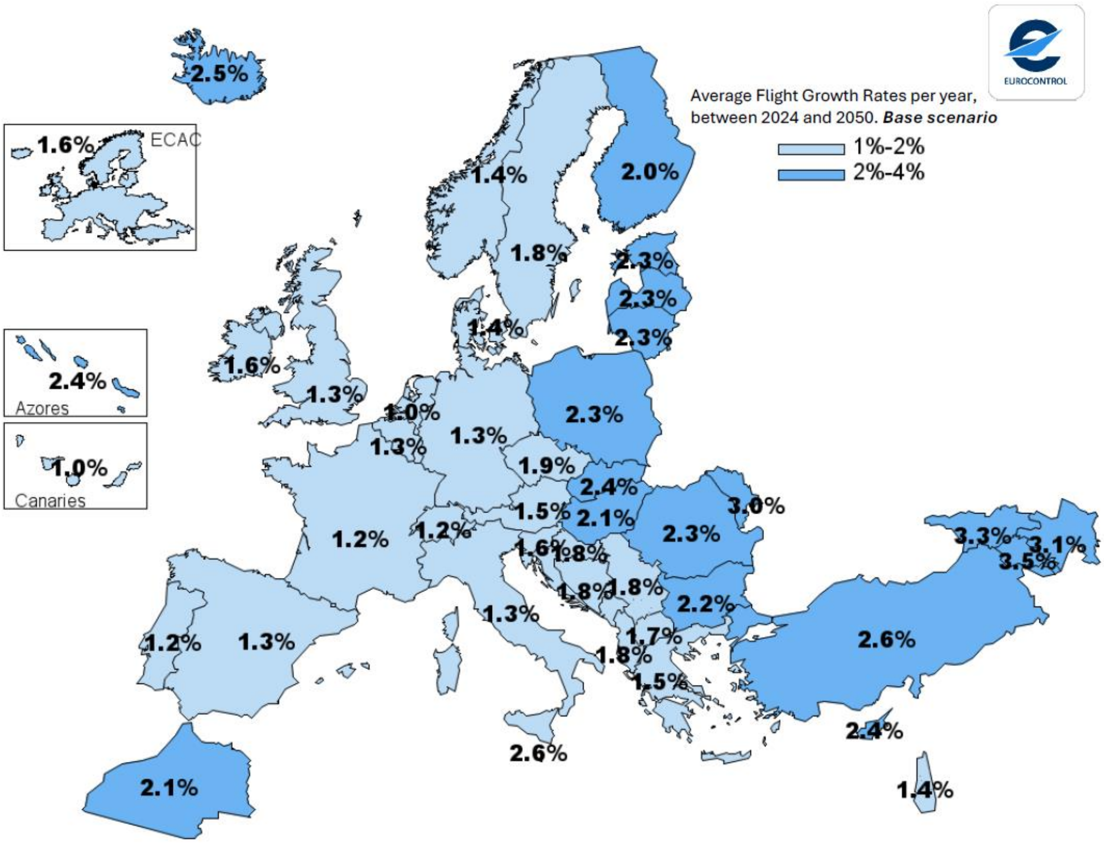


Figure 2-13: Average annual flight growth rates between 2014 and 2050 (base scenario)

For more information on traffic and service unit forecasts, please visit the EUROCONTROL STATFOR web page @ https://www.eurocontrol.int/forecasting.

2.2 Air transport punctuality

EUROCONTROL area in 2024	
Arrival Punctuality	Avg. departure delay
72.5 %	**17.7 minutes**
+ 1.9 pp vs. 2023	-0.2 min vs. 2023
- 5.3 pp vs. 2019	+4.5 min vs. 2019

Punctuality is a key indicator from a passenger point of view as it compares actual performance to published airline schedules.

Figure 2-14 shows the share of flights arriving or departing within 15 minutes of their scheduled times in the EUROCONTROL area between 2019 and 2024.

Following the improvement during the pandemic, when reduced air traffic eased pressure on the European network, stakeholders across the industry- airports, airlines, and ATC - struggled to handle the rapid rebound in demand in 2022 and 2023, primarily due to staff shortages.

European punctuality remains at historically low levels for the 3rd consecutive year

Despite some progress in 2024, punctuality across the network remained close to its lowest point in two decades**.**

In 2024, only 72.5% of flights arrived within 15 minutes of their scheduled time - a modest improvement over the 70.6% punctuality rate in 2023.

During the peak summer months (June to August 2024), more than one-third of flights (35.5%) experienced delays exceeding 15 minutes upon arrival.

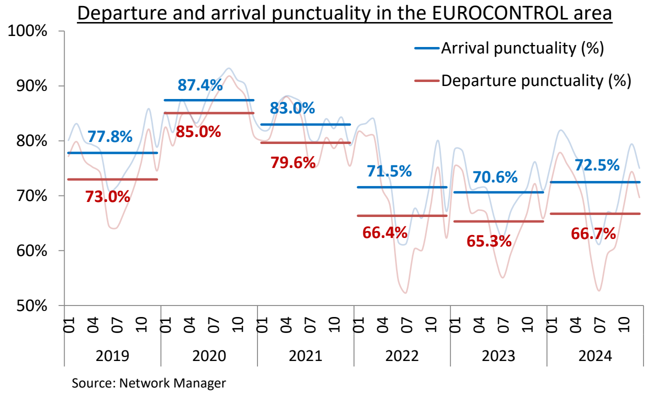


Figure 2-14: Evolution of arrival and departure punctuality

It is worth noting that the gap between departure and arrival punctuality has widened over time, indicating that airlines are increasingly adding time buffers to their schedules to help maintain on-time arrivals and overall schedule reliability.

Average all cause departure delay remained high but decreased slightly from 18.0 minutes per flight in 2023 to 17.7 minutes in 2024 (Figure 2-15).

In 2024, reactionary delays from previous flights continue to be a significant issue.

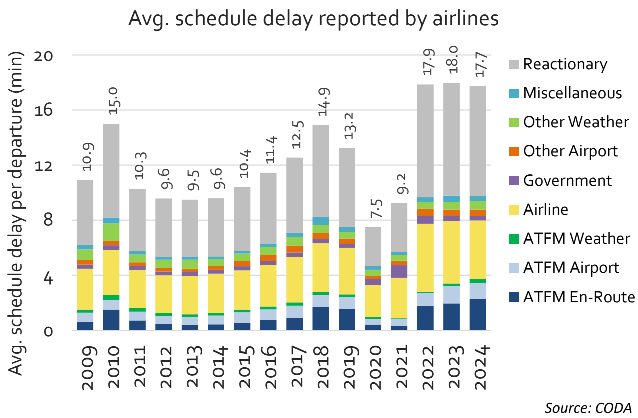


Figure 2-15: Avg. departure delay (vs. schedule)

Whereas most of the other categories decreased or remained stable compared to 2023, the relative contribution of ANS-related delays (blue bars) has notably increased over the past three years, which increasingly contributes to the system's poor punctuality performance.

A thorough analysis of non-ANS related delay causes reported by airlines is available from the EUROCONTROL Central Office for Delay Analysis (CODA).

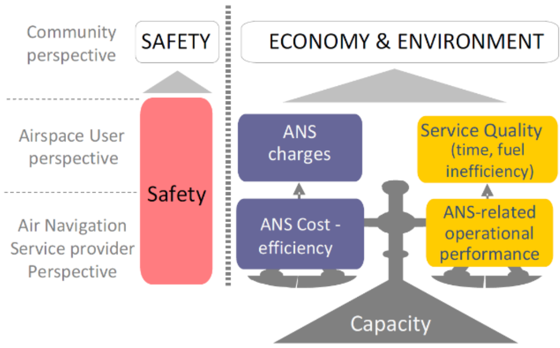
En-route ANS performance and the underlying delay causes of the poor punctuality performance at airports is analysed in more detail in Chapter 5 and 6 of this report.

2.3 ATM PERFORMANCE – DRAWING A MORE HOLISTIC PICTURE

The European aviation system is a dynamic and interconnected network, characterised by constantly fluctuating levels of capacity and demand. The role of Air Traffic Management (ATM) is to accommodate airspace users' needs in a safe, efficient, and cost-effective manner.

Safety lies at the heart of ATM and is typically assessed independently. There is however an interrelationship between cost-efficiency, capacity provision, and service quality.

Insufficient capacity can degrade service quality, resulting in significant delays and higher costs for airspace users. On the other hand, maintaining capacity levels that consistently exceed demand leads to inefficient resource utilisation, driving up ATM provision costs and charges for airspace users.



ATFM delays soar when traffic exceeds available capacity

Understanding the non-linear relationship between capacity and delays is essential for evaluating overall ATM performance. When traffic demand exceeds capacity, ATFM delays rise almost exponentially, resulting in significantly higher costs for airspace users. As a result, users not only pay for the ATM/CNS provision costs but also face additionally disproportionately higher delay costs due to insufficient capacity.

Figure 2-17 therefore shows the combined long-term trend for en-route ANS costs[4] , flight hours controlled, and en-route ATFM delays since 2003.

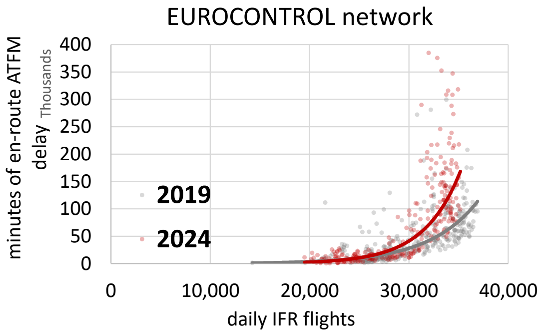


Figure 2-16: Relationship between traffic and delay – each dot represents a day in the network

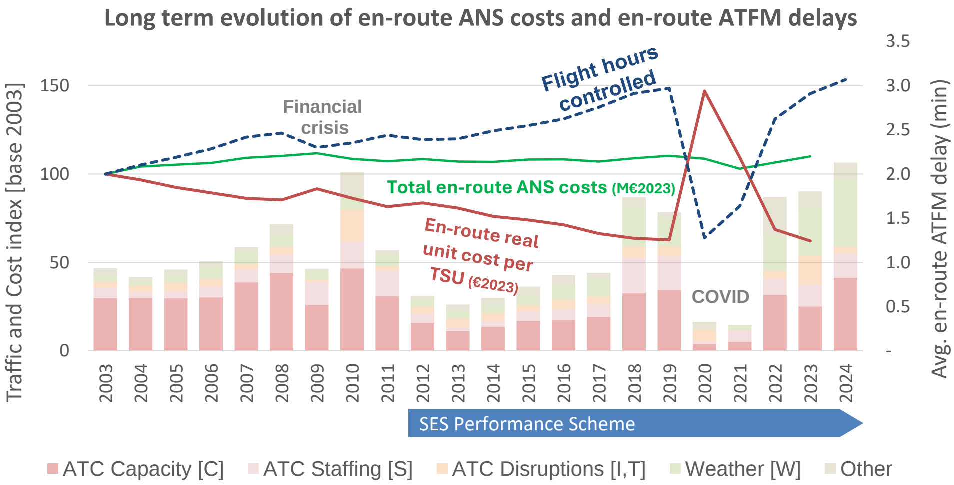


Figure 2-17: Long term evaluation of en-route ANS performance

4 For a consistent set of 30 en-route charging zones. Consistent time-series are not available for Armenia, Bosnia-Herzegovina, Estonia, Georgia, Latvia, Lithuania, Poland, Serbia and Montenegro and Ukraine en-route charging zones. These States were therefore excluded.

The analysis reveals clear trends and cycles over the past two decades. The long-term trend shows steady growth in flight hours controlled, coupled with a relatively stable en-route cost-base in real terms, which led to a consistent decline in en-route unit costs until the pandemic struck in 2020.

Industry struggles to quickly scale operations and costs

The pandemic forced ANSPs to rapidly scale back operations in response to reduced demand, while still maintaining safety and reliability for ongoing flights. Due to the magnitude of the traffic downturn, the cost-containment measures implemented by several ANSPs could not avoid a sharp increase in ANS unit costs in 2020 and 2021. With traffic rebounding as of 2022, ANS unit costs began to decline again, falling below pre-pandemic levels in 2023 and reaching their lowest recorded level since monitoring began.

While ATM cost-efficiency improved over time, the first signs of trouble began to emerge in 2014 when en-route ATFM delays started to rise gradually before surging sharply in 2018 and 2019. The unprecedented drop in traffic caused by the pandemic in 2020 then shifted the focus to financial viability, but as demand rebounded, several ANSPs struggled to scale up operations quickly enough, exposing capacity limitations that had already emerged before the pandemic.

A growing share of these en-route ATFM delays was attributed to ATC capacity and staffing issues, suggesting persisting shortcomings in capacity planning and deployment. Additionally, the increasing frequency of adverse weather events in recent years, combined with a significant shift in traffic patterns following the war in Ukraine—resulting in some areas significantly exceeding 2019 traffic levels—has further strained the ATM network.

As a result, en-route ATFM delays continued to rise between 2022 and 2024, reaching historically high levels, even with the Single European Sky (SES) performance scheme and binding capacity targets in place since 2012. In 2024, en-route ATFM delay totalled 22.4 million minutes which corresponds to an estimated additional €2.8 billion[5] in costs for airspace users.

High costs of ATFM delay dwarf cost-efficiency gains

A holistic assessment of ANS performance should account for both the direct costs of ANS provision and indirect costs incurred by airspace users, such as delays, additional flight time, and fuel burn, all while ensuring compliance to ANS safety standards.

Figure 2-18 shows a more complete picture of the en-route ATM performance by combining the en-route ANS costs (blue bars) and the estimated costs of en-route ATFM delay$_2$ (red bars), both borne by the airspace users.

The analysis shows that the additional costs to airspace users caused by **en-route ATFM delays were already substantial in 2018 and 2019 and continued to rise between 2022 and 2024, representing 30% of the ANS costs by 2024**.

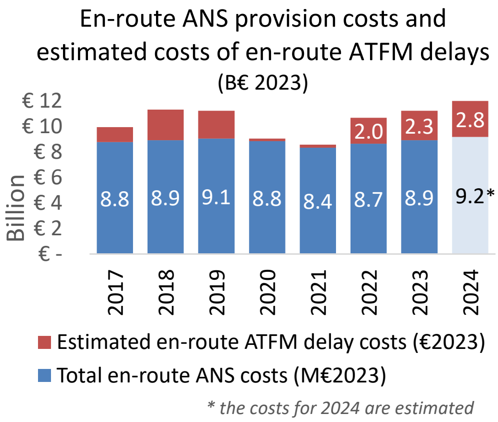


Figure 2-18: En-route ANS provision costs and estimated costs of en-route ATFM delay

[5] The cost of ATFM delays (estimated at €127 per minute in 2023) is based on the findings of the study "European air-line delay cost reference values" conducted by the University of Westminster in March 2011 and updated in December 2015 (the value is adjusted annually based on EU-27 average inflation rate).

Due of the disproportional increase in delays and associated costs, capacity shortfalls can quickly cancel direct cost-efficiency gains. **Given the long lead times for recruitment and investment, this underscores the importance of proactive planning, the need for flexibility and some buffers in capacity development, and a balanced approach that accounts for the broader economic context.**

Cost efficiency gains cut costs, but low recruitment and delayed investments drive up delays

The analysis based on ACE data [4] shows that between 2008 and 2023, IFR flight-hours controlled increased by +21.8% while ATCO hours on duty increased by 2.6%. Hence, not only overall cost-efficiency (see Figure 2-17) but also ATCO productivity (green line) improved notably during that time.

However, at the same time, the intake of Ab-initio and on the job trainees reduced notably between 2010 and 2016 (dotted red line), most likely as the result of the cost containment or optimisation measures implemented by ANSPs, following the traffic downturn in 2009 and the start of the SES performance scheme in 2012.

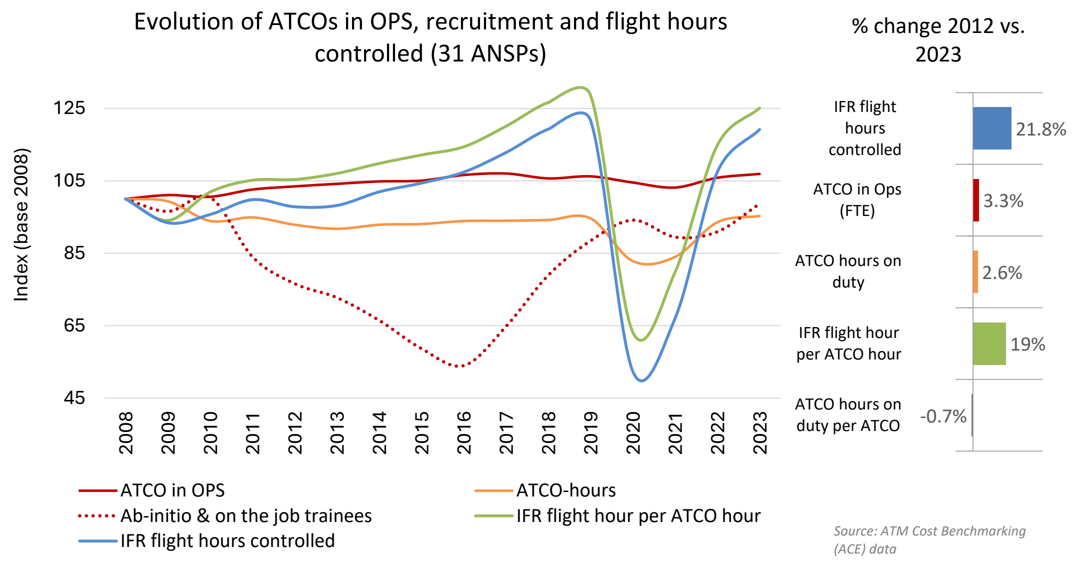


Figure 2-19: Evolution of ATCOs, recruitment and IFR flight hours controlled between 2008 and 2023

The Covid-19 period resulted in several parallel trends - departure of senior controllers, reduced ATCO hours on duty, and reduced training and recruitment, partly due to cost containment measures but also difficulties related to COVID social distancing requirements.

The latest data from the SES Performance Scheme monitoring report highlights a similar observation, revealing a 5% gap between planned and actual ATCO staffing levels in SES member states in 2023, with indications that this gap may widen in the coming years [5].

A similar trend can be observed in capital expenditures in the states subject to the SES Performance scheme. **Between 2012 and 2017[6], capital expenditures were some 25% below plan which means that projects have not been executed as foreseen** [6] [7]**.**

While this may result in temporary cost savings for some ANSPs, it poses a **risk that adequate capacity will not be available when required, potentially leading to disproportionally high delays and additional costs for airspace users who are already paying for these improvements through their en-route route charges.**

6 Time-series for this analysis is only available up to 2019. In the 3rd reference period, the reporting changed which does not allow the continuation of the analysis.

Since 2014, the plans of ANSPs (in all 10 approved editions of Network Operations Plans) have failed to align with the Network targets for capacity. Furthermore, actual capacity delivered has often been less than what was planned. ANSPs face limited consequences for not planning or not providing sufficient capacity.

Both, reduced recruitment and the delay of planned projects generated cost savings for some ANSPs but are likely to have contributed to the widening capacity gap since 2013 causing substantial additional costs to airspace users due to unacceptably high delays.

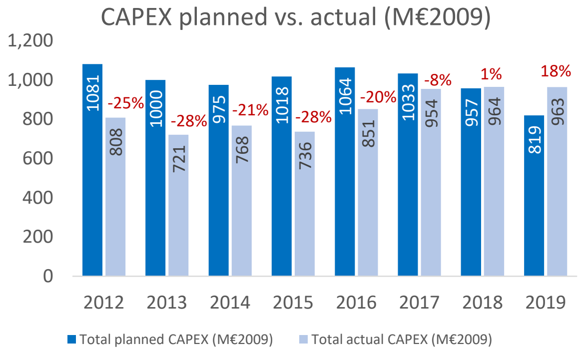


Figure 2-20: Planned vs actual CAPEX (2012-2019)

Performance scheme yields some gains, but was expected to deliver much more

The introduction of a performance-oriented approach to ATM over 20 years ago, followed by the launch of the SES performance scheme in 2012, led to some performance improvements in the EUROCONTROL area. **However, progress has fallen short of expectations, both in terms of speed and scale**.

Increased transparency and **focus on performance have sparked numerous local and regional initiatives that have contributed to improved ATM efficiency** amid rising traffic levels. However, the **airspace architecture in Europe, as well as the operational concept, processes, and technology, remain largely unchanged and still adhere to national boundaries** rather than operational needs, resulting in a non-optimal airspace organisation.

Shift to network-centric, trajectory-based operations driven by innovation is needed

To accommodate future traffic growth including new entrants, a more comprehensive approach to airspace design is essential—one that aligns operations with traffic flows rather than rigid national borders. The fragmentation of ATM provision across Europe presents challenges across operational, technological, and institutional dimensions. Despite visible local performance improvements**, there is a pressing need to adopt a true network-oriented approach to maximise performance benefits across airspace interfaces, capacity planning and deployment, and information flows**.

Marginal increase in ATCO costs could sharply reduce delay costs

The planning and deployment of adequate capacity levels may entail a cost to be borne by the ANSP but failing to deploy sufficient staffing levels results in disproportionally higher costs to airspace users and passengers which are in most cases sufficiently high to justify for example adding extra ATCOs. **Indeed, the cost of additional ATCOs to significantly reduce existing staffing-related delays would be only a fraction of the estimated €2.8 billion incurred due to delays in 2024.**The challenge for ANSPs is to ensure an adequate number of qualified ATCOs to meet current and future demands. This includes addressing present needs such as staffing shortages, sickness, retention, and competency, as well as preparing for future requirements, including staff replacement and the implementation of projects (e.g. SESAR).

Better capacity planning processes and a balanced approach will yield further gains

This underscores the **need for a balanced approach that considers the "total economic costs", which includes not only the direct ATM provision costs but also the indirect costs arising from inefficiencies, such as delays and additional fuel burn**.

The long-term perspective underscores the importance of a dynamic and proactive capacity planning processes with sufficient flexibility to adjust the capacity plans within a certain allowance. In a dynamic interconnected system such as the ATM network, the ability to adapt to changing conditions (flexibility/scalability) and to mitigate effects of unexpected events (resilience) becomes more and more important, particularly in view of the increasing impact of weather at both at local and network level. This will also help to better adjust the ATM network to economic and political turbulences and possible demand changes following the environmental debate.

Given the insufficient capacity plans and the reduced or delayed ATCO recruitment over the past years, **there is a critical need for robust monitoring, increased transparency, and a strengthened network planning process. This will ensure that future capacity plans are fully aligned with performance expectations and that they are effectively delivered**.

The European Network Manager (NM) has demonstrated the value of coordinated airspace management, capacity planning and flow management. **Strengthening the NM's role is crucial to effectively managing the European ATM network for the benefit of all stakeholders** (see also Chapter 5.4).

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

A future enabler with considerable synergy effects and benefits for the ATM network will be the increased digitalisation with common standards to enhance data accuracy and sharing. This transformation - which must also integrate airports as crucial traffic hubs - will enhance predictability and situational awareness. It will also enable the use of emerging technologies, such as artificial intelligence, to support decision-making and planning, while optimising the use of available resources.

The PRC's Transformation Support Strategy explained in the next chapter aims at supporting the implementation of innovative, data driven, solutions for the benefit of the European ATM network.

2.4 PRC TRANSFORMATION SUPPORT STRATEGY (TSS)

Despite numerous successful local and regional improvements which greatly enhanced the operational, economic and safety performance of ATM in Europe, the operational concept, processes and technology remained essentially the same over the past 20 years.

Given the high safety requirements, the coordination effort needed to harmonise standards, and regulatory requirements, substantial technological change has been slow compared to other industries.

Additionally, the organisation of ATC remains largely structured around national boundaries rather than operational requirements with many issues revolving around the level of operational, technological and institutional fragmentation and its impact on ATM performance in terms of operations and costs.

The PRC believes that addressing these challenges of the future and to benefit from network effects, this will require a fundamental rethinking of the current operations and the successful and targeted deployment of agreed strategic transformation priorities, based on the European ATM Master Plan. This process requires changes in local ANSPs, greater engagement of the network manager, and regulatory support to drive and sustain progress.

In support of this much-needed change and in alignment with established political strategies and policies, the PRC has developed its Transformation Support Strategy (TSS). This strategy positions the PRC as an independent broker, facilitating collaboration between stakeholders and initiatives. It seeks to promote dialogue among stakeholders, spotlight and monitor the performance of key flagship initiatives, and identify and address implementation challenges.

So far, the PRC hosted three successful workshops with key stakeholders to identify and discuss some major innovative projects already underway. These include:

- Digitalisation/ virtualisation: Digital and Remote towers; Virtual Centres;
- Trajectory based operations: "Green" trajectory (CO_2-optimal & user-preferred);
- Airport Operations: Airport Operations Centre (APOC); Time-based separation (TBS); and,
- Open Performance Data

Discussions with aviation stakeholders highlighted the significant potential of innovative projects and services, as well as the challenges hindering their widespread deployment. A major concern was the lack of regulatory support at both local and European levels, which increases time and costs and may foster reluctance towards adopting real innovation within the ANS community. Technological readiness alone does not guarantee widespread deployment; it must be complemented by coordinated and effective regulatory support.

More information on the PRC TSS is available @ ansperformance.eu/transformation/

PRC Transformation Support Strategy Workshops

Read the full summary reports of the workshops, including insights on ongoing projects with the potential to make a substantial contribution to the performance of the ATM system in Europe.

Workshop 1: In search of flagships for ATM transformation (February 2023).

Workshop 2: Flagships for ATM Transformation – Continuing the Journey (November 2023)

Workshop 3: Flagships for ATM Transformation – Continuing the Journey (November 2024)

3 Environment

CO_2 emissions EUROCONTROL area in 2024	ATM contribution EUROCONTROL area in 2024	Sustainable Aviation Fuel (SAF) & Out-of-Sector Measures are estimated to contribute 70% towards achieving Net Zero in 2050	Non-CO2 impact on climate change requires more research to carefully balance future actions
202.7 Mt + 9% vs. 2023	**ca. 9 %** Current best estimate of the benefit pool that can be influenced by improved ATM performance		

Reducing aviation's climate impact[7] is one of the industry's biggest challenges in the coming decades. While aviation also affects noise levels and local air quality, this chapter focuses on emissions and their impact on the climate.

The aviation industry now collectively strives towards the common global goal[8] of achieving net-zero carbon emissions by 2050.The PRC objective is to provide an insightful impartial assessment of the aviation industry's progress towards environmental targets in Europe and to highlight the role that ANS can play in reaching these established targets.

CO_2 has long-lasting effects on the global climate, regardless of when or where it is emitted. Non-CO_2 emissions, while shorter-lived, may impact the climate up to twice as much as CO_2, though significant uncertainties persist and further research is needed. Unlike CO_2, which directly correlates with fuel burn, contrail-related non-CO_2 effects are more complex and less understood. Their impact varies by location and duration, and they can have both warming and cooling effects on the climate.

The overarching goal is the mitigation of the climate impact of aviation (CO_2 and non-CO_2) and the PRC is committed to working in close collaboration with stakeholders to help achieve the challenging environmental goals.

3.1 THE ROAD TOWARDS NET ZERO EMISSIONS FROM AVIATION BY 2050

Globally, aviation is estimated to contribute 2.5-3.5% of total anthropogenic CO_2 emissions [8]. While this proportion may seem relatively small, it's expected to grow significantly in the coming years as aviation faces tougher decarbonisation challenges than other sectors, which are likely to reduce emissions more easily—assuming enough renewable energy becomes available.

The Paris Agreement sets global targets for reducing greenhouse gas (GHG[9]) emissions (all industries) to limit global warming, while the European Green Deal [9] outlines specific measures and policies to achieve carbon neutrality[10] in the European Union by 2050. As an intermediate goal, the European

7 The impact of aviation on climate originates from direct or indirect effects from emitting carbon dioxide (CO_2), nitrogen oxides (NOx), particular matter (PM) and water vapour into the atmosphere.

8 ICAO's Long-Term Aspirational Goal (LTAG) for international aviation and IATA's Fly Net Zero resolution.

9 GHG are the gases against which emission reduction targets were agreed under the Kyoto Protocol. Global warming factors are applied to each gas 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. Water vapour is an important natural GHG that is not covered by the Protocol.

10 The amount of greenhouse gas produced is equal to the amount removed from the atmosphere.

Green Deal aims to reduce emissions by at least 55% compared to 1990 levels by 2030. For the transport domain, the European Green Deal calls for a 90% reduction in GHG emissions by 2050 compared to 1990 levels, while working towards a zero-pollution ambition.

The latest figures from the European Environmental Agency (EEA) [10] show aviation's share of total GHG emissions dropped from 4.1% in 2019 to 2.3% in 2021 due to pandemic-related flight reductions but rebounded to 3.6% in 2022 (latest year for which data is available).

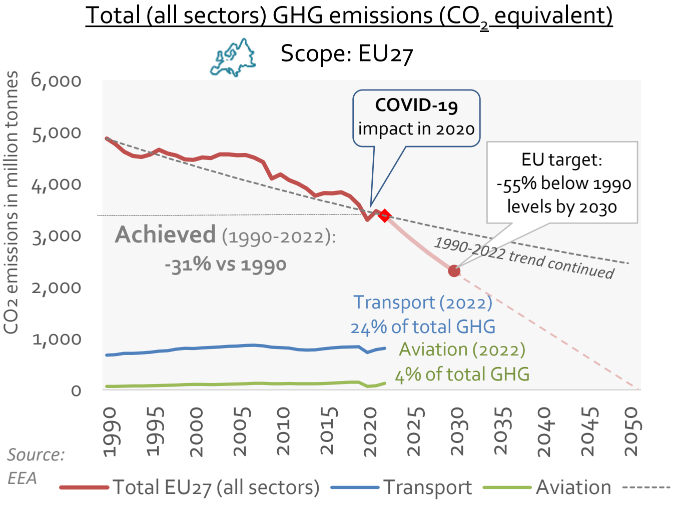


Figure 3-1: EU climate goals and road to climate neutrality

Figure 3-1 provides an overview of the total GHG emissions in the EU 27 States, agreed targets, and the relative share of transportation and aviation. It shows that a much quicker reduction than over the past 30 years is needed if the targeted carbon neutrality by 2050 is to be achieved.

The EUROCONTROL Aviation Sustainability Unit (ASU) supports the industry's efforts to reduce its environmental impact, particularly with regard to sustainability and decarbonisation. Using a validated method, ASU calculates data for potential use in the EU Emissions Trading System (ETS).

CO2 emissions back to 2019 levels - with less flights, longer routes, and larger aircraft

CO_2 emissions are calculated only for flights departing from the European region, based on aircraft type and the actual flown distance from origin to destination (arrivals are attributed to the countries of origin outside the area).

Figure 3-2 shows that, after the temporary break during the pandemic, the total CO_2 emissions are back to the level of 2019 (-0.4% vs 2019) even though there are still some 5% less flights which is partly due to on average longer flights and the use of larger aircraft.

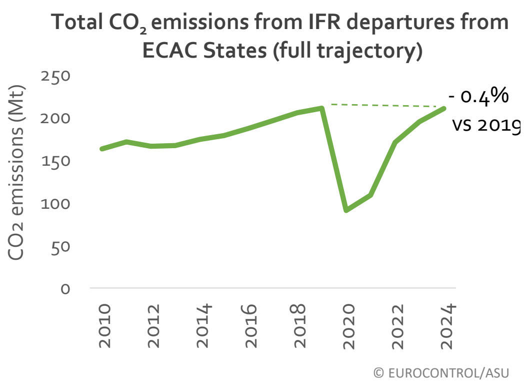


Figure 3-2: Total CO_2 emissions from ECAC departures

Total CO_2 emissions from aviation are primarily determined by three factors: the demand for air travel (number of flights), the energy efficiency per payload kilometre, and the carbon intensity of the energy used to power flights.

Despite the efficiency gains achieved through fleet renewals and improved energy efficiency thus far, it is clear that meeting the ambitious environmental targets set for 2050 will be an immense challenge, requiring a substantial acceleration of current efforts, especially with air transport expected to continue to grow.

Tech and Ops advances help but SAF and other measures key to achieving net zero

The latest EUROCONTROL Outlook 2050 [3], published in December 2024, groups the areas supporting the decarbonisation of aviation into: (1) fleet and technology (airframes and engines), (2) operations and infrastructure, (3) sustainable aviation fuel (SAF), and (4) out of sector measures (market based measures, carbon removal).

The most likely scenario forecasts 15.4 million flights in Europe in 2050, representing an increase of 52% or an additional 5.3 million flights compared to 2023. The uptake of SAF[11] (33%) and out of sector measures (37%) are seen as the key to achieving net-zero emission by 2050 (see Figure 3-3). Fleet renewals and aircraft technology are expected to contribute 20%, followed by Operations and Infrastructure (10%), which also includes ATM, airports and aircraft operations.

Aviation measures on the road to net zero need strong Out-of-Sector support

Given the time required for aviation industry-led measures to take effect and the ambitious timeline of the targets, additional out-of-sector actions will be needed to achieve the targeted reductions in net CO_2 emissions.

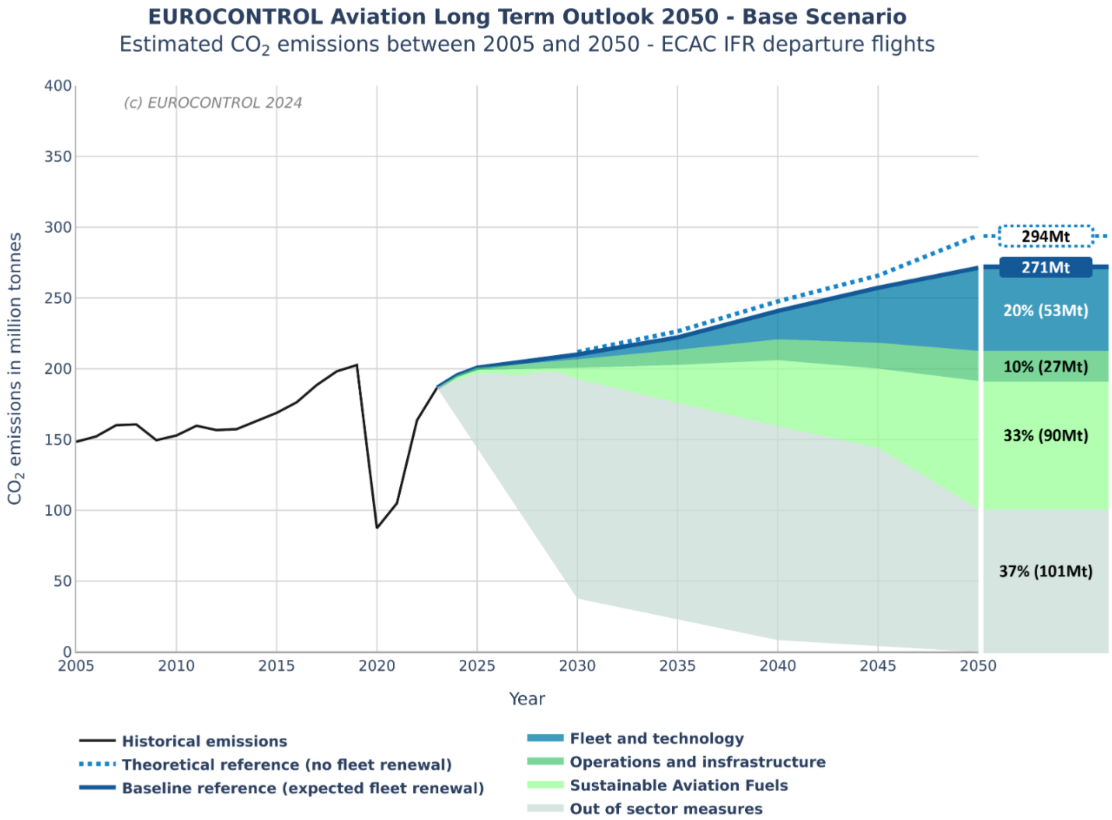


Figure 3-3: EUROCONTROL Aviation Outlook 2050 (base scenario)

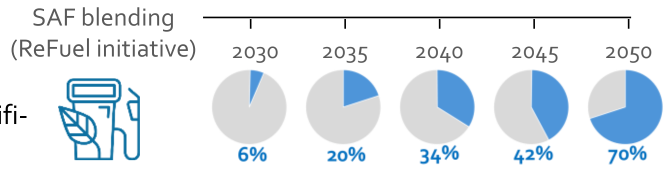
Sustainable fuel vital to reach net zero, but competition for energies is fierce

Sustainable fuel can boost the journey towards net zero but there is competition with other sectors for production capacities and renewable energy.

SAF can be produced from various sources: biofuels from biomass, synthetic fuels from carbon-based feedstocks, and power-to-liquid fuels using renewable energy to convert water and CO_2 into hydrocarbons. The main challenge lies in the high cost of SAF production, driven by the need for renewable resources and energy, which also compete with other decarbonising sectors. All these solutions require vast amounts of renewable energy to be viable.

[11] SAF has a similar energy density as fossil jet fuel and the existing infrastructure can be used largely unchanged.

SAF uptake in Europe in 2024 was still below 1%. As part of the EU "Fit for 55" package [11], the ReFuelEU Aviation initiative mandates gradual milestones aimed at reaching 70% SAF uptake by 2050. Given current progress and the financial and energy resources needed, reaching the first big milestone of 6% SAF by 2030 will be very challenging and requires a significant acceleration of efforts.



As aviation strives for net-zero emissions, out of market measures will also be necessary to complement technological and operational advancements. These measures include global or regional emissions trading schemes, taxes on fuel or tickets, and adjusted charges to incentivise decarbonisation. The EU Emissions Trading System (EU ETS) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) encourage airlines to reduce CO_2 emissions. EU ETS uses a "cap and trade" model, while CORSIA allows emissions to grow if offset by projects like reforestation. Though still in early stages, carbon removal technologies could also offer a cost-effective way to help aviation meet climate targets.

Fleet renewal and innovations will drive benefits, but take years to spread

Innovations in aircraft design, propulsion, and aerodynamics have significantly improved fuel efficiency over time [12] and will also play a role in reducing future emissions. However, new aircraft technology typically takes decades to develop due to stringent safety standards and certification processes. Given the typical aircraft lifespan of 20-30 years, and with current supply chain issues delaying scheduled fleet renewals, it will take time for efficiency gains from fleet replacements to fully impact the entire fleet.

Alternative propulsion systems, such as hydrogen and electric-powered aircraft, could be pivotal for short- to medium-haul flights but are still years, if not decades, from becoming viable. The first electric aircraft was certified by EASA in 2020, but current battery technology limits its use to small, short-range planes. Hydrogen-powered small aircraft may arrive by the mid-2030s, but larger aircraft will require a complete redesign to accommodate liquid hydrogen.

SAF uptake will be particularly relevant for long haul flights - but boost is required

The decarbonisation of long-haul flights will remain one of the key challenges for aviation as they have and will continue to have a disproportionate impact on CO_2 emissions. While flights over 3,000 km make up less than 10% of all European flights, they are responsible for more than 50% of aviation's CO_2 emissions, with no viable alternative transport options in sight [3].

At the heart of aviation's decarbonisation problem is essentially the need to find a safe, cost-effective, and renewable alternative to fossil fuel with the energy density needed to provide the power for flight. A thorough examination of the extreme challenges and technological possibilities for decarbonising long-haul flights is provided in specific EUROCONTROL think papers [13] [14]. The amount of electricity needed to help decarbonising long haul flights would be equivalent to 24% of all ECAC electricity production in 2023.

Ultimately, achieving net-zero emissions in aviation will require significant time, resources, and financing, with a mix of technological, operational, and economic solutions.

While most initiatives will require time and take only real effect beyond 2030, improved ATM performance can already help now by addressing operational inefficiencies in the ATM system. For every tonne of fuel saved, an equivalent amount of 3.15t of CO_2 can be avoided.

3.2 DETERMINING THE ATM SHARE

In collaboration with the EUROCONTROL Aviation Sustainability Unit and interested stakeholders, the PRC has developed a methodology to systematically monitor CO_2 emissions from a gate-to-gate perspective and to identify ATM-related environmental inefficiencies in the EUROCONTROL area[12].

The work will enable a holistic view of the level of inefficiencies by flight phase, along with a breakdown by stakeholder group and geographical area. Validation of the methodology using actual gate-to-gate fuel data from 1.2 million flights revealed a 2.3% underestimation of fuel burn. To further refine the calculations, ongoing work with interested parties is focused on further validating the model and investigating the reasons behind this discrepancy.

The results are available on the EUROCONTROL "Flying Green" platform which offers a wide variety of tools and information in support of the transition from fossil fuels to sustainable aviation [15].

Total gate to gate CO_2 emissions

Different from the results presented in Figure 3-2, the CO_2 emissions in this section only consider flights within the EUROCONTROL area or the part of the trajectory within the airspace for flights to and from the area.

In 2024, the total gate to gate CO_2 emissions within the EUROCONTROL area were 202.7 million tonnes which represents an increase of 8.9% over 2023[13].

The left side of Figure 3-4 shows the daily total CO_2 emissions by flight between 2022 and 2024. The seasonal variation mainly driven by the higher number of flights in summer and the continuous recovery from the COVID-19 pandemic between 2022 and 2024 is clearly visible.

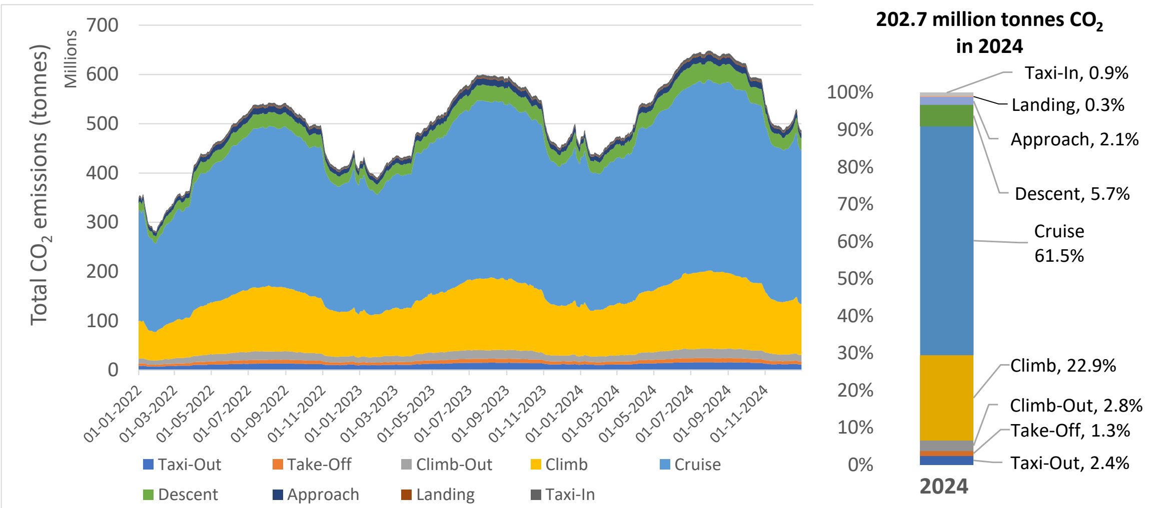


Figure 3-4: Total CO_2 emissions within EUROCONTROL area by flight phase

As expected, the cruise phase (blue) has the highest share of the emissions. It is apparent that the climb phase has the second highest share of emissions which can be related to the high-power settings to climb to the cruising altitude and the higher weight when compared to the descent phase.

More, longer and heavier flights increase CO2, but more efficient aircraft reduce impact

[12] The calculation is based on the EUROCONTROL advanced emission model (AEM). As no timestamps for the start of the take-off roll and end of the landing roll are available, a standard take-off roll of 42 sec. and a landing roll of 40 sec. have been used.

[13] Please note that the 2023 figures have been slightly revised compared to last year's report.

In 2024 there were still some 5% less flights than in 2019, but total CO_2 emissions have almost reached the level of 2019.

Figure 3-5 illustrates the underlying trends for the disproportionally higher growth of total CO_2 emissions compared to flight numbers over the past years.

Despite the growing number of more fuel-efficient next-generation aircraft reducing CO_2 emissions per unit of aircraft weight, total emissions still increased. **This was due to a rise in flight numbers, with flights becoming longer and heavier on average—outpacing the gains in fuel efficiency**.

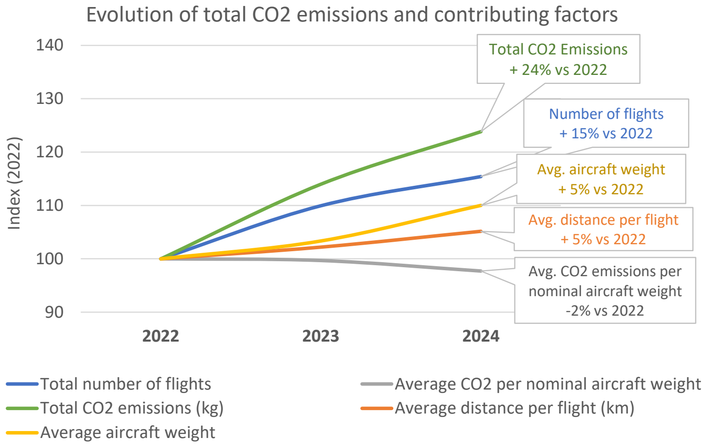


Figure 3-5: Evolution of total CO_2 emissions and contributing factors

Figure 3-6 shows the share of flights, distance flown within the EUROCONTROL area, and the CO_2 emissions by market segment in 2024.

Mainline and low-cost carriers operate a similar number of flights, but the distance flown and the share of CO_2 emissions is notably higher for mainline carriers. This is driven by fleet differences—low-cost carriers typically use a uniform fleet of fuel-efficient narrow-body aircraft, while mainline carriers operate a more diverse mix, including larger aircraft for long-haul routes, which increases overall emissions.

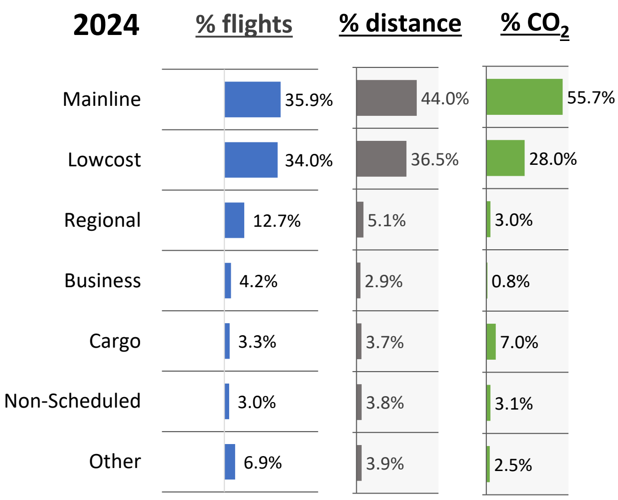


Figure 3-6: CO_2 emissions by market segment in 2024

It's also worth highlighting that **regional services and business aviation accounted for 12.7% and 4.2% of flights in 2024 but contributed only 3% and 0.8% of total CO_2 emissions,** respectively.

As highlighted in previous analyses, a significant share of CO_2 emissions comes from larger aircraft operating long-haul routes. In 2024, **the two largest aircraft categories accounted for just 13.6% of flights but generated nearly 48% of total CO_2 emissions**. In contrast, narrowbody aircraft contributed a similar share of emissions but accounted for two-thirds of all flights in the EUROCONTROL area.

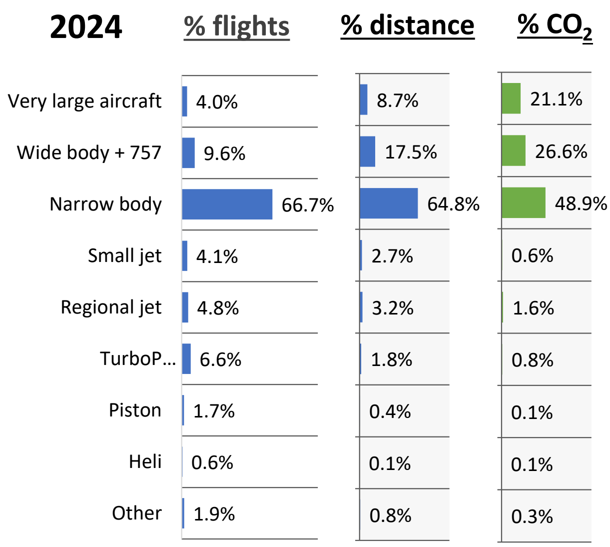


Figure 3-7: CO_2 emissions by aircraft class in 2024

It's important to note that the contribution of each market segment or aircraft class to the total CO_2 emissions does not provide an understanding of the CO_2 efficiency per unit transported. The PRC is conducting complementary analyses to better assess performance improvements from more fuel-efficient aircraft and will report on these findings in future publications.

But what is the level of inefficiency?

Despite a considerable number of analyses addressing emissions from aviation, it is still difficult to get a good gate-to-gate perspective of the level of operational inefficiencies and the "benefit pool" that can realistically be addressed by ATM improvements. In this context it is important to point out that a certain level of inefficiency will remain (see Figure 3-8).

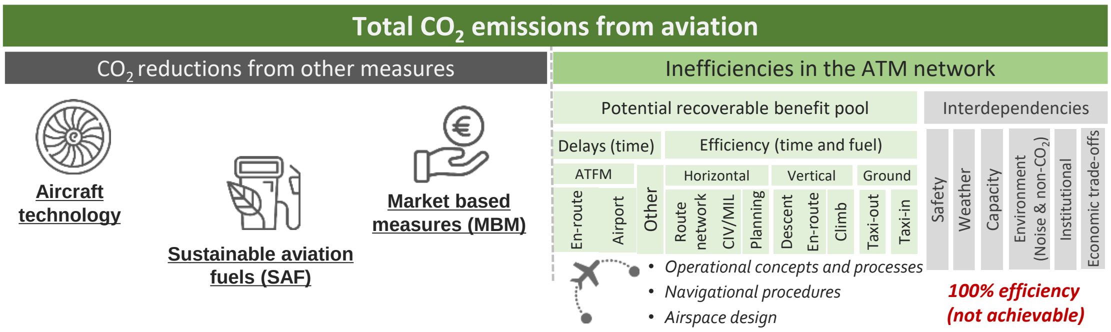


Figure 3-8: Determining the ATM share of the total CO_2 emissions from aviation

For a high-level estimate, the PRC used a percentile approach (10th percentile) based on gate-to-gate fuel burn for trajectories within the EUROCONTROL area, categorised by airport pair and aircraft type combination. The results suggest an **ATM-related benefit pool of 9.1% for flights within the EUROCONTROL area in 2024 (9.3% in 2023)**.

Complementary, the PRC is developing a methodology based on (optimal) trajectories to enable a further breakdown of the inefficiencies.

Figure 3-9 illustrates the trajectories used in this analysis together with the key factors (right side) considered to contribute to inefficiency between two trajectories. These impacting factors include wind, weather phenomena (thunderstorms and turbulence if available), ATM and network constraints (e.g. RAD constraints, ATFM regulations, scenarios), flight planning choices and tactical interventions done by ATC and airlines.

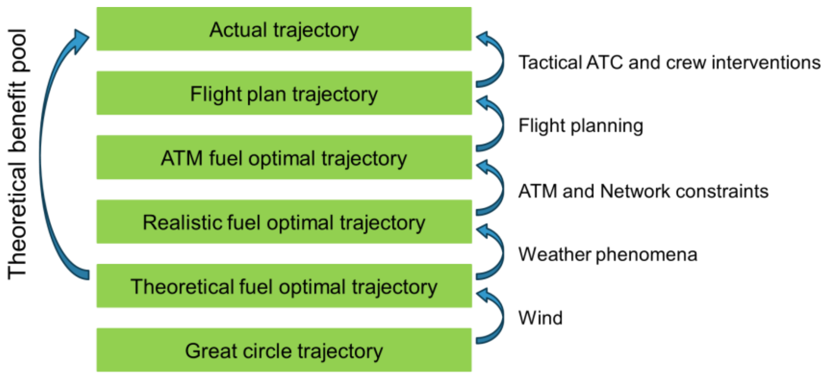


Figure 3-9: Optimal trajectories

The **great circle trajectory** represents the optimal flight path based on aircraft type, departure and arrival aerodromes, and take-off time. The **theoretical fuel-optimal trajectory** follows the great circle route but is further optimised for wind conditions. When weather phenomena (e.g., thunderstorms, turbulence) are also considered, the **realistic optimal trajectory** is obtained. Finally, the **ATM fuel-optimal trajectory** incorporates ATM and network constraints into the optimisation, reflecting operational restrictions.

The initial focus in the next section is put on the **great circle trajectory** and the **theoretical fuel optimal trajectory**.

Figure 3-10 and Figure 3-11 show the lateral and vertical views of a flight from Vienna (LOWW) to Tel Aviv (LLBG), depicting the actual trajectory (red), flight plan trajectory (green), optimal trajectory without wind (great circle – purple), and optimal trajectory with wind (theoretical fuel-optimal – cyan). This flight benefits from a favourable wind, as the optimal trajectory with wind (cyan) results in a shorter flight time despite covering a longer distance.

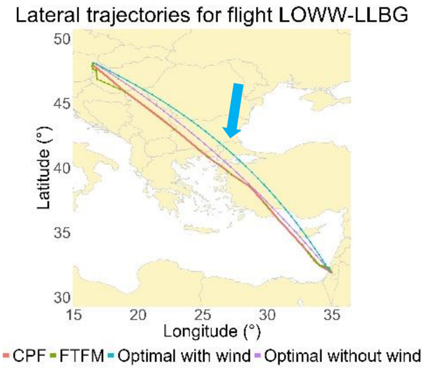


Figure 3-10: Lateral trajectories for an example flight from LOWW to LLBG

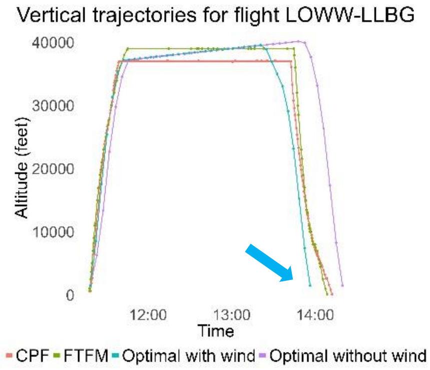


Figure 3-11: Vertical trajectories for an example flight from LOWW to LLBG

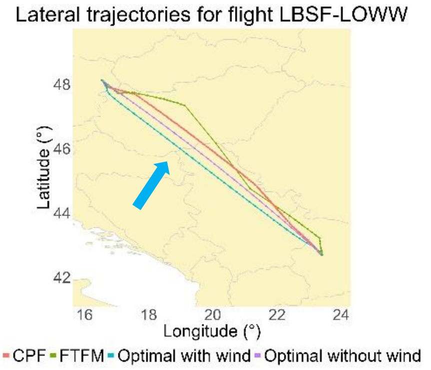


Figure 3-12: Lateral trajectories for an example flight from LBSF to LOWW

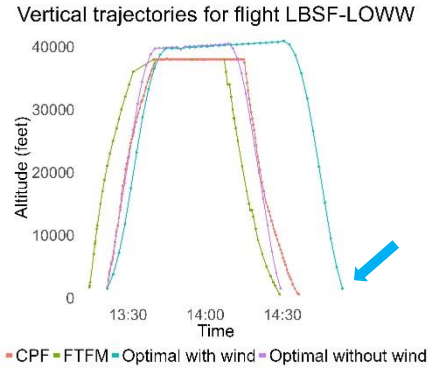


Figure 3-13: Vertical trajectories for an example flight from LBSF to LOWW

Conversely, a second example flight from Sofia (LBSF) to Vienna (LOWW) (Figure 3-12 and Figure 3-13) experiences a negative wind impact, increasing flight time. The optimisation algorithm models a cruising phase with a continuously increasing altitude to account for aircraft mass reduction, with future updates planned to limit cruising altitudes to typical Flight Level Allocation System (FLAS) levels.

Initial calculations from a sample of January 2024 flights indicate that 48.6% of flights produce lower CO_2 emissions due to wind, while 51.4% experience increased emissions, with **wind estimated to contributing to an overall CO_2 emissions increase of 0.7%**.

An additional feature to be considered in the definition of the future set of reference trajectories will be the ability to attribute inefficiencies to the relevant stakeholders. This will require to decompose the reference trajectories into multiple segments (e.g., FIR/State level, flight phase).

3.3 NON-CO_2 IMPACT OF AVIATION ON CLIMATE

Non-CO_2 effects from aviation on the climate could be as significant as, or even greater than, CO_2 emissions. However, their climate impact remains highly uncertain due to the complexity of modelling their evolution and the lack of observational data.

Non-CO_2 aviation effects are complex and therefore climate research is crucial

Current research suggests that Contrails - frozen water vapor trails formed in ice-supersaturated regions (ISSRs) as a result of aircraft exhaust - are a significant driver of aviation's non-CO_2 climate impact. Contrails formation depends on a variety of factors, including atmospheric conditions, location, aircraft type, and fuel composition, making their occurrence challenging to predict. Contrails can influence the climate in two ways: they can cool the planet by reflecting incoming solar radiation or warm it by trapping outgoing longwave radiation. The warming effect is however more significant. While their lifespan is significantly shorter than that of CO_2 emissions - lasting from minutes to hours - only persistent contrails significantly contribute to climate change due to their sustained impact.

The climate impact of persistent contrails can be mitigated through: (1) operational measures to avoid flying through ISSR, (2) technical advancements such as low-soot combustion engines, and (3) the use of alternative fuels like sustainable aviation fuels (SAF) and hydrogen to minimise soot emissions.

However, avoiding persistent contrails is challenging due to the difficulty of accurately forecasting ISSR in both time and location. Rerouting flights based on inaccurate forecasts can lead to higher CO_2 emissions from increased fuel burn without reliably preventing contrail formation if ISSR conditions exist along the new route. Accurate, flight-specific forecasts are essential to ensure climate benefits.

Balancing CO_2 and non-CO_2 effects is key

The key challenge will be determining whether an action ultimately benefits the climate. This requires calculating CO_2 equivalents, including non-CO_2 effects, to assess a flight's overall climate impact—whether during pre-flight planning or in-flight trajectory optimisation. Both approaches currently involve significant uncertainty and may also increase pilot and ATC workload.

Improving research, data and monitoring for better models and understanding

To better understand and mitigate non-CO_2 emissions from aviation, more comprehensive data and improved predictive models are crucial. Several initiatives have been launched to further develop the knowledge on non-CO_2 emissions from aviation:

- Non-CO_2 Monitoring, Reporting and Verification (non-CO_2 MRV): The European Commission (EC) has introduced new regulations requiring aircraft operators under the EU Emissions Trading System (EU ETS) to monitor and report non-CO_2 effects starting in January 2025. Airlines have raised concerns about the timing, data complexity, costs, and scientific uncertainty regarding the new reporting requirement. Initially, reporting applies to intra-EEA flights and flights from the EEA to Switzerland and the UK for 2025 and 2026. From 2027, the scope will expand to include all flights. Supported by EUROCONTROL, the EC is developing the non-CO_2 Aviation Effects Tracking System (NEATS) to automate monitoring and reporting in support of airspace users.
- The Aviation Non-CO_2 Expert Network (ANCEN): Also launched by the EC, ANCEN comprises experts from diverse sectors, including airlines, air navigation service providers, manufacturers, fuel producers, government agencies, regulatory bodies, and academia —to provide objective, timely, and credible technical advice about ways to mitigate aviation's overall climate impacts from both

CO_2 and non-CO_2 emissions. ANCEN will inform policy discussions on developing and implementing effective actions within Europe and internationally.

- ContrailNet: Launched by EUROCONTROL, Airbus and Thales, is an initiative to facilitate and stimulate the exchange of observation data relating to contrails. The aim of this data exchange is to support research into physical and observational models and to promote the development of validation tools.
- SESAR: Several SESAR Green Deal projects (CICONIA, CONCERTO, E-Contrails, AEROPLANE, F4EClim …) that will contribute to enhance knowledge about contrails formation and climate impact as well as operational mitigations.

Given the uncertainties surrounding the climate impact of non-CO_2 emissions and the experimental nature of contrail avoidance technologies, future measures must strike a careful balance. Further research is essential to:

- deepen our understanding of non-CO_2 emissions;
- improve the dynamics of contrail formation and forecasting; and,
- assess the interplay between CO_2 and non-CO_2-related climate effects.

The PRC will continue to follow the discussions and research progress on non-CO_2 emissions.

3.4 FUTURE CONSIDERATIONS

Joint effort: While it is essential for aviation to minimise its impact on climate, the chapter emphasises that achieving the ambitious environmental targets will be challenging. It will not only require close collaboration among all stakeholders in the aviation value chain but also the support of policymakers.

SAF uptake: The ReFuelEU Aviation initiative is driving aviation's transition with a progressive mandate for SAF blending, aiming to increase SAF usage from under 2% today to 6% by 2030 and 70% by 2050. However, with current SAF production lagging, the scale of investment, energy resources, and infrastructure needed is immense. Accelerated efforts and stronger funding and incentives are essential to boost SAF production and commercialisation, making large-scale adoption viable and timely.

Non-CO_2 impact of aviation: Until the effects of non-CO_2 emissions are better understood, actions should weigh possible trade-offs to ensure a net climate benefit. This requires further research to improve predictive models and assess the scalability, fuel consumption impacts, capacity, and workload associated with solutions aimed at minimising non-CO_2 emissions.

Monitoring: Tracking aviation's environmental impact requires a transparent and comprehensive approach, incorporating new data such as SAF types and uptake. This will enable better monitoring of progress and help identify obstacles across key areas, ensuring the industry stays on track to meet climate goals.

Performance indicators: As more data becomes available, complementary indicators will allow to better assess aviation's direct climate impact of a flight. For example, a metric that calculates "net" CO_2 emissions per payload (passenger or cargo) could integrate factors like SAF uptake and aircraft efficiency. This would provide a more nuanced view of emissions, reflecting both fuel choices and technological advancements.

The PRC will continue to follow the discussions and research progress on the impact of aviation on climate and provide updates in publications. For more information on the PRC's work on environment visit the web page (ansperformance.eu).

4 Safety

Accidents with ATM contribution EUROCONTROL area	Reported Operational incidents EUROCONTROL area	Reported Technical incidents EUROCONTROL area	GPS Interference EUROCONTROL area
0	-4.7%	-25.6%	Up to 40%
Number of total reported accidents with ATM contribution between 2020 and 2023	2023 vs 2019 Reported Severity A+B Ops Occurrences	2023 vs 2019 Reported Severity A+B Tech Occurrences	flights potentially impacted by Radio Frequency Interference

Safety remains the top priority for ANS. Decades of advancements in equipment, operations, and safety tools have boosted Europe's safety standards. But with future growth and new environmental, operational, and technological challenges, continued vigilance is essential.

The first part of this chapter (Section 4.1) is based on occurrence data in the European Central Repository (ECR), reported to the European Aviation Safety Agency (EASA). With a view to show a more holistic perspective on ATM safety performance in Europe, Section 4.2 provides the Composite Risk Index (CRI) results. With the analyses relying on occurrence reporting usually lagging one year behind, Section 4.3 provides a different approach based on the detection of operational safety risks from trajectory data which enables to also look at results for 2024. Finally, the new section 4.4 will provide an overview on Communication, Navigation and surveillance risks.

4.1 REPORTED SAFETY ACCIDENTS AND INCIDENTS (2023)

The review of ANS safety performance in this section[14] is based safety occurrence data reported to the competent authorities of the EASA member States in the European Central Repository (ECR). The latest year for which reported data from the ECR is available is 2023.

No accident with ATM contribution over the past 4 years, but incidents increase

4.1.1 ACCIDENTS

No accidents involving aircraft over 2,250 kg Maximum Take-off Weight, with direct[15] or indirect[16] ATM contribution, were reported between 2020 and 2023.

In 2019, there was one accident with direct ATM contribution.

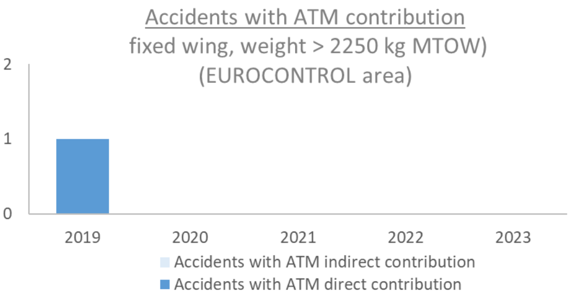


Figure 4-1: Accidents with ATM contribution

[14] Please note that, due to differences in methods, geographical scope and definitions, some of the figures shown in this chapter may differ slightly from safety reports prepared by other organisations.

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

[16] Where no ATM event or item was judged to be DIRECTLY in the causal chain of events leading to an accident or incident, but where at least one ATM event potentially increased the level of risk or played a role in the emergence

4.1.2 INCIDENTS

Different from the analysis of accidents, no MTOW limit applies for the analysis of ATM-related incidents in Figure 4-2 and Figure 4-3.

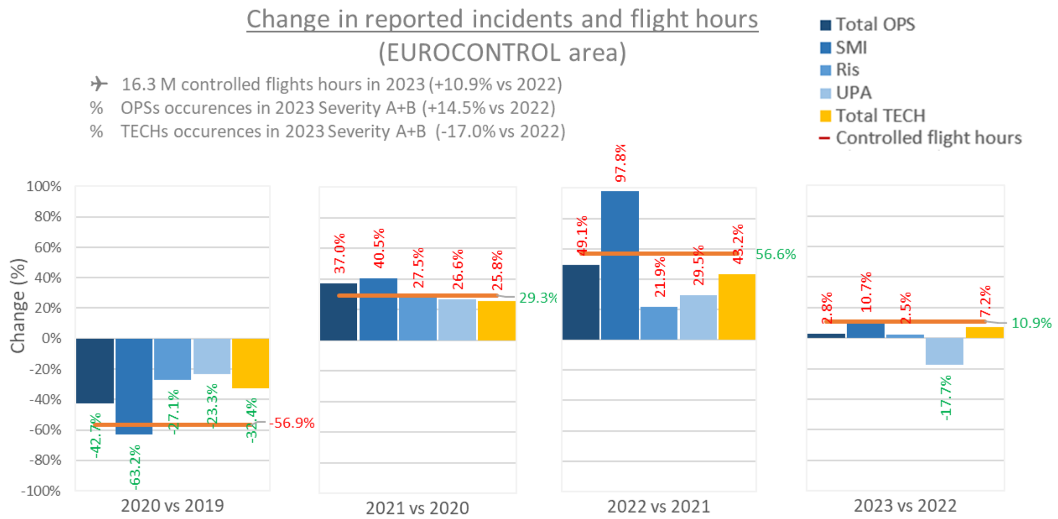


Figure 4-2: Change in reported incidents (2019-2023)

As air traffic continues to grow back after the COVID-19 pandemic, the number of incidents increased in 2023, particularly regarding Separation Minima Infringements (SMI).

The breakdown of incidents reported via ECR in 2023, as shown in Figure 4-2, categorises operational occurrences (62.3%) as follows:

9.2% Unauthorised Penetration of Airspace (UPAs), 3.5% Separation Minima Infringements (SMIs), and 3.8% Runway Incursions (RIs).

For more information about annually reports with general figures about safety, you can visit EASA Annual Safety Review and ICAO Safety Report.

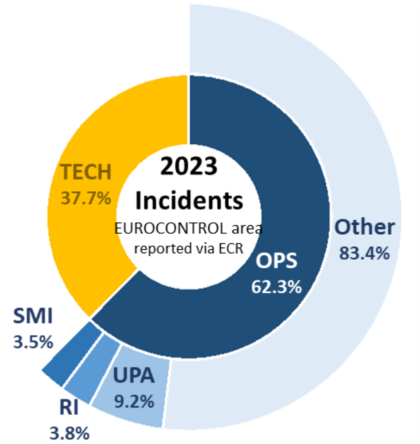


Figure 4-3: Distribution of incidents reported

4.2 COMPOSITE RISK INDEX (2023)

The PRC developed the Composite Risk Index (CRI) to provide a more comprehensive view of safety performance across States, accounting for multiple influencing factors. Based on historical safety data, the CRI serves as a proxy for safety risks within specific airspaces by combining four components:

(1) **safety data** from ECR, including occurrence types and severity;
(2) **traffic and exposure**, measured by flight hours and airport movements;
(3) **complexity**, which includes density and structural factors; and
(4) **reporting practices**, factoring in reporting rates and culture.

Unlike simple occurrence counts, the CRI also considers local conditions like reporting practices and traffic, offering scalable insights by State to identify key performance drivers.

of the occurrence encountered by the aircraft. Without such ATM event, it is considered that the accident or incident might still have happened.

Figure 4-4 shows the CRI for each State by traffic complexity in 2023. The State with the red arrow has for instance a medium traffic complexity but a comparatively high CRI.

Figure 4-5 shows the CRI grouped by traffic volume. The analysis shows the State with red arrow had a comparatively high CRI but a low traffic level. There were also several states with high traffic volumes and low CRI (blue bars in the middle section).

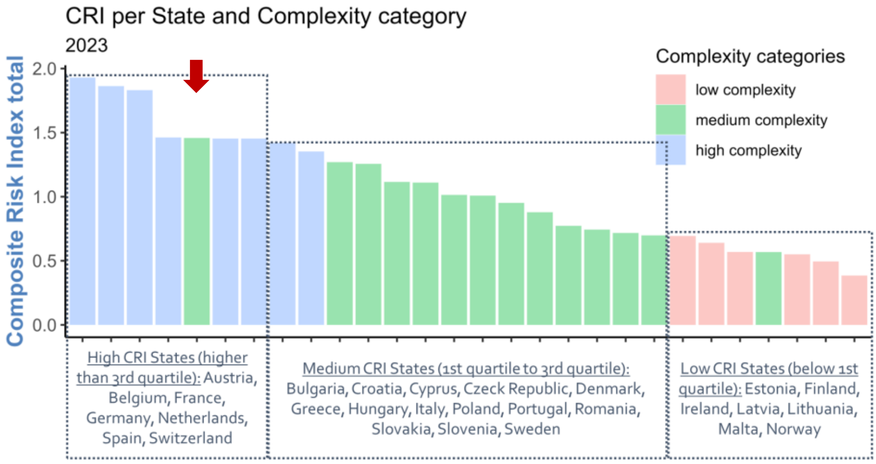


Figure 4-4: CRI per State and Complexity category (2023)

Complementary to the high-level view in Figure 4-4 and Figure 4-5, the index can be analysed over time and by its components to gain a deeper understanding of the underlying factors at play.

This analysis not only offers high-level insights for policy-makers but also provides local operational staff and safety specialists with a clearer view of risk exposure.

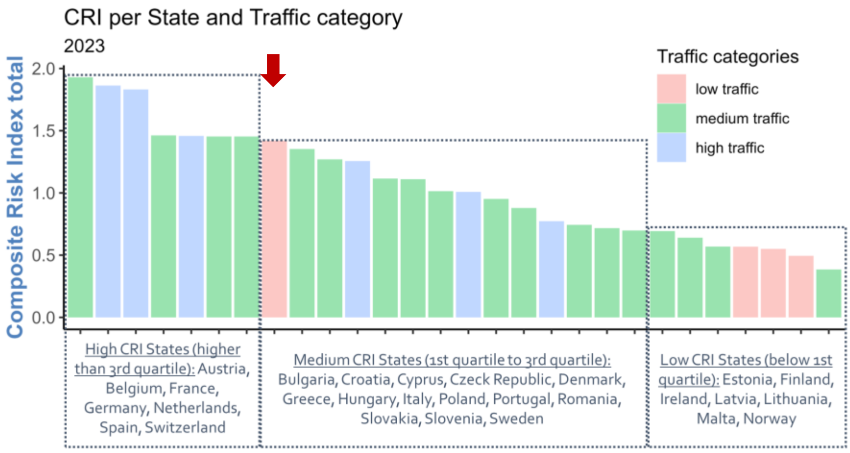


Figure 4-5: CRI per State and Traffic category (2023)

The PRC encourages active engagement of Member States and ANSPs and is committed to helping further improving the safety levels in Europe.

For more information the CRI methodology webpage and the PRC Technical Note explains the overall CRI computation, statistical methods used to model index weights, use and limitations and areas of further improvement and expansion.

4.3 ANALYSIS OF OPERATIONAL SAFETY RISKS

In addition to incident-report-based analyses, the PRC has begun assessing safety performance by detecting operational risks directly from trajectory data. This approach reduces reliance on potentially inconsistent reporting levels across states and allows for faster, near-real-time safety analysis following daily operations.

In this section, **Close Proximity Events** and Traffic Alert and Collision Avoidance System (**TCAS) Resolution Advisory (RA) events** are analysed to provide a comprehensive perspective on operational safety risks. **Close Proximity Events** identified solely from trajectory data, help detect potential precursors to loss of separation and provide insights into airspace density and traffic complexity.

TCAS RA Events occur when onboard systems issue advisories to pilots in response to detected conflicts, based on real-time in-flight alerts. Analysing both datasets allows the PRC to assess airspace safety from two complementary perspectives: identifying potential precursors through trajectory-based monitoring and evaluating instances where automated safety systems intervened.

4.3.1 Close Proximity Events

Ensuring safe separation between aircraft is a key aspect of ATM. Monitoring Separation Minima Infringements (SMI) is essential for safety performance, as these events occur when two aircraft breach the required minimum distance signalling a loss of safe separation.

Historically, SMI data has been monitored through state-reported incident reports, leading to inconsistencies across Europe due to variations in reporting cultures. To get a better understanding, the PRC is developing a data-driven approach to provide a more standardised and objective analyses across European states.

As an initial step, a **case study in European airspace (July 2024)** was conducted to explore the feasibility of using trajectory data for identifying **Close Proximity Events**—cases where aircraft were in proximity but without implying a confirmed infringement or a safety concern. This study was carried out in collaboration with CRIDA[17], evaluating whether their validated classification tool, already implemented in Spain, could be applied to detect close proximity events while filtering out cases that do not reflect actual separation concerns due to trajectory data constraints.

Previous studies tested ADS-B data for detecting potential safety relevant events but found it unsuitable due to excessive false positives. Instead, an alternative approach using Network Manager (NM) trajectory data was explored. Recorded at 30-second intervals, these trajectories reduce false positives but may miss brief separation losses due to data granularity.

A **purely geometric approach**—defining separation as **≤5NM horizontally and ≤1000ft vertically**—was found to be insufficient for accurate monitoring. Many such cases do not indicate actual separation loss due to **ATC interventions, procedural manoeuvres, or surveillance data fluctuations**. Relying solely on these thresholds would result in a high number of false positives, distorting the safety picture and requiring extensive manual review.

To improve detection, a classification model developed by CRIDA was applied to distinguish **Close Proximity Events** that may be precursors to safety-relevant situations from those that are operationally acceptable. This model integrates additional factors such as aircraft convergence, trajectory trends, and track anomalies, allowing for a more refined selection of cases requiring further safety assessment.

In Figure 4-6, the distribution of **Close Proximity Events** is represented, comparing **Geometric Close Proximity Events** (identified solely based on separation thresholds) with **Model-Identified Close Proximity Events** (filtered through the advanced classification model).

Results from the analysed period in Spanish airspace show that approximately **25 Model-Identified Close Proximity Events per 100,000 flight hours** were detected as potential precursors to separation concerns. These cases

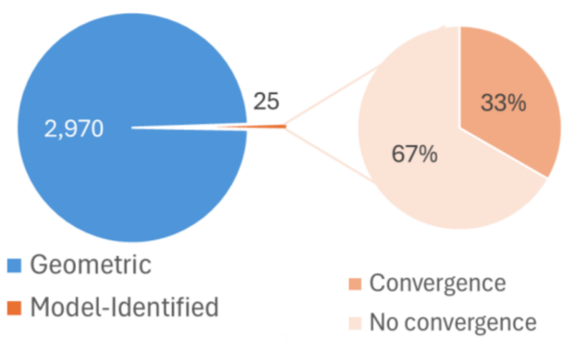


Figure 4-6: Close Proximity Events per 100k flights hours, Europe July 2024 (Geometric vs Model-Identified). Convergence distribution.

[17] Reference Center for Research, Development and Innovation in ATM. This Center brings together theoretical research through the participation of participation of the Polytechnic University of Madrid (UPM) and Spanish service provider, ANSP, ENAIRE.

account for only **0.8% of all Geometric Close Proximity Events**, emphasizing the importance of advanced classification techniques in distinguishing operationally relevant cases.

Additionally, **one-third of these events involved converging trajectories**, highlighting **convergence** as a significant factor when assessing close proximity events.

This proof of concept demonstrates the possibility of trajectory-based detection on a European scale.

A classification-based methodology ensures a standardised, objective assessment of close proximity events, enhancing airspace safety evaluations and consistency across operational environments. This supports the PRC's goal of harmonised, comparable safety metrics across Europe.

The PRC will continue enhancing its approach by increasing the temporal resolution of trajectory data to reduce undetected events and refining the classification model to improve accuracy and minimise false detections.

4.3.2 TCAS RA EVENTS

The Traffic Collision Avoidance System (TCAS) is an onboard system designed to enhance air traffic safety by detecting potential conflicts between aircraft and providing **Resolution Advisories (RAs)** to pilots. TCAS monitors the surrounding airspace using surveillance data primarily from **Mode S transponders and ADS-B transmissions**. When a potential risk of collision is detected, TCAS issues **Traffic Advisories (TAs)** to increase situational awareness and, if necessary, **Resolution Advisories (RAs)**, which provide specific vertical manoeuvre instructions to avoid conflicts.

The data used in this report is obtained from **EUROCONTROL's Big Data LIVE environment**, capturing **ADS-B and Mode S** transmissions directly from aircraft. It is important to note that these are **not direct TCAS system logs**, but rather **downlinked broadcast messages** from aircraft. This means the dataset represents **raw surveillance data** without explicit validation regarding the operational nature or context of each recorded RA event.

Furthermore, it is essential to distinguish between **TCAS RA events** and situations that represent an **actual operational collision risk**. **Only few RA events indicate an imminent hazard**; some occur as part of TCAS's normal functioning, including **preventive advisories**. The **most operationally significant events** are those involving **closer proximity encounters**, particularly when **RAs require corrective manoeuvres with significant deviations from the original flight path**. This distinction is critical for accurately interpreting the data and assessing its relevance for **airspace safety analysis**.

TCAS: A vital additional safety net and data source for further risk reduction

Figure 4-7 shows the monthly distribution of flights with TCAS RA per 100,000 flight hours (May–Dec 2024), providing insight into RA frequency relative to flight activity. The observed rate is **1 RA every 12,500 flight hours**, lower than the 1 RA per 7,250 flight hours reported in *EUROCONTROL's ACAS Guide* [16]. This difference may be due to variations in data collection, geographical scope, traffic density, and RA identification criteria. Additionally, the guide found that **only 20%** of initial RAs lead to a subsequent RA. For the system to work, pilot compliance with TCAS RA is crucial in reducing the risk of collisions.

It is also important to clarify that Figure 4-7 **represents Flights with TCAS RA, not Encounters**. A flight with a TCAS RA refers to an RA occurring within a single flight, while an encounter involves two aircraft, where one or both may receive an RA. These metrics are distinct, as encounters do not always result in both aircraft receiving an RA. According to the *EUROCONTROL ACAS Guide*, **16%** of encounters had RAs on both aircraft, **80%** had an RA on only one, and **4%** involved Mode A/C intruders that could not receive an RA.

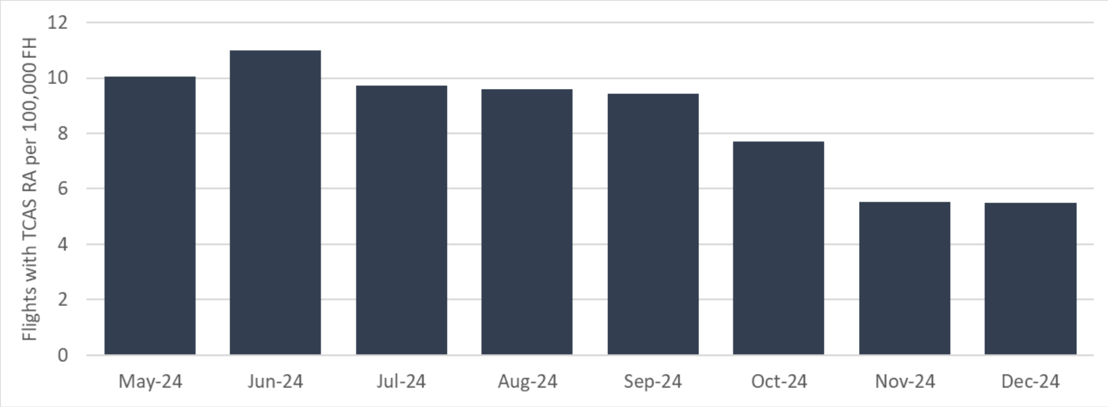


Figure 4-7: Monthly distribution of flights with TCAS RA per 100,000 flight hours (May-Dec 2024)

Figure 4-8 presents the distribution of TCAS RA events by altitude intervals, providing insight into where RAs occur across different phases of flight. This analysis helps assess whether specific operational conditions, such as high-density airspace in TMAs or en-route encounters, contribute more significantly to TCAS RA occurrences.

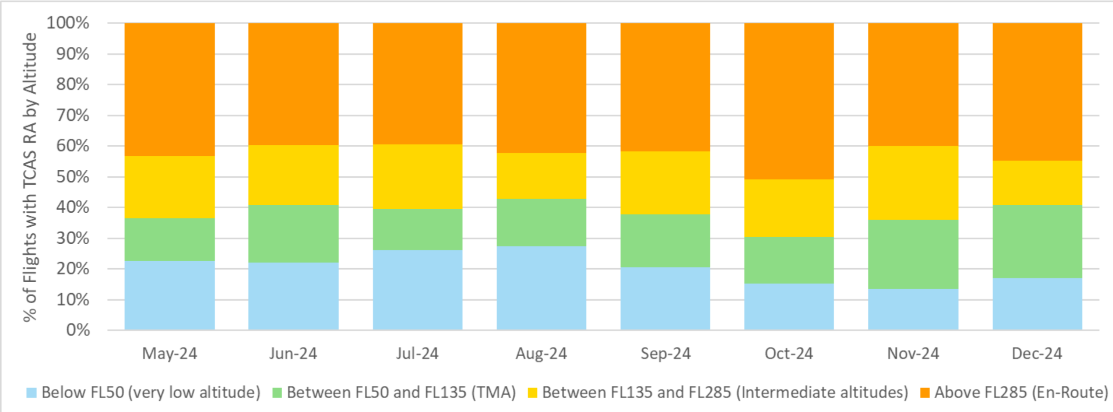


Figure 4-8: Altitude-Based Breakdown of TCAS RA (May-Dec 2024)

Most Flights with TCAS RA occurred at cruise altitudes, with over 40% above FL285, likely due to high traffic density and crossing trajectories. Around 20% were below FL50, linked to climb and descent operations or general aviation, and another 20% between FL135 and FL285, reflecting transition phases. The least affected range (15%) was FL50 to FL135. These trends highlight key phases where TCAS activations are more frequent.

This section provides an initial assessment of TCAS RA occurrences based on raw surveillance data from ADS-B and Mode S transmissions. **While the dataset offers valuable insights into RA trends, it does not include detailed trajectory information or encounter-level validation**. Future work will focus on refining the dataset to better capture operationally significant events and enhance understanding of TCAS behaviour in different airspace environments. This iterative approach will contribute to more precise safety assessments and inform ongoing monitoring of TCAS performance in European airspace.

Low number of high risk TCAS RA events suggests high safety levels in airspace

The observed rate of **one TCAS RA every 12,500 flight hours** serves as a valuable indicator of airspace safety in Europe. **RAs play a crucial role in preventing potential conflicts**, though the majority do not pose direct safety threats, as only a small fraction escalate into serious incidents.

While the primary goal is to prevent accidents and serious incidents entirely, some level of risk remains. Although absolute safety is unattainable in any operational setting, the industry is committed to ensuring and maintaining high safety standards across Europe. This is supported by robust safety systems, such as TCAS, which continuously mitigate risks. Ongoing efforts focus on detecting and monitoring safety-relevant events, as well as better understanding associated risk levels, with the aim of further enhancing safety in a complex and dynamic operating environment.

Together with interested stakeholders, the PRC will continue to explore the use of **trajectory data as a complementary source** for detecting operational safety events and will report on progress in future PRC publications.

4.4 COMMUNICATIONS, NAVIGATION AND SURVEILLANCE RISKS

Safety risks associated with GNSS (Global Navigation Satellite System) radio frequency interference and COMLOSS (Communication Loss) are critical issues in aviation that can compromise navigational accuracy, communication reliability, and ultimately flight safety.

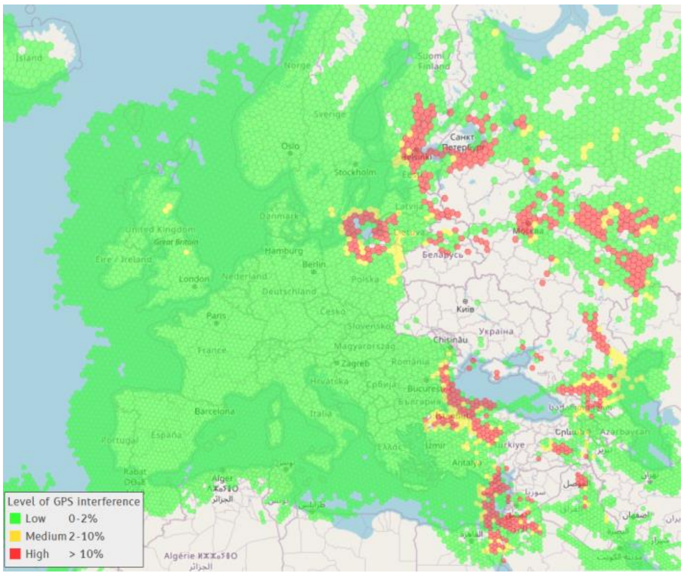
4.4.1 GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) RADIO FREQUENCY INTERFERENCE

GNSS signals play an important role in providing position, navigation, and timing information in support of aircraft operations ATM systems. Over the years, aviation has become increasingly reliant on Global Positioning System (GPS) - based navigation and surveillance systems to enhance accuracy, safety, and efficiency.

Up to 40% of flights potentially impacted by Radio Frequency Interference

However, GPS signals are relatively weak and thus vulnerable to both unintentional and intentional interference, leading to navigation errors or system malfunctions and a potential loss of situational awareness. This may force pilots and ATC to revert to older, less precise ground-based navigation aids, potentially leading to a higher workload on pilots and air traffic controllers, reduced airspace capacity and lower efficiency.

The impact of interference can vary, but signal jamming[18] and spoofing[19] can seriously affect aircraft navigation systems resulting in abnormal avionic system behaviour.



Source: https://gpsjam.org

Figure 4-9: GPS interference in Europe (27-October-2024)

Over the past years, a massive rise in GNSS Radio Frequency Interference (RFI) has been reported. The majority of RFI hotspots appear related to conflict zones but aircraft in flight can be affected at distances of up to 300km from these areas.

18 Locally generated interference to interrupt or distort GPS signals.

19 Transmission of false signals.

Up to 38% of European en-route traffic operates through regions intermittently but regularly affected by RFI [17].

While aircraft can fly safely without GPS, the significant increase in interference not only reduces the overall efficiency of the aviation system but, more importantly, poses a potential safety risk if no further mitigating actions are taken.

GPS interference can compromise the accuracy and reliability of navigation and surveillance systems integral to ATC, leading to efficiency losses, increased workloads, and safety risks. To mitigate these risks, key initiatives include:

- **Maintaining Backup Systems:** Keep and maintain traditional ground-based aids and inertial navigation systems as reliable complementary alternatives.
- **Raising Awareness**: Educating pilots and ATC on GNSS RFI and its operational impact.
- **Detection and Reporting**: Developing systems to identify, monitor, and share information on GPS interference hotspots.

4.4.2 COMLOSS

COMLOSS refers to the loss of reliable communication between the aircraft and ATC, which is essential for managing air traffic and ensuring flight safety.

COMLOSS can significantly impair situational awareness, leaving controllers unaware of an aircraft's intentions during unexpected manoeuvres, diversions, or emergencies, which increases the risk of conflicts with other aircraft. Without clear communication, delays in resolving conflicts arise, heightening the chances of mid-air collisions or near misses. Additionally, ATC's inability to provide real-time guidance during communication loss for unexpected weather, turbulence, or emergencies puts both the aircraft and passengers at greater risk.

A COMLOSS can also lead to operational delays, rerouting, and increased fuel consumption, while pilots and ATC may face added stress and workload as they work to reestablish contact while managing the flight.

Data provided by CNS unit of EUROCONTROL covering May to November 2024 was analysed to evaluate communication loss events in commercial flights. Only flights with a valid ICAO operator code and events lasting longer than 10 seconds were included, while test flights were excluded. Figure 4-10 shows the monthly count of Mode A "7600" events (over 10 seconds) in commercial flights. The analysis shows that, although COMLOSS remains a potential risk in aviation, the frequency of such events is low.

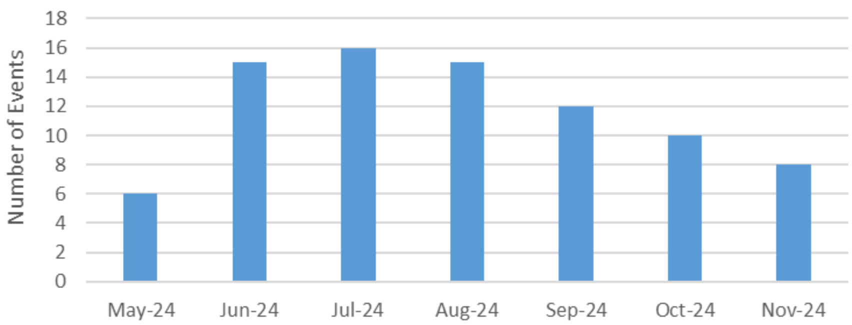


Figure 4-10: Monthly COMLOSS Mode A Code Events (Duration > 10 sec), (May-Nov 2024)

The impact is minimised through advanced communication technologies, procedural safeguards, and increasingly reliable backup systems. Nevertheless, it is essential that both aircraft and ATC have robust contingency plans in place to ensure safety.

Figure 4-11 categorises monthly COMLOSS (Mode A "7600") events based on their duration using the following indicative thresholds: events lasting less than 30 seconds are displayed in green, those lasting between 30 and 60 seconds are shown in yellow, and events exceeding 60 seconds are marked in red. Please note that these duration thresholds are indicative and not officially standardised, serving only as a guideline for visual trend analysis and risk evaluation.

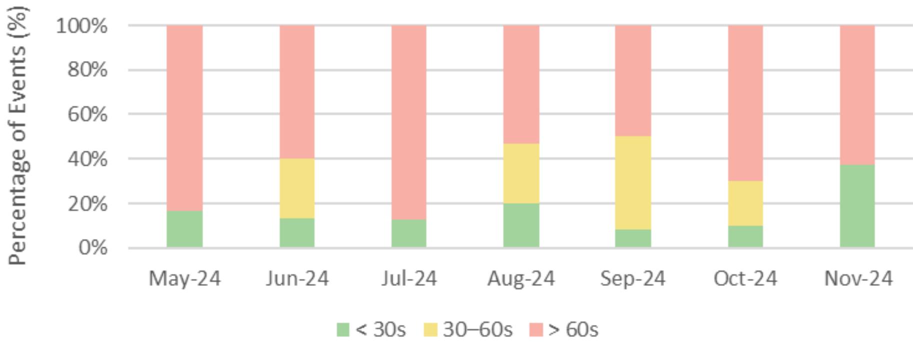


Figure 4-11: Monthly COMLOSS Events (Duration > 10 sec) by Duration, (May-Nov 2024)

Short-duration COMLOSS are often caused by equipment malfunctions or human error, but they are typically resolved quickly. To minimise the risk, commercial aircraft are equipped with multiple communication systems, such as VHF, SATCOM, and Datalink services. ATC uses redundant systems to monitor aircraft, even during a COMLOSS, and established procedures guide pilots when communication is lost.

5 Operational en-route performance

This chapter reviews operational en-route ANS performance in the EUROCONTROL area. Section 5.1 looks at the en-route capacity situation and Air Traffic Flow Management (ATFM) delays in 2024. Section 5.2 provides an analysis of horizontal and vertical en-route flight efficiency in the EUROCONTROL area in 2024. Given the potential capacity and efficiency gains and the positive impact on environment, the flexible use of airspace and civil military cooperation and coordination is addressed in Section 5.3. Finally, 5.4 evaluates the performance of the European Network and the Network Manager.

5.1 EN-ROUTE CAPACITY AND ATFM DELAYS

Total en-route ATFM delay	En-route ATFM delay per flight	% en-route ATFM delayed flights > 15 min.	Estimated costs of en-route ATFM delay
EUROCONTROL area in 2024	EUROCONTROL area in 2024	EUROCONTROL area in 2024	EUROCONTROL area in 2024
22.4 million minutes	**2.13 minutes per flight**	**4.8 %**	**2.8 billion Euro**
+ 24% vs. 2023	+ 0.32 min vs. 2023	+ 0.7 pt. vs. 2023	+ 0.5 bn vs. 2023
+ 30% vs. 2019	+ 0.56 min vs. 2019	+ 1.2 pt. vs. 2019	+ 0.65 bn vs. 2019

5.1.1 GENERAL OVERVIEW OF 2024

Overall, controlled flights in 2024 increased by 4.5% compared to 2023 but remained 4.3% below the level in 2019. Despite traffic still below 2019 levels, it is worth noting that the war in Ukraine and the conflict in the Middle East have led to a reduction in available airspace and notable changes in traffic flows resulting in traffic levels exceeding 2019 levels in some regions (see also Chapter 2.1).

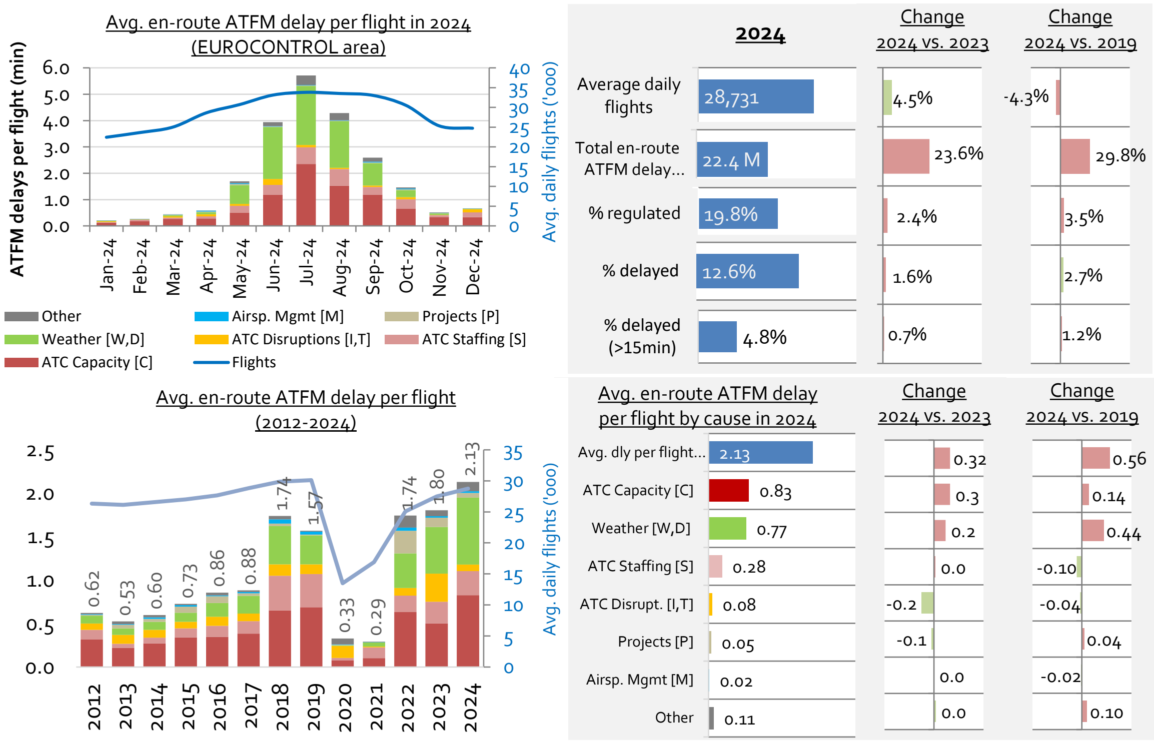


Figure 5-1: En-route ATFM delays in the EUROCONTROL area

En-route ATFM delay in 2024 continued to increase reaching the worst level since 2001

Following disappointing performance in 2022 and 2023, largely due to challenges in scaling operations to match the rapid rebound in traffic from the COVID pandemic, en-route ATFM delays surged further in 2024, reaching 22.4 million minutes - an increase of 23.6% compared to 2023. The total estimated cost[20] of the en-route ATFM delays add up to €2.8 billion.

The average en-route delay per flight rose from 1.80 minutes in 2023 to 2.13 minutes in 2024, the worst level since 2001. On average, 12.6% of flights in the EUROCONTROL area experienced en-route ATFM delays, with 4.8% delayed by more than 15 minutes.

En-route ATFM delays were not only higher than in 2023, they were also more concentrated during the summer compared to 2023, partly due to the absence of the 3 million minutes of en-route ATFM delays caused by ATC industrial action mainly in France in March and April 2023.

The number of days with an average en-route ATFM delay greater than 1 minute in the EUROCONTROL area consequently decreased from 218 in 2023 to 179 in 2024.

ATC Capacity and adverse weather attributed as the main reasons for high ATFM delays

When an ATFM regulation is implemented, the local Flow Management Positions (FMPs) assign a delay cause based on guidelines detailed in the Air Traffic Flow and Capacity Management (ATFCM) Operations Manual.

In 2024, ATC capacity (38.8%) was attributed as the main reason for en-route ATFM delay, closely followed by adverse weather (36.2%), ATC Staffing (13.0%), Other (5%), ATC disruptions (3.6%), and Special events / Projects (2.5%).

ATC Staffing considered to be a significant unknown factor when attributing ATFM delay

The PRC have previously raised concerns about the lack of transparency in the attribution of ATFM delays, leading to the Provisional Council and the Permanent Commission of EUROCONTROL adopting recommendations to improve the robustness of the ATFM system (PC/49).

Operational trials with stakeholders, completed in 2022, showed potential improvements in transparency with **ANSPs reporting that more than 80% of ATFM delays attributed to ATC Capacity or adverse weather, could be re-attributed to reflect that staffing was a factor at the time of regulation** [18].

Mis-identifying the real cause of capacity constraints, for example unavailability of ATCOs, prevents the effective mitigation and potential resolution of such constraints in the future.

The ANSPs, through the Network Operations Team (NETOPS), have now accepted the need for additional transparency in regard to the influence of staffing on capacity constraints attributed to ATC capacity, with the pending introduction of an additional delay code to be used when extra capacity could have been provided if additional ATCOs had been available. **However, to date, progress has not yet been made in efforts to improve transparency surrounding capacity constraints attributed to adverse weather conditions**.

[20] The delay has been monetarised using the results of the University of Westminster Study. The system wide average of 127 Euro (adjusted for inflation) per 1 minute of en-route ATFM delay has been used.

En-route ATFM delays attributed to bad weather & other skyrocket, requiring more analysis

Delays attributed to adverse weather conditions have increase from 866k minutes in 2012 to 8 119k in 2024 (+837%), which equates to more than €1.0 billion in costs to airspace users in 2024.

Thunderstorms, and associated turbulence, are the main meteorological phenomena affecting en-route capacity. "**Thunderstorms are most likely** in the spring and summer months and **during the afternoon and evening hours**, but they can occur year-round and at all hours."[21]

One of the functionalities of the ATFCM process is that changing the reason for a regulation in real-time, also changes the coding for all previous delays registered for the same regulation. For example, if a regulation was applied because of a lack of ATC staffing 'S' for six hours but was kept in place because of adverse weather conditions for one hour, the records will show that the weather regulation was applied for seven hours. All delays will be attributed to weather.

Since en-route weather delays are more likely in the afternoon or evenings, it is very likely that they will follow on from existing unrelated regulations, especially in constrained ACCs. In such cases, it is highly likely that the ATFM delays attributed to the weather regulations will also contain the delays that originally were attributed to other causes.

The ATFCM Operations manual refers to the regulation reason "Other". It states that "Other" should only be used in exceptional circumstances when no other category is sufficient. Over the period 2012 - 2024, ATFM delays attributed to 'Other' causes have risen ten-fold from 103k minutes in 2012 to 1 093k minutes in 2024, which equates to €139 million in costs to airspace users, in 2024.

Since there are regulation reasons already covering factors including excess demand and reduction in capacity due to military activity or training, it is not clear why the use of the 'other 'code is required.

Reducing en-route ATFM delay means managing all ATFM delay causes

The PRC is aware that twelve[22] SES – States, and one non-SES State, have chosen to implement incentive schemes for their ANSPs that apply differently for the various attributed reasons for the ATFM delays.

Such incentive schemes consider only ATFM delays attributed to ATC capacity (C); ATC routeings (R); ATC staffing (S); ATC equipment (T), Airspace Management (M) and Special Events (P). These incentive schemes therefore exclude all delays attributed to ATC industrial action (I); Weather (W) and Other (O).

Attributing an ATFM delay to ATC capacity, Airspace Management or ATC staffing could result in a financial penalty for the ANSP, which might not be applicable if the same delay is attributed to adverse weather or 'Other'. In fact, attributing ATFM delay to 'Weather' or 'Other' could even result in a financial bonus to the ANSP, if the C, R, S, T, M, P attributions are below certain levels.

If all ANSPs across the network were subject to such selective incentive schemes in 2024, more than 9 355k minutes of delay (>40% of the total network en - route delay) would not be considered even though this represents a cost of almost €1.2 billion for airspace users.

21 NOAA National Severe Storms Laboratory: https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

22 SES States: Belgium, France, Germany, Italy, Luxembourg, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain & Switzerland; non-SES State: United Kingdom.

5.1.2 PERFORMANCE OF INDIVIDUAL ACCs

En-route ATFM delays in 2024 were mainly attributable to DSNA which generated 21.2% of all en-route ATFM delay, followed by DFS (17.8%), HungaroControl (12.9%), ENAIRE (10.7%), ENAV (6.7%), and Croatia Control (6.5%).

The most delay generating individual ACCs in 2024 were Karlsruhe UAC (13.1%), Budapest (12.9%), Marseille (7.0%), Zagreb (6.5%), and Reims (6.0%).

Together the 5 most penalising ACC (out of 65 ACCs) generated 45.5% of the total en-route ATFM delay in 2024 (10.6% of total controlled flight hours).

Share of total en-route ATFM delay in 2024 (%)

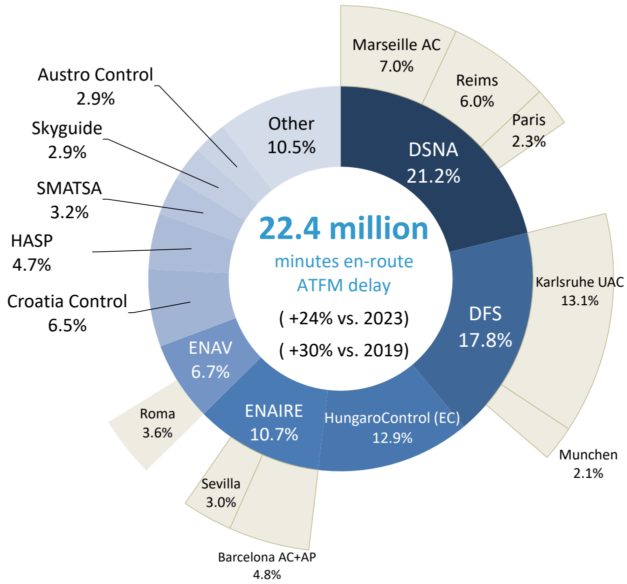


Figure 5-2: Share of total en-route ATFM delay in 2024

The PRC performed capacity analysis for each of these ACCs and contacted the relevant ANSPs to both confirm the PRC findings and to ask about planned actions for mitigation and resolution of identified capacity issues. The individual analyses are presented in Annex 1 to this document.

The Network Manager, in the Network Operations Report, identified some general issues that affected capacity performance in 2024:

- DSNA (France): lack of the delivery of the capacity committed in the NOP for some ACC;
- DFS (Germany): structural capacity issues to due lack of staff (Karlsruhe UAC), frequent adverse weather this summer;
- HungaroControl: did not deliver the capacity committed in the NOP (unexpected staffing issues), very high traffic demand (partly due to Ukraine). Adverse weather was also a factor;
- ENAIRE (Spain): did not deliver their NOP commitments for some of their ACCs;
- ENAV (Italy): did not deliver the capacity committed in the NOP (temporary staffing issues); some adverse weather.

5.1.2.1 Capacity bottlenecks in 2024

The ten most constraining ACCs for 2024 are shown below.

	Days >1 min	Total flights	Delayed flights	Total delay ENR	ATC Capacity 'C'	ATC Staffing 'S'	ATC Disruptions [I,T]	Weather 'W'	Other 'O' & Special Event 'P'
Karlsruhe UAC	155	1 851k	182k	2 934k	1 452k	103k	25k	1 291k	18k
Budapest ACC	152	1 060k	151k	2 895k	1 213k	61k	14k	662k	944k
Marseille ACC	115	1 217k	88k	1 556k	241k	721k	80k	434k	8k
Zagreb ACC	108	879k	67k	1 459k	619k	37k	6k	785k	5k
Reims ACC	129	1 111k	88k	1 352 k	558k	266k	17k	463k	45k
Barcelona ACC	105	1 059k	68k	1 071k	723k	4k	12k	309k	24k
Athinai + Makedonia ACC	117	1 028k	56k	1 051k	12k	864k	<1k	174k	0
Roma ACC	46	1 058k	39k	805k	478k	0	58k	267k	2k
Paris ACC	74	1 149k	48k	740k	89k	23k	18k	248k	361k
Beograd ACC	51	956k	36k	718k	134k	15k	2k	567k	0

Figure 5-3: Capacity bottlenecks in 2024

5.1.2.2 Capacity bottlenecks in 2023

	Days >1 min	Total flights	Delayed flights	Total delay ENR	ATC Capacity 'C'	ATC Staffing 'S'	ATC Disruptions [I,T]	Weather 'W'	Other 'O' & Special Event 'P'
Karlsruhe UAC	192	1 761k	214k	2 892k	1 679k	117k	28k	828k	187k
Reims ACC	163	1 039k	92k	1 476k	443k	462k	225k	308k	30k
KFOR Sector Group	157	160k	14k	183k	181k	0	0	3k	0
München ACC	157	932k	87k	1 103k	16k	73k	16k	246k	753k
Marseille ACC	146	1 118k	112k	1 774k	306k	579k	943k	421k	27k
Budapest ACC	105	998k	58k	1 015k	165k	32k	0	474k	337k
Paris ACC	103	1 120k	108k	1 774k	110k	227k	1 113k	287k	32k
Athinai + Makedonia ACC	87	957k	78k	838k	31k	577k	42k	188k	0
Bremen ACC	71	470k	21k	312k	162k	21k	3k	29k	26k
Lisboa ACC	62	621k	56k	328k	277k	23k	8k	4k	16k

Figure 5-4: Capacity bottlenecks in 2023

5.1.2.3 Persistent capacity bottlenecks

Note: In this section, and the sections that follow, the PRC looks at two of the main capacity drivers defined in the Capacity Planning Assessment & Guidance Document: Increasing sector throughput (sector capacity) and increasing number of sectors open (sector hours).

Several ACCs are present in both tables, indicating persistent problems with delivering the required capacity: Karlsruhe UAC, Budapest ACC, Marseille ACC, Reims ACC, Athinai & Makedonia ACC and Paris ACC.

2024 performance	Compared to	Traffic	Sector capacity	Sector hours	En-route delay	Comment
Karlsruhe UAC	2017	- <1%	Some up, some down	-17%	+70%	Lower staffing levels than in 2017.
	2023	+5%	Slight increase	-2%	+1%	Reduction of 170k mins of ATFM attributed to Special event / Other.
Budapest ACC	2018	+23%	Significant increase in some sectors	-14%	+726%	
	2023	+6%	General increase	-1%	+185%	
Marseille ACC	2019	+3%	Slight increase in summer 2024	+11%	-27%	
	2023	+7%	Slight increase in summer 2024	+1%	-32%	
Reims ACC	2017	+11%	Slight increase	-6%	+422%	
	2023	+7%	Restoration of reduced capacity	+6%	-8%	
Athinai & Makedonia ACC	2022	+20%	No change	+3%	+661%	
	2023	+7%	No change	+4%	+25%	
Paris ACC	2017	-5%	Slight reduction	-29%	+418%	
	2023	+3%	Restoration of reduced capacity	+10%	-60%	

Figure 5-5: Persistent en-route capacity bottlenecks

5.1.2.4 Improvements in performance

Several ACCs appeared in 2023 but are missing from the 2024 table, indicating a relative improvement in performance: Munich ACC, Bremen ACC, Lisboa ACC.

2024 performance	Compared to	Traffic	Sector capacity	Sector hours	En-route delay	Comment
Munich ACC	2023	+5%	Restoration of capacity	-3%	-58%	Partial restoration of sector capacities after iCAS implementation in 2023.
Bremen ACC	2023	+7%	No change	No change	-35%	Fewer capacity constraints due to military activity and training.
Lisboa ACC	2023	+8%	No change	+1%	-14%	Lots of capacity constraints due to ATC equipment in 2023.

Figure 5-6: Improvements in en-route capacity performance

5.1.2.5 New entrants

The third category of ACCs involves those that are making an entrance in the table for 2024, when they were not causing such a relatively significant bottleneck for capacity in 2023: Zagreb ACC, Roma ACC, Barcelona ACC, Beograd ACC.

2024 performance	Compared to	Traffic	Sector capacity	Sector hours	En-route delay	Comment
Zagreb ACC	2023	+13%	General increase	+1%	+278%	
Roma ACC	2023	+15%	Reduction in capacity	-1%	+3605%	NM reports staffing issues as causing significant constraint.
Barcelona ACC	2023	+9%	Slight increase in 1 sector	+7%	+38%	
Beograd ACC	2019	+29%	General increase	+7%	+1132%	

Figure 5-7: En-route capacity bottlenecks – new entrants

5.1.2.6 Excellent capacity performance

The PRC notes the high level of capacity performance provided by many ANSPs and ACCs, specifically those that had zero days where ATFM en-route delays were > 1 minute per flight in 2024: Dublin; Riga, Chisinau, Stockholm, Shannon, Yerevan, Vilnius, Ankara, Istanbul, Malta, Nicosia; Helsinki, and Tallinn ACCs.

5.1.3 OUTLOOK FOR 2025 AND BEYOND

En-route ATFM delay forecast for 2025 doubles to 2.7 min. per flight

Figure 5-8 shows the latest (NOP March 2025) en-route ATFM delay forecast for the period 2025-2029.

The delay forecasts are published by the Network Manager in the Network Operations Plan (NOP) and are based on the capacity plans, agreed with the ANSPs by January each year, combined with the EUROCONTROL STATFOR 7-year forecast traffic scenario.

The NOP delay forecasts use the STATFOR High scenario for the first year and the Baseline scenario for subsequent years.

Two values are provided for each year: one without disruptions such as industrial action and technical failures; the other including a statistical average of 0.15 minutes per flight to estimate the additional delays associated with technical disruptions and industrial action.

They do not include the effects of network measures that will be implemented due to expected major capacity bottlenecks. They include a statistical value for weather attributed delay of 0.49 min/flight which is significantly inflated from the previous value of 0.31 min/flight used in 2020 (pre-COVID).

The previous delay forecast from NOP 2024 and the binding Union-wide en-route capacity targets for 2025 - 2029, under the SES Performance Scheme, are also presented.

The forecast delays for 2025 and 2026 are double what was predicted for the same years in NOP 2024-2029. For the entire period, the forecast delays are more than 100% higher than the 'binding' Network targets they are intended to satisfy.

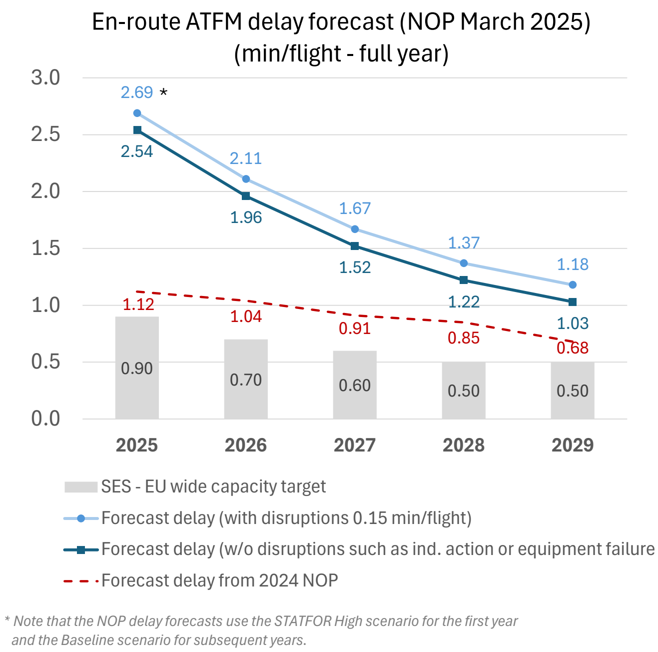


Figure 5-8: En-route ATFM delay forecast at Network level draft NOP 2025-2029 (Mar 2025)

Assuming traffic growth in the Network of 5.1% for 2025, en-route ATFM delay of 2.69 minutes/flight corresponds to a cost of €3.8 Billion for airspace users.

For the first time, the latest edition of the NOP also presents a view of the sector hours requirements for each ACC/ sector-group. It presents the sectors deployed over a sample period in 2024 and, based on existing declared capacities, provides an indication of the number of sectors that will be required during summer 2025 to handle the expected traffic demand.

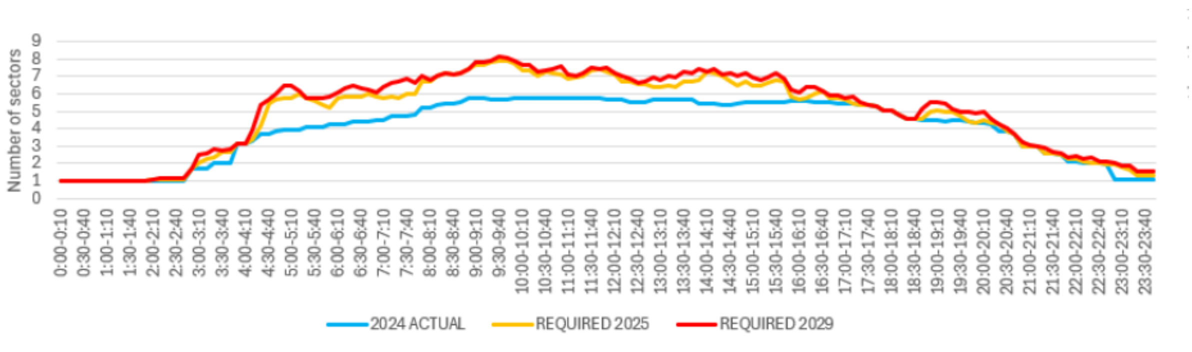


Figure 5-9: Extract from NOP 2025-2029 showing sector hour requirements for a specific sector group

This is a welcome development, providing additional information on the expected capacity requirement. The NOP could be further improved by comparing the current and historic sector hour commitments from the ANSP, to show how ANSPs have responded to the expected demand, considering past performance.

5.2 EN-ROUTE FLIGHT EFFICIENCY

This section evaluates en-route flight efficiency in the EUROCONTROL area with respect to its horizontal (distance) and vertical (altitude) aspects. There is a close link between flight efficiency and environmental performance (see Chapter 3). Every unused tonne of fuel saves an equivalent amount of 3.15t of CO_2.

The efficiency of a flight in the en-route phase is affected by a considerable number of factors involving different stakeholders (see Figure 5-10).

Not all those factors are under the direct control of ANS (adverse weather, military exercises) but ANS has clearly a role to play in reducing the constraints to a necessary minimum while maximising the use of airspace and ensuring safe separation of flights.

In view of external factors such as adverse weather and necessary as well as desired trade-offs, there will always be a certain level of flight inefficiency.

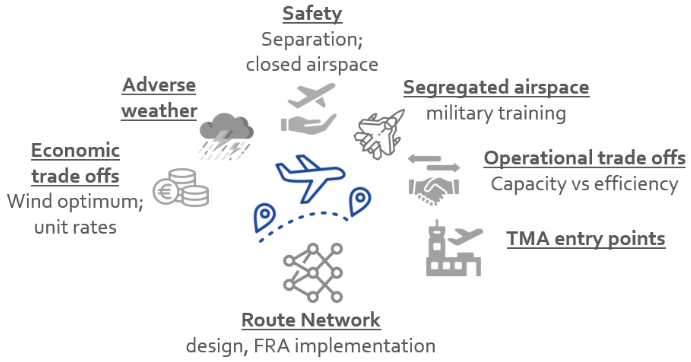


Figure 5-10: Factors affecting en-route flight efficiency

5.2.1 HORIZONTAL EN-ROUTE FLIGHT EFFICIENCY

Horizontal en-route flight inefficiency (%)	Horizontal en-route flight inefficiency (%)	Horizontal en-route flight inefficiency (%)	Inefficiencies related to cross border (%)
EUROCONTROL area Actual trajectory in 2024	EUROCONTROL area Shortest constrained route in 2024	EUROCONTROL area Filed flight plan route in 2024	EUROCONTROL area 2024
3.16 %	4.39 %	4.57 %	57 %
+/- 0.0 pt. vs. 2023	- 0.1 pt. vs. 2023	- 0.1 pt. vs. 2023	+/- 0.0. vs. 2023
+ 0.3 pt. vs. 2019	+ 0.1 pt. vs. 2019	+/- 0.0 pt. vs. 2019	+ 3.4 pt. vs. 2019

Horizontal Flight Efficiency (HFE) measures additional distance travelled compared to the great circle distance. While it does not fully account for meteorological conditions or user preferences, making complementary indicators necessary, HFE remains a reliable benchmark for tracking trends in flight efficiency over time.

Figure 5-11 illustrates HFE at the network level for three trajectories: (1) actual flown trajectory, (2) the planned trajectory according to the flight plan and (3) the shortest constrained route[23].

The shortest constrained route defines the limits for filing a flight plan, influenced by ANS constraints (like route networks and operational trade-offs) and state requirements (such as military airspace). The filed flight plan incorporates additional factors like airline preferences and weather considerations, while the actual flown trajectory reflects operational decisions made by ATC, often resulting in more direct routings.

For more information on the applied methodology and data downloads for your own analyses, please visit our web site @ https://ansperformance.eu/methodology/horizontal-flight-efficiency-pi/

[23] 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.

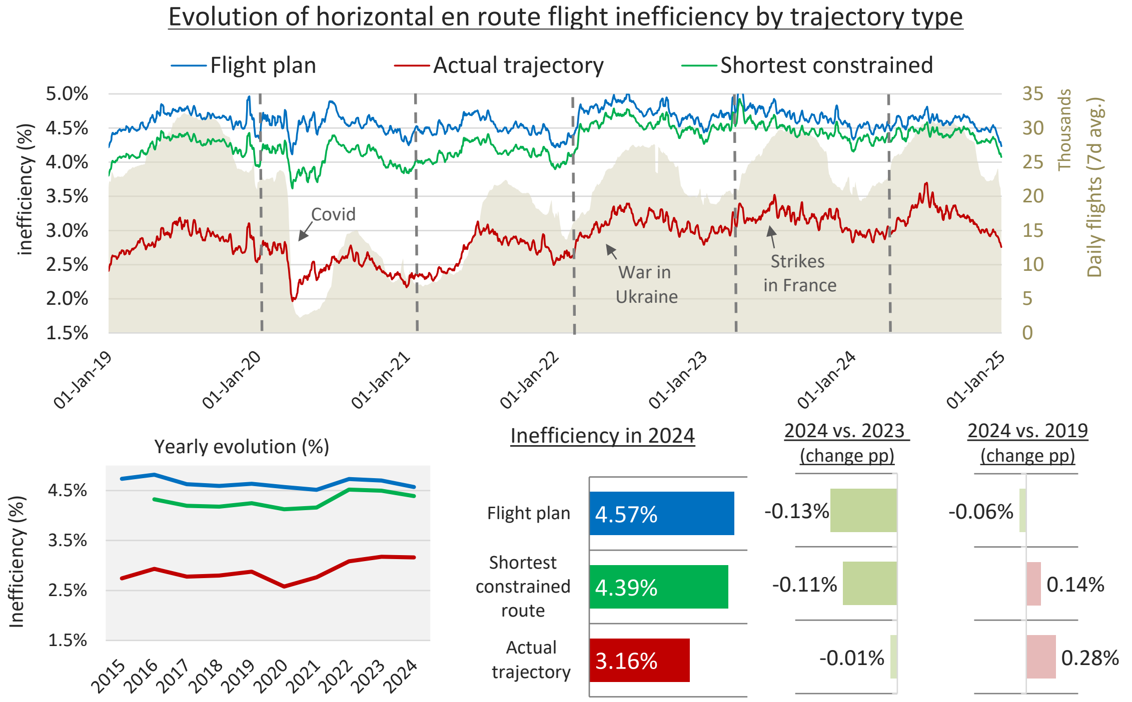


Figure 5-11: Horizontal en-route flight inefficiency (EUROCONTROL area)

Horizontal en-route flight efficiency saw significant improvement across all monitored trajectories after the COVID-19 outbreak in March 2020, as flight numbers in Europe dropped sharply (see Figure 5-11 at the top). Since then, traffic has gradually returned, reaching near pre-pandemic levels in 2024. However, as traffic rebounded, horizontal flight inefficiencies also rose again, surpassing even 2019 levels.

Flight efficiency declines due to Ukraine war, capacity issues, and severe weather

The observed decline in flight efficiency has several causes. Although most flights were not directly affected by airspace closures due to the war in Ukraine in early 2022, flight efficiency worsened in neighbouring states, affecting the entire network. An analysis suggests an increase of approximately 0.2-0.3 percentage points in the EUROCONTROL area.

Widespread strikes in France during March and April 2023 further contributed to inefficiencies. Additional factors included ATC capacity shortfalls and an increase in adverse weather events, which forced many flights to alter routes to avoid ATFM regulations. Together, these elements have driven a noticeable decline in overall flight efficiency between 2021 and 2024.

Compared to 2023, the efficiency of actual flight paths remained the same in 2024, but both flight planning and shortest constraint routes saw improvements. This suggests a slight reduction in network constraints, allowing airspace users to benefit from more optimal routing options when filing their flight plans.

Gap between planned and actual trajectory narrows, but more action is needed

Although this slightly narrowed the gap between the actual flown trajectory (red line) and the filed flight plan (blue line) in 2024, there is still a difference of 1.4 percentage points which suggests scope for further reducing constraints already in the flight planning phase.

While tactical shortcuts and operational flexibility are environmentally beneficial due to reduced fuel burn, these improvements in actual flight trajectories can introduce variability across the network, potentially decreasing predictability for ANSPs. Exploring ways to reduce network constraints, allowing for flight planning that aligns more closely with actual flown trajectories, will bring benefits to all stakeholders.

Figure 5-12 provides a breakdown of the horizontal en-route flight efficiency (actual trajectories) by day and enroute ATFM delay in 2024.

Each dot represents a day in 2024. Horizontal flight efficiency is clearly worse in summer.

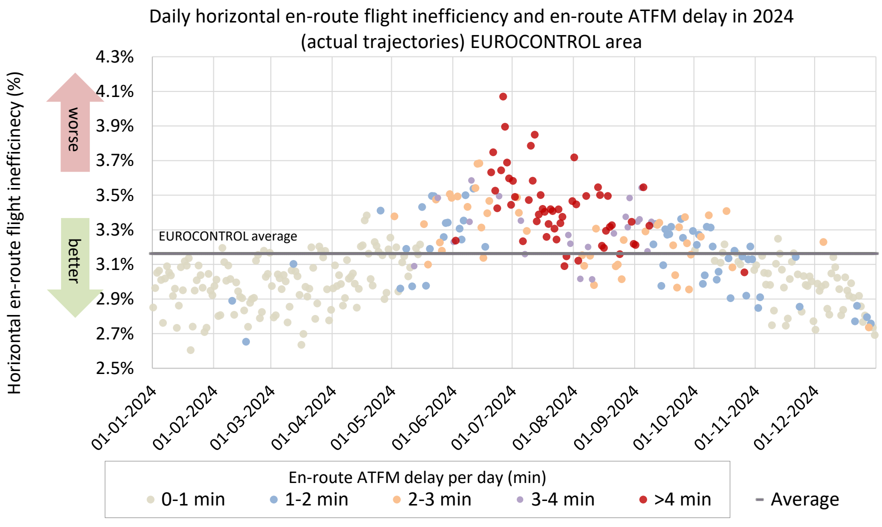


Figure 5-12: Daily horizontal en-route flight efficiency and en-route ATFM delays (2024)

The analysis indicates that the lack of capacity and particularly adverse weather events in summer 2024 had a notable negative effect on flight efficiency. Days with high en-route ATFM delays tend to have notably lower flight efficiency.

Figure 5-13 shows the HFE results in 2024 (actual trajectory) by State. The total additional distance on the right side is determined by the number of flights (left), the length of the flight segment in the airspace and the level of flight inefficiency (centre).

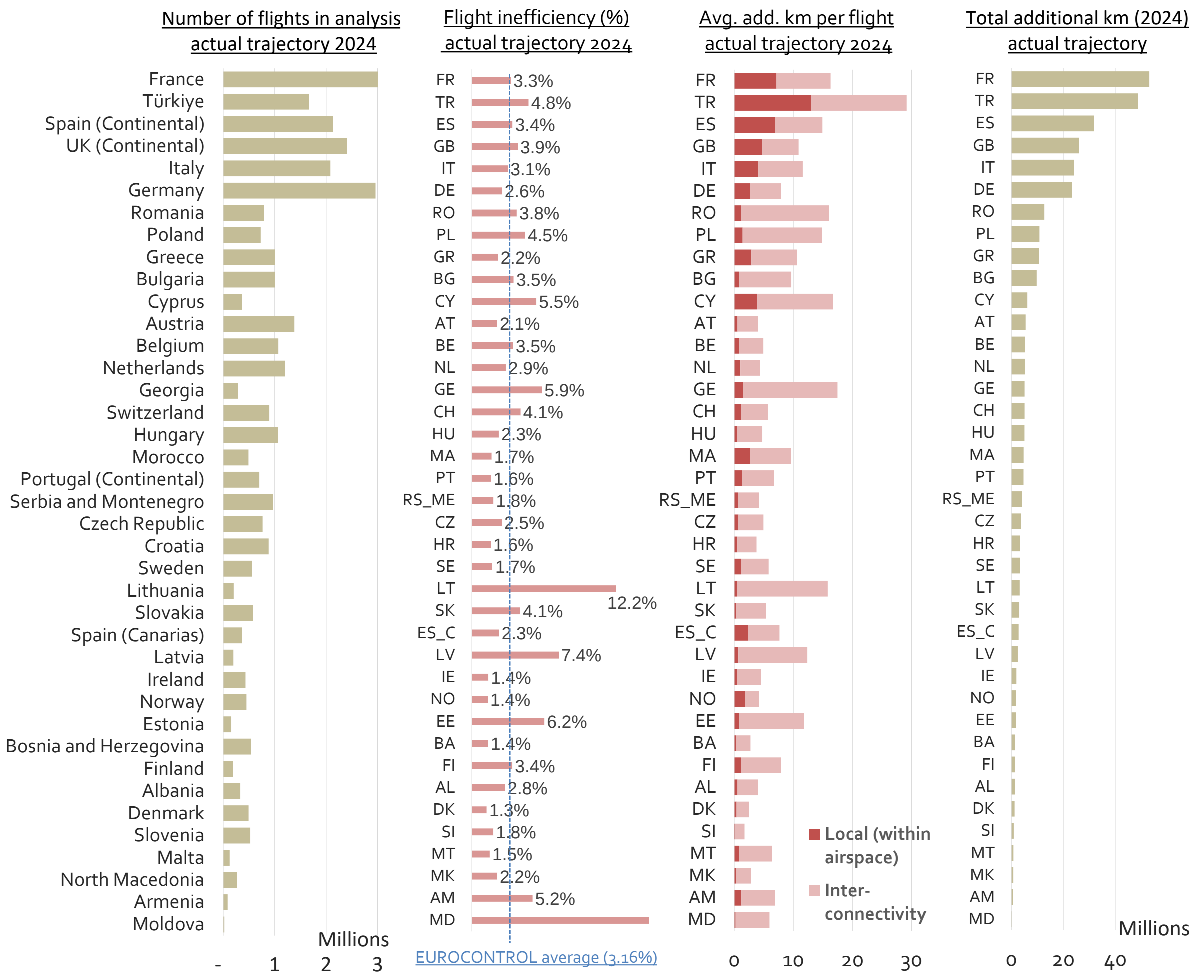


Figure 5-13: Horizontal en-route flight inefficiency by State in 2024 (actual trajectories)

Local efficiency, average distances flown, and traffic volume drive total extra distance

The largest states are the biggest contributors to the total additional distance, driven by a combination of inefficiency levels and the volume of flights in their airspace. However, some still show a relatively high local flight inefficiency component (indicated by the dark red bar), suggesting that further improvements within their airspace are possible.

Moldova, Lithuania, Latvia, and Estonia show a comparatively high level of inefficiency which is largely due to the impact of the war in Ukraine and the resulting airspace closures.

Flight efficiency is complex to measure due to the number of influencing factors (see Figure 5-10), and pinpointing the "inefficiency" to a specific actor or root cause can be challenging, especially when breaking it down into geographical regions. **Unlike local service providers, who focus on their immediate airspace (a "service-centric" view), flight efficiency metrics adopt a "flight-centric" perspective, evaluating the entire route from origin to destination, regardless of how many airspaces are crossed**.

Flight efficiency can therefore also be influenced by "interconnectivity effects," which occur when local inefficiencies are impacted by the surrounding airspaces. While the local component looks at inefficiency within a given airspace between entry and exit points, the interconnectivity component takes the entire route from origin to destination into account. This means that even if a flight crosses an airspace in a straight line, inefficiencies can still arise from the interfaces where the flight enters and exits that airspace, impacting the overall flight efficiency.

Free-Route Airspace in larger states and better interconnectivity to drive further benefits

The continuous implementation of Free Route Airspace (FRA) in Europe over the past years has been an enabler for improved flight efficiency, as it provides more airlines with a more flexible environment to file more efficient flight plans.

FRA was first implemented in Portugal in 2009 and mandated by EC legislation in 2011 [19].

According to the European ATM Master Plan [14] and EC Regulation No. 2021/116 [15] constant FRA implementation with cross-border dimension and connectivity to TMAs should be implemented by 31 December 2025.

Figure 5-14 shows the level of flight inefficiency in actual trajectories (x-axis) and filed flight plans (y-axis) by State in 2024, together with the FRA implementation level.

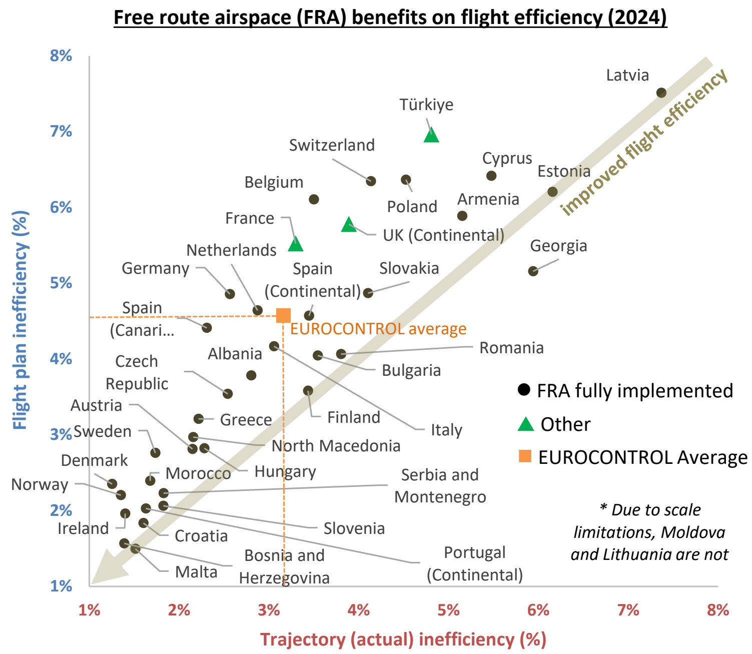


Figure 5-14: Horizontal en-route flight efficiency and FRA implementation

Except for Türkiye and some areas in France and the UK, FRA is now either partly or fully implemented in most parts of Europe. Given the size and traffic volume in those remaining states, there is clear potential for further improvement of horizontal en-route flight efficiency in the EUROCONTROL area.

Europe's free route airspace must grow together to unlock further network benefits

It is important to note that with the increased local implementation of FRA in Europe the network component gains in importance.

The analysis in Figure 5-15 illustrates this trend and shows that in 2024 more than half of the additional distance flown in the EUROCONTROL airspace can be attributed to the interconnectivity component meaning that States will have to explore cross-border initiatives with their neighbouring States.

In other words, if only local flight efficiency within national airspaces were considered, more than half of the inefficiencies would be overlooked.

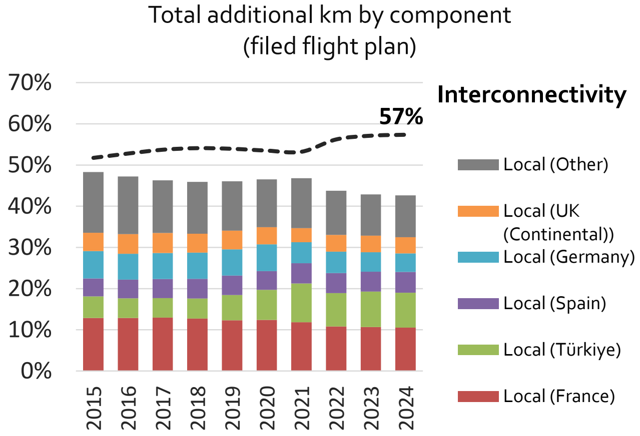


Figure 5-15: Interconnectivity vs local component

It's important to note that the interconnectivity component is also influenced by entry and exit points where flights connect to the EUROCONTROL network. Additionally, closed or restricted airspace along the most direct route, such as that around Ukraine or Russia, can negatively affect the interconnectivity component, further impacting the overall efficiency of the flown trajectory.

5.2.2 VERTICAL EN-ROUTE FLIGHT EFFICIENCY

Vertical en-route flight efficiency has a notable impact on fuel consumption as, in general, fuel burn decreases with increasing aircraft altitude. ATM can influence performance through the implementation of specific constraints such as level capping or other ATFM measures.

Vertical en-route flight efficiency notably improved following the COVID-related traffic reduction and the subsequent removal of many flow management measures.

Figure 5-16 shows the evolution of total vertical flight inefficiency (VFI) since 2019 for all airport pairs during the summer months. The total en-route vertical flight inefficiency during the 2024 summer was still below 2019 summer values but the year-on-year increase continues.

This increase in mainly due to the increase in traffic since the average vertical flight inefficiency per flight only marginally increased with respect to 2023.

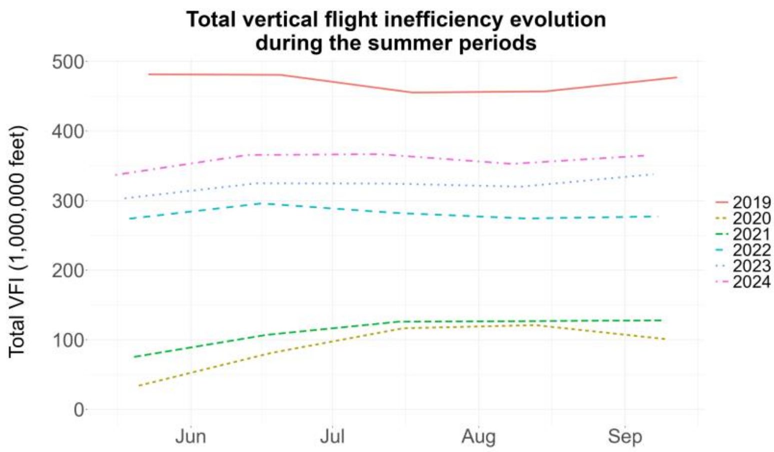


Figure 5-16: Total en-route vertical flight inefficiency during summer

The top 20 airport pairs with the highest amount of average vertical flight inefficiency per flight during AIRAC cycle 2407 (Jul-Aug 2024) are shown in Figure 5-17. The arrows indicate the directions of flight and are accompanied by the altitude constraint that is applicable to the full flight profile.

The top 20 airport pairs are concentrated in the core area and have almost all a constraint to keep flights below the upper airspace (below FL245).

For more information on the applied methodology and data downloads for your own analyses, please visit our web site @ https://ansperformance.eu/methodology/en-route-vertical-flight-efficiency-pi/

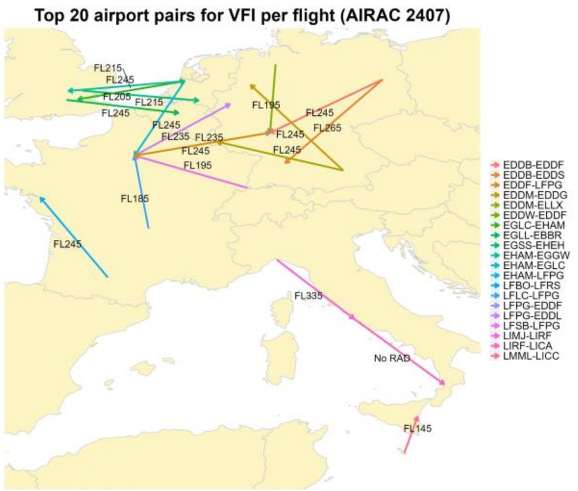


Figure 5-17: Top 20 airport pairs in terms of average VFI per flight during AIRAC 2407

5.3 CIVIL MILITARY COOPERATION AND COORDINATION

The demand for European airspace is changing with increasing civil traffic, a new safety environment, new entrants including uncrewed aircraft systems (UAS), high-altitude operations (HAO) and new generation military aircraft requiring a larger volume of airspace to operate.

To maintain a resilient, adaptable, and sustainable aviation sector in Europe, all stakeholders must collaborate to find efficient solutions that accommodate diverse requirements. This includes balancing the needs of civil and military users with those of emerging technologies and new entrants, while ensuring an optimal utilisation of available airspace and minimal environmental impact.

One of the challenges is related to a harmonised integration of military requirements into the European ATM ecosystem and the development of operational and technical interfaces for the benefit of both civil and military airspace users. The Flexible Use of Airspace (FUA) principles, developed by EUROCONTROL and reflected in EU legislation, aim to coordinate civil and military airspace needs through effective civil-military coordination. Based on this coordination, daily European Airspace Use Plans (AUP) are published the day before of operations with Updated Airspace Use Plans (UUP) issued on the day of operations. These plans often activate Conditional Routes for traffic planning and allocate airspace reservations for military exercises and training.

FUA principles can boost efficiency — but situational awareness Is key

Although civil military coordination and cooperation have improved notably over the years, bringing efficiency and capacity gains, PRC research suggested that there is still scope for further optimisation, particularly in terms of processes and information flows. The large-scale Air Defender 2023 exercise in Germany [20] demonstrated the potential of effective civil-military coordination in managing complex airspace scenarios through the application of FUA principles.
The key success factors were:

- **Strategic planning and coordination** well in advance of the exercise.
- **Dynamic real-time airspace management and optimised scheduling** of exercises to avoid peak travel periods, thereby reducing disruption to civilian flights.
- **The use of modern technology**, simulation tools, enhanced communication protocols, and tools to ensure efficient interaction between civil and military stakeholders at local and network level.

Additionally, the exercise was supported by continuous feedback loops, allowing for real-time adjustments as needed. As a result, despite its large scale, the exercise caused limited delays, thanks to traffic flow management measures implemented based on high-level of awareness and coordination on military activities.

Rigid airspace reservations still hinder optimisation

An analysis of Airspace Reservations/Restrictions (ARES) management between revealed that some states still apply a restrictive approach at strategic ASM level resulting in the publication in AIPs of restrictions to civil airspace planning that could be avoided (airspace reservation dedicated to military planning H24 for 365 days and released by NOTAM, AUP or UUP). Such a static approach is not in line with the FUA principles, according to which, airspace segregations should be of a temporary nature and used upon operational requirements.

The heat maps in Figure 5-18 and Figure 5-19 show for instance the trajectories based on submitted flight plans for weekdays (left) and weekends (right) in March 2024. The maps were generated using the EUROCONTROL PRISMIL-CURA tool, which analyses airspace users' behaviour concerning airspace reservations and restrictions. The tool supports analyses at both network and local levels, focusing on flows or individual flights.

The maps show no significant differences between weekdays and weekends, despite limited military training activity on weekends. By focusing on specific areas, such analyses help identify regions with high civil traffic demand, where further airspace management optimisation is possible.

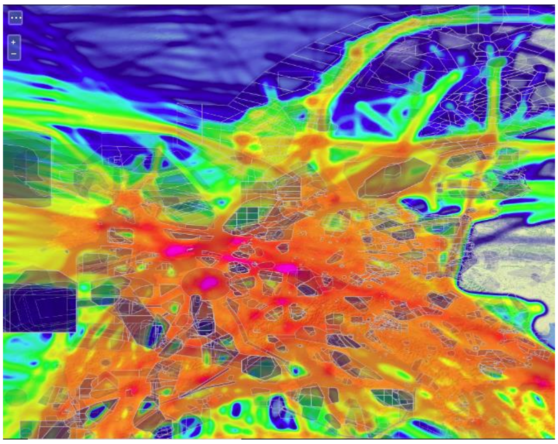


Figure 5-18: ECAC area WEEKDAYS: FTFM (last filed flight plan) density map of flight plans filed during March 2024

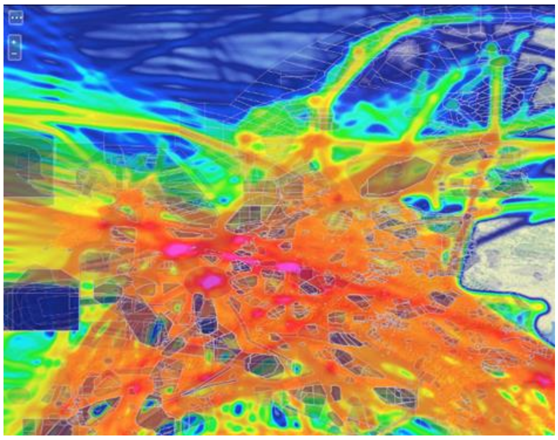


Figure 5-19: ECAC area WEEKEND: FTFM (last filed flight plan) density map of flight plans filed during March 2024

States should revise their ASM strategic approach to airspace reservations availability and the subsequent AIP publications to allow greater flexibility in flight planning, while ensuring adequate access for military training and exercises. Additionally, differences in airspace availability between weekdays and weekends should be taken into account.

More dynamic airspace management needs better data sharing – and user engagement

A study focused on the systemic issues between civil and military stakeholders was conducted in 2023 using five major military actors in Europe: France, Germany, the UK, Italy, and Spain. The study found that the **extension of flight distance was between 2 and 4% longer when flights were not using the shortest constraint route after ARES release**. The study particularly identified two areas for improvement:

Flight planning gap: Civil airspace users typically complete flight planning 5-10 hours before departure, limiting their ability to take advantage of planning opportunities presented by deactivated ARES reservations within this time window.

Tactical gap: There is often a delay between airspace activity changes and the publication of the next Updated Airspace Use Plan (UUP), which is updated every 30 minutes. Changes with less than 3 hours' notice are often not considered for planning purposes and availability is then managed tactically. As a result, stakeholders find the UUP less useful on the day of operations and handle traffic through coordination between military and civil positions, without updating the UUP.

This gap is underlined by the comparison between the last filed flight plans (FTFM – left map), the shortest constrained routes (SCR - centre) and the actual flown trajectories (CPF – right map) in Figure 5-20 which shows that flight planning generally adheres to published route availability. However, the actual flight execution shows deviations, suggesting opportunities for flexibility that were either not present or not utilised during the planning phase (see also horizontal flight efficiency section on page 43).

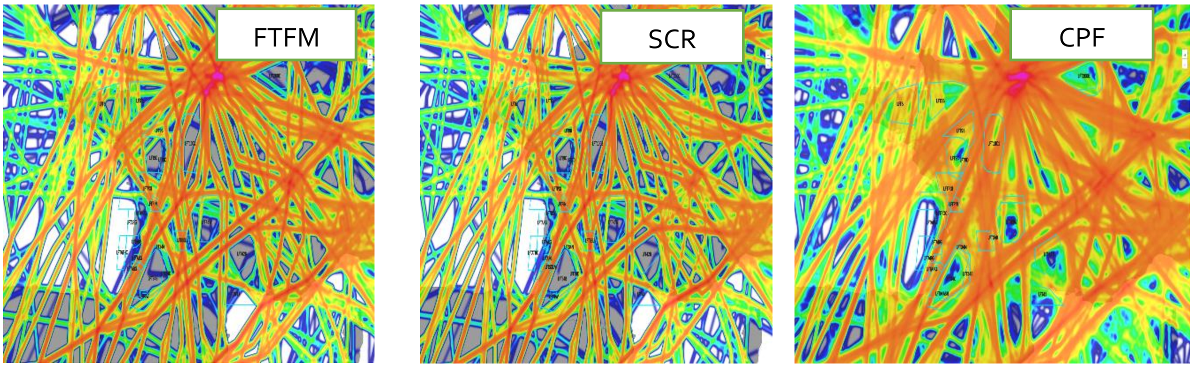


Figure 5-20: Comparison between filed flight plans (FTFM) shortest constrained routes (SCR) and actual flown trajectories (CPF)

The AUP and UUP are meant to provide the latest information to the network on the status of airspace reservations/restrictions. However, in practice - although distributed in the flight planning systems - the primary source of updates to aircraft operators seems to be the Notice to Airmen (NOTAM) publications. Analyses showed that on average, between 4 and 7% of flights did not consider the AUP in their flight planning, which suggests scope for further improvement.

Timely access to accurate information is crucial for optimising airspace usage. This includes both local and network-wide awareness of reserved airspace status, enabling service providers and airlines to better capitalise on available opportunities.

Leveraging existing technology will enhance coordination and airspace use

Existing tools for civil-military coordination, such as PRISMIL[24] and LARA[25], appear to be presently underutilised, which limits their ability to identify opportunities that could enhance capacity, improve flight efficiency, and reduce CO_2 emissions.

Additionally, digitalising NOTAMs could speed up the communication of time-sensitive information, improving integration with ATFCM systems and enhancing airline flight planning for more efficient use of available airspace.

24 Pan-European Repository of Information Supporting Civil-Military Performance Measurements.

25 Local and sub-regional airspace management support system.

Intensified use of existing tools for systemic monitoring, reporting and analyses of the airspace usage status at pre-tactical and tactical level will further help improving the utilisation of airspace for the benefit of all users.

States should consider the use of available technologies and tools to enhance the analysis, monitoring, and improvement of FUA implementation and performance. Civil and military aviation authorities, ANSPs, and the network manager should jointly analyse flexibility opportunities used in the tactical ASM phase at the local level to optimise strategic and tactical ASM processes.

5.4 EUROPEAN ATM NETWORK MANAGER PERFORMANCE

Network management is a crucial role in the European ATM system. Originally set up as the Central Flow Management Unit (CFMU) in 1989 to manage air traffic flows and other tasks within the EUROCONTROL area, the European Network Manager (NM) was formally established within the Single European Sky (SES) framework in 2012, legally strengthening the network function [19] [20]. This evolution gave the NM a more proactive role in ATFM, enhancing air traffic control capacity, developing airspace structure, and supporting technological improvements across the ATM network. Despite its strengthened role, the NM in Europe remains weaker than its equivalent in the U.S.

The NM centrally monitors traffic in the EUROCONTROL area, coordinating flow measures through collaborative decision-making with relevant stakeholders. Local Flow Management Positions (FMPs), integrated into ACCs, request the NM to implement flow measures for their jurisdictions.

European Network Manager has pivotal role but requires stakeholder support

The NM also supports European capacity planning and airspace design through collaboration, with key plans and updates shared through publications like the Network Operations Plan (NOP) and the European Route Network Improvement Plan (ERNIP).

The benefits of a centrally managed ATM network were evident during crises like the 2010 volcanic ash cloud and the more recent COVID-19 pandemic. Additionally, network management plays a vital role in addressing severe capacity shortfalls and managing the impact of adverse weather across the network. Considering future challenges like digitalisation and environmental issues, the NM is likely to play an increasingly strategic and tactical role in optimising European ATM performance and developing measures to mitigate disruptions, such as industrial action and severe weather.

While the NM is expected to improve network-wide performance, actual delivery depends on individual stakeholders (such as FABs, ANSPs, airports, aircraft operators, and the military).

Current capacity planning and deployment process fails to deliver expected benefits

The PRC has repeatedly raised concerns about perceived weaknesses in the current Network capacity planning and deployment process (see PRR 2023 and passim). PRR 2023 suggested that individual ANSPs may perceive that they do not have to plan sufficient capacity; since even plans which do not meet the targets are likely to be approved by the Network Management Body, through endorsement of the NOP. Figure 5-21 below lays out the supporting evidence for this.

It presents the delay forecasts and binding capacity targets as published in annual NOPs since 2012. It also presents the actual annual en-route ATFM delay. Two important factors are evident: (1) the aggregated individual ANSP capacity plans have consistently failed to align with the binding network targets from the SES performance scheme; (2) the actual ATFM delay experienced by airspace users is usually significantly higher than the forecast delay, even from the year of operations, indicating that ANSPs are failing to implement their own capacity plans.

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TARGET	**0.7**	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.9**	**0.9**	**0.7**	**0.5**	**0.5**	**0.9**	**0.7**	**0.6**	**0.5**	**0.5**
NOP (Y-5)								0.57	.				2.32					0.69
NOP (Y-4)							0.62	0.91	0.50	0.55	1.01	2.96	1.01		2.26	0.97	0.85	1.03
NOP (Y-3)						0.67	0.91	0.50	0.54	1.09	3.99	1.22		2.32	1.19	0.91	1.22	
NOP (Y-2)			0.32		0.64	0.90	0.56	0.51	1.23	4.04	1.46		2.41	1.28	1.04	1.52		
NOP (Y-1)		0.45	0.65	0.55	0.83	0.63	0.54	1.19	2.68	1.42		2.64	1.47	1.12	1.96			
NOP Y	0.45	0.60	0.51	0.74	0.68	0.73	1.35	2.46	1.49		1.28	1.47	1.47	2.54				
Actual delay	**0.63**	0.54	**0.61**	**0.76**	**0.91**	**0.94**	**1.83**	1.67	0.36	0.33	**1.69**	**1.80**	**2.13**					

Delay forecast higher than target
Actual higher than forecast in Year Y

Figure 5-21: Extracts from historic NOPs with actual delay

As previously mentioned in section 5.1.3, the latest delay forecasts from NOP 2025-2029 differ significantly from the required Network capacity performance targets over the same period. The forecasts for 2025 and 2026 are practically double what was predicted last year in 2024, highlighting a failure of certain ANSPs to plan and implement sufficient capacity.

When specific ANSPs fail to plan sufficient capacity, it forces the NM and other ANSPs to implement flow measures (like re-routing and level capping) to ease pressure on the congested airspace and reduce ATFM delays, at the expense of longer flight times and less efficient flight profiles.

Since the Network Manager's effectiveness depends so much on the collaboration and cooperation of a wide range of stakeholders, throughout the highly fragmented operational domain, it is very difficult to establish clear performance indicators that reflect the specific responsibilities of the Network Manager.

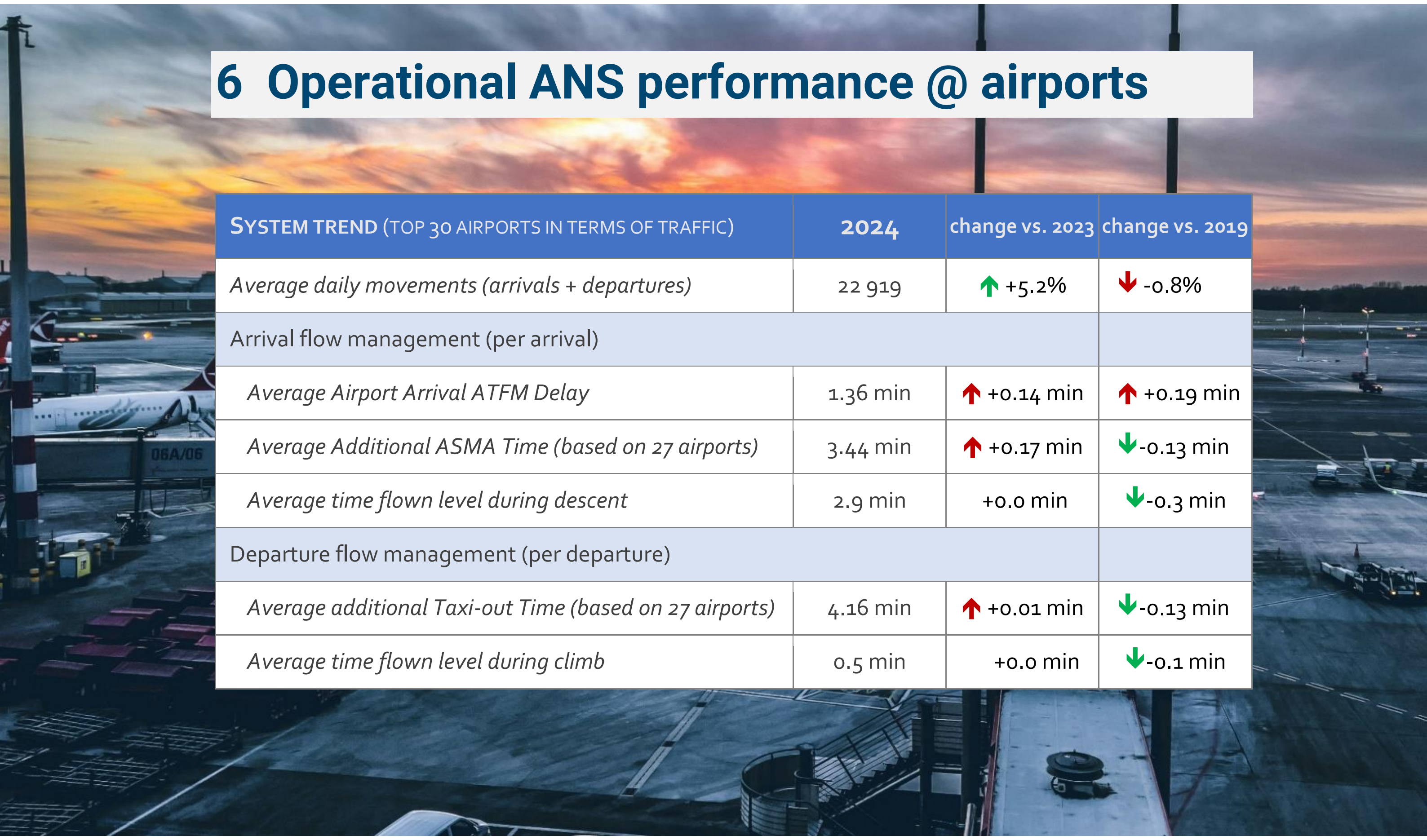
When the SES framework introduced an EU-wide performance scheme for ANS, it required the NM to develop a Performance Plan as part of the Network Strategy Plan before each reference period.

Within the SES Performance scheme, the NM's performance indicators include:

- **Safety**: over-deliveries[26] above the capacity limits of a sector declared by the air navigation service provider where ATFM regulations are imposed
    - In 2024 this value was 10.4%; an increase from 9.0% in 2023.
- **Capacity**: the percentage of en-route and airport ATFM delay savings through NM Operations Centre direct action on individual flights as well as the share of IFR flights with ATFM delay above 15 min.
    - The percentage of en-route ATFM delay savings in 2024 was 11% of the total en-route delays
    - The percentage of airport ATFM delay savings was 9.6% of the total airport ATFM delays.
    - The share of flights with ATFM delays greater than 15 minutes in 2024 was 6.4%
- **Environment**: level of improved flight efficiency in the last filed flight plan trajectories (KEP), generated by the European Route Network Design function (KEP target of 3.75% by 2024)
    - The flight efficiency of the last filed flight plan trajectories in 2024 (KEP) was 4.59% compared to a target of 3.75%.
- **Cost-efficiency**: costs per service unit
    - Only available following publication of audited account.

Given the necessary transformational challenges required to meet future traffic demands, the Network Manager is expected to play an increasingly vital strategic and tactical role in coordinating initiatives, optimising European ATM performance, and developing measures to mitigate network disruptions. The PRC will continue to assess the NM's critical role in European ATM performance and provide updates on relevant topics in future editions of the report.

[26] *Definition – an occurrence when the declared rate of the ATFM regulation is exceeded by the actual number of aircraft that enter a regulated sector during a particular period (% of regulated hours with actual demand/ capacity >110%).*



6 Operational ANS performance @ airports

SYSTEM TREND (TOP 30 AIRPORTS IN TERMS OF TRAFFIC)	2024	change vs. 2023	change vs. 2019
Average daily movements (arrivals + departures)	22 919	↑ +5.2%	↓ -0.8%
Arrival flow management (per arrival)			
Average Airport Arrival ATFM Delay	1.36 min	↑ +0.14 min	↑ +0.19 min
Average Additional ASMA Time (based on 27 airports)	3.44 min	↑ +0.17 min	↓ -0.13 min
Average time flown level during descent	2.9 min	+0.0 min	↓ -0.3 min
Departure flow management (per departure)			
Average additional Taxi-out Time (based on 27 airports)	4.16 min	↑ +0.01 min	↓ -0.13 min
Average time flown level during climb	0.5 min	+0.0 min	↓ -0.1 min

This chapter provides a review of operational ANS performance at the top 30 European airports (T30) in terms of movements in 2024 which have the strongest impact on network performance. **Together the T30 accounted for 44% of all arrivals in the EUROCONTROL area in 2024**. The chapter evaluates the situation at airports in terms of traffic and operational performance throughout the year and provides a comprehensive analysis of the poor punctuality observed, especially during the summer, for the third year in a row.

Average delay per departure	**Flights with a departure delay <15 min (OTP15)**	**ATM related inefficiencies per flight**	**Total reactionary delay (departures)**
Top 30 airports Summer 2024	Top 30 airports Summer 2024	Top 30 airports in 2024	Top 30 airports in 2024
24.1 minutes	**58%**	**-0.7 % vs. 2019**	**17.8 million minutes**
+ 44% vs. 2019	- 8.6 ppt. vs. 2019	(AIRPORT ARRIVAL ATFM DELAYS, ADD TAXI-OUT AND ASMA TIMES)	+ 1.2 mil vs. 2019

For information on the operational performance of most European airports, please visit our Airport Performance Dashboard. It enables time series analyses across a wide spectrum of indicators including punctuality, ATFM delays, operational inefficiencies.

6.1 AIRSIDE CAPACITY MANAGEMENT

6.1.1 TRAFFIC EVOLUTION @ THE T30 EUROPEAN AIRPORTS

The T30 airports in 2024 saw 8.4 million flights landing or taking off (+5.2% vs 2023) carrying a total of 1.210 million passengers who passed through these airports (+9% vs 2023, showing once again an increase in load factors in the past year).

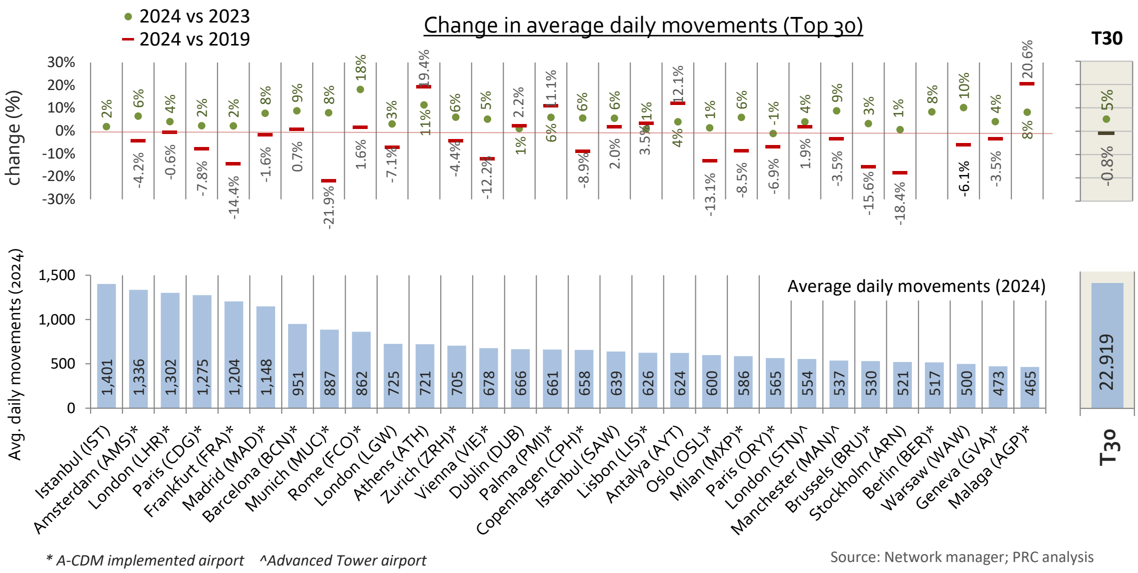


Figure 6-1: Traffic variation at the top 30 European airports (2024)

Overall, the T30 airports have almost fully recovered compared to 2019 (only 0.8% below 2019 traffic). However, it is important to note that the comparisons for Istanbul Airport (which saw the transfer of commercial flights from Atatürk in April 2019) and Berlin Brandenburg (compared to the previous EDDB: Berlin Schönefeld, as Brandenburg only opened in October 2020) are not representative.

There were not many drastic changes, with the list of airports in the Top 30 being exactly the same as the year before and the Top 9 keeping the same ranking. For the third consecutive year in 2024, Istanbul claimed the title of the busiest airport in terms of air traffic movements.

Holiday destinations experience the highest traffic growth, surpassing 2019 levels by far

Noteworthy increases in traffic compared to 2023 were noted at Rome (+18%), Athens (+11%) and Warsaw (both +10%).

A third of these T30 airports surpassed in 2024 their 2019 traffic levels, with holiday destinations showing once more the most significant increases: Malaga (+20.6%), Athens (+17.7%), Antalya (+12.1%) and Palma (+11.1%).

Munich continued to show the worst recovery in terms of traffic, with 21.9% less flights than in 2019.

6.2 ANS-RELATED OPERATIONAL EFFICIENCY @ AIRPORTS

6.2.1 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 6-2 shows the breakdown and evolution of arrival ATFM delay (left of figure) and the additional ASMA time (right of figure) per arrival at the T30 European airports in 2024. It also shows the monthly evolution for the T30 airports over the past 6 years at the top.

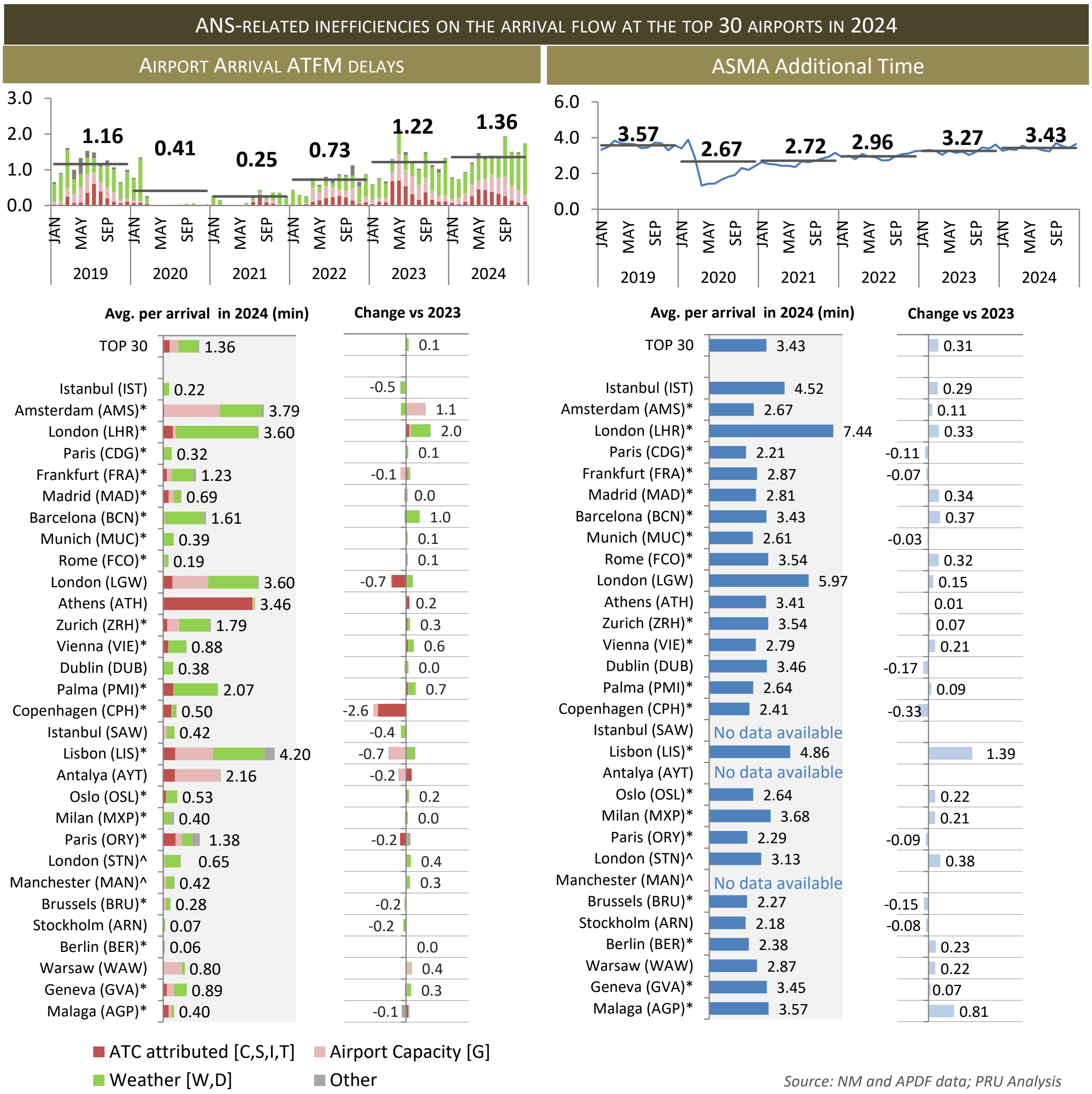


Figure 6-2: ANS-related inefficiencies on the arrival flow at the top 30 airports (2024)

Airport arrival ATFM delays: the highest in the last 10 years

Arrival ATFM delays at the T30 airports in 2024 were 0.2 minutes per arrival higher than in 2019, despite traffic levels remaining 0.8% below 2019 figures.

The highest arrival ATFM delays were recorded at Lisbon (4.20 min/arr), followed by Amsterdam (3.76 min/arr), London Heathrow and Gatwick (both 3.60 min/arr), and Athens (3.46 min/arr).

At Lisbon, traditionally affected by aerodrome capacity regulations, ATFM delays decreased noticeably after May 2024, coinciding with the implementation of the Point Merge System.

Amsterdam experienced persistent ATFM delays in 2024, primarily driven by aerodrome capacity issues linked to construction activities in March and April and consistently high demand throughout the year. Additionally, occasional but severe weather-related delays compounded the situation.

At London Heathrow, arrival ATFM delays increased significantly due to weather, the primary cause, and aerodrome ATC capacity issues. December saw exceptionally high weather-related delays, averaging 7.5 minutes per arrival.

London Gatwick, which previously faced substantial ATFM delays due to ATC staffing in 2022 and 2023, saw these nearly eliminated in 2024. Current delays are primarily linked to aerodrome capacity and weather.

Athens continued to experience notable ATFM delays due to ATC capacity restrictions, particularly from April to September, with an average delay exceeding 9 minutes per arrival in May 2024.

On a positive note, staffing-related delays at Copenhagen decreased significantly in 2024.

Additional ASMA times at T30 in 2024 showed a slight increase compared to 2023 but remained below the levels recorded in 2019.

London Heathrow and Gatwick reported the highest additional ASMA times, at 7.44 min/arr and 5.97 min/arr, respectively. Lisbon followed with 4.86 min/arr along with Istanbul at 4.52 min/arr.

Lisbon experienced a significant rise (+ 1.39 min compared to 2023) in ASMA times. This trend was observed after the implementation of the Point Merge procedure in mid-May 2024. During the same period (May to December), Lisbon recorded a reduction in arrival ATFM delays (as explained above) due to less regulated time and higher acceptance rates. Despite the Point Merge implementation, runway capacity continues to be the primary limitation at Lisbon. With increasing demand with respect to previous years and a reduction of the ATFM control measures, delays have effectively shifted to the approach phase.

Additionally, Malaga showed a notable increase in additional ASMA times, averaging 3.57 min/arr., marking an increase of 0.81 min compared to 2023.

There is a clear interest in finding a balance between regulating arrivals (absorbing delay on the ground) and airborne delays during the approach phase. Airborne delays allow for tactical management of the arrival flow, potentially optimising the approach sequence and maximising runway throughput. However, excessive airborne delays are not necessary and have a clear impact on emissions and fuel burn. The EUROCONTROL Innovation Hub has studied the feasibility and benefits of transferring airborne delays (when predicted to exceed certain threshold) into ATFM arrival delays accounting for the capability to "control" airborne delays few hours in advance [21]. A dashboard is available with the results for the T30 airports.

6.2.2 DEPARTURE FLOW MANAGEMENT

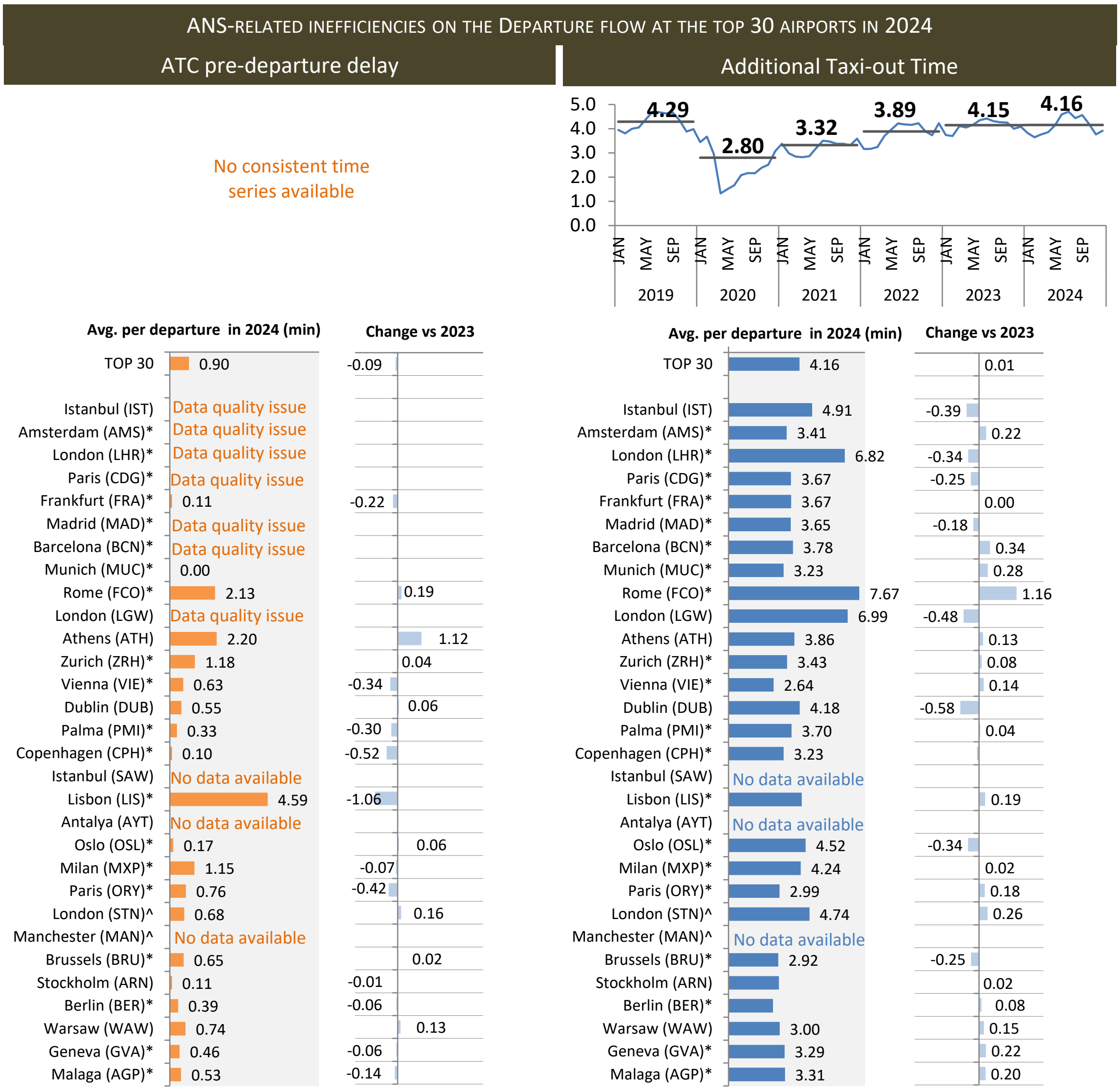
This section analyses ANS-related operational inefficiencies on the departure flow at the T30 European airports in terms of **ATFM departure slot adherence**, **additional taxi-out time** and **ATC pre-departure delays** at the gate.

Figure 6-3 shows the local ATC departure delays (left of figure) and the taxi-out additional time (right of figure) at the T30 airports in 2024. Like for the inbound flow in the previous section, it also shows the monthly evolution of the global indicator for the T30 airports over the past 6 years at the top.

The data quality and availability from some airports was once again insufficient which prevents the calculation of ATC pre-departure delay at system level. Disagreements over the criteria for reporting code 89, which is associated with this indicator, make it a contested metric and its reporting highly open to interpretation.

In 2024, among airports where the indicator was available, Lisbon once again exhibited the highest **ATC pre-departure delay** at 5.59 min/dep. This is however an improvement of 1.06 min/dep compared to 2023, mostly observed during the summer months.

Athens showed the second highest ATC pre-departure delay (2.20 min/dep on average) marking a notable increase with respect to 2023 and surpassing the delay at Rome (2.13 min/dep).



Source: APDF data; PRU Analysis

Figure 6-3: ANS-related inefficiencies on the departure flow at the top 30 airports (2024)

In terms of **additional taxi-out times**, there was minimal change compared to 2023, with values remaining slightly lower than in 2019. A significant increase was observed at Rome from May to September, where additional taxi-out times rose by 1.16 minutes per departure, resulting in the highest value within the T30, averaging 7.67 minutes per departure. Despite some improvement compared to

2023, Gatwick and Heathrow recorded the second and third highest additional taxi-out times, averaging 6.99 and 6.82 minutes per departure, respectively.

Similar to the observation made when reviewing the management of arrivals, extended taxi-out durations contribute to higher fuel consumption and CO_2 emissions, and ATC pre-departure delays present an alternative means of regulating runway traffic. **Recognising that establishing a departure sequence enhances runway efficiency and that airports may occasionally need to clear stands for arriving flights, striking a balance between ATC pre-departure delays and added taxi-out times is essential for minimising environmental impact**.

ATFM 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 6-4 illustrates the share of regulated departures from T30 airports in 2024, which reached 30.3%, marking the highest percentage on record. Despite this increase, adherence to the ATFM departure slot window was the best observed to date.

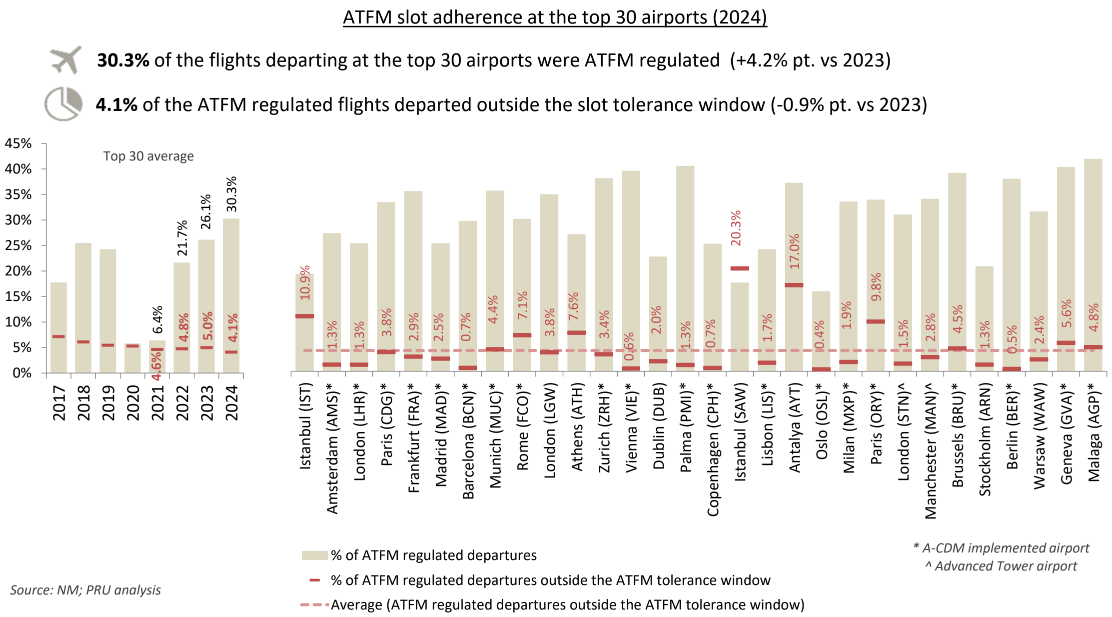


Figure 6-4: ATFM slot adherence at the top 30 airports in 2024

The lowest adherence was recorded at Istanbul Sabiha and Antalya, where 20% and 17% of departures, respectively, occurred outside the designated slot window.

The high volume of regulated departures, while offering some benefits in terms of network predictability, occasionally creates challenges for airports in managing departure flows, as regulated flights are given priority over non-regulated ones. This issue was particularly pronounced during the summer (e.g. 61% of departures from Malaga in August were regulated).

6.2.3 ADDITIONAL TAXI IN TIMES

Measuring inbound queuing time in terms of additional taxi-in time makes it possible to assess the efficiency of the gate allocation and management process and, thus, the operational cost associated with unavailability of gates or congestion during taxi-in.

In 2024, additional taxi-in times at T30 airports decreased compared to 2023 but remained higher than in 2019. Unlike other additional time indicators, such as ASMA and taxi-out, taxi-in times do not follow the same trend. They are more heavily influenced by ground handling challenges, including staffing shortages, which affect stand availability.

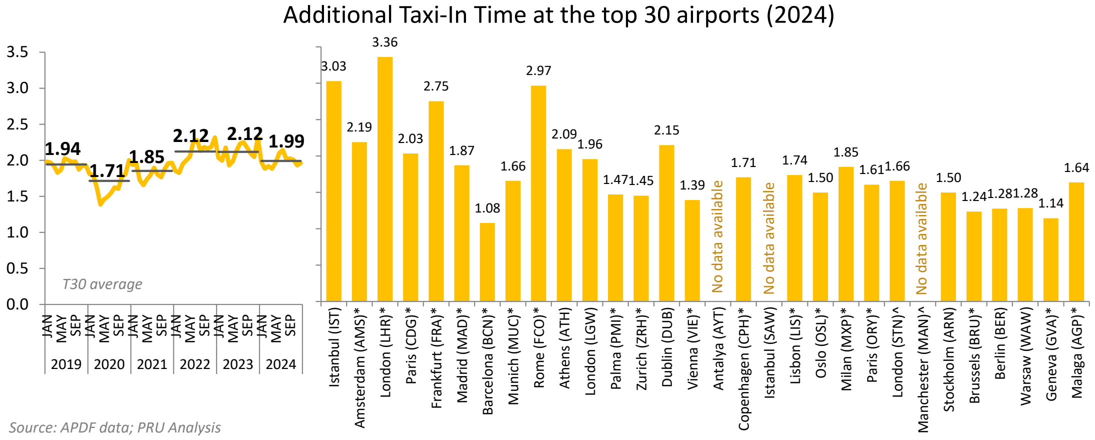


Figure 6-5: Additional Taxi-in time at the top 30 airports in 2024

Most airports kept their additional taxi-in times below 2 minutes per arrival, though some showed significantly higher values: Heathrow (3.36 min/arr), Istanbul (3.03 min/arr), Rome (2.97 min/arr), and Frankfurt (2.75 min/arr).

6.2.4 INTEGRATED VIEW OF CONTRIBUTING INEFFICIENCIES

Figure 6-6 and Figure 6-7 provide an integrated view of various inefficiencies, facilitating the analysis of their individual contributions to delays in the arrival or departure flow. This comprehensive perspective also includes ATFM delays caused by en-route constraints and allows for a detailed examination of how each inefficiency factor influences the overall operational timelines.

Additional taxi times and airborne holdings impact greater than all ATFM delay combined

In general, arrivals at the T30 airports experienced greater delays due to the additional ASMA and taxi in times than from all ATFM delays combined. These additional times were not only longer, but they are also unknown in advance. In contrast, ATFM delays can be anticipated from 3 hours before departure (when flight plans are submitted) to right before the departure, allowing for some adjustment in the planning of the aircraft operators.

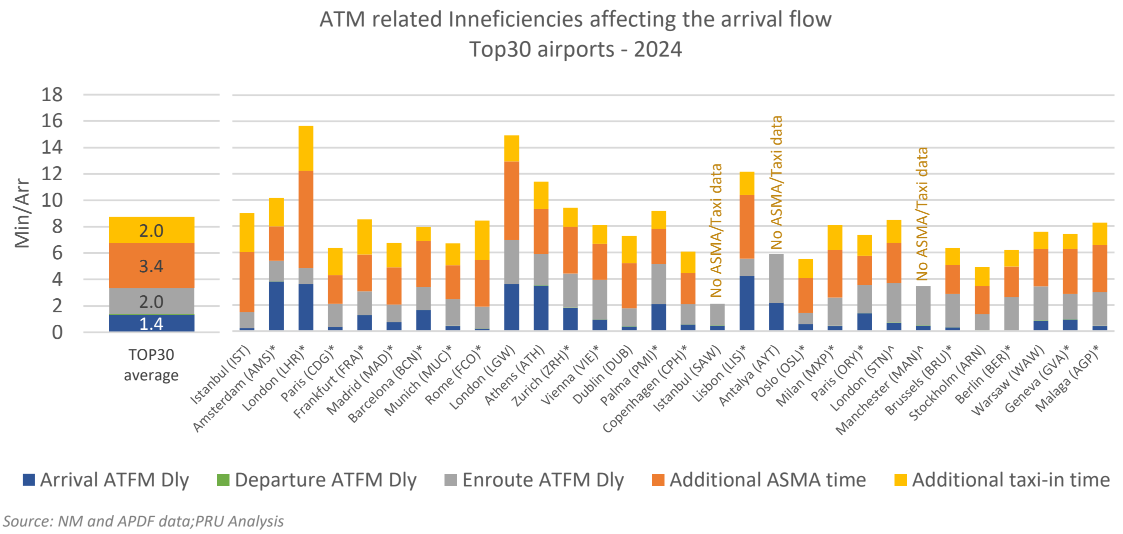


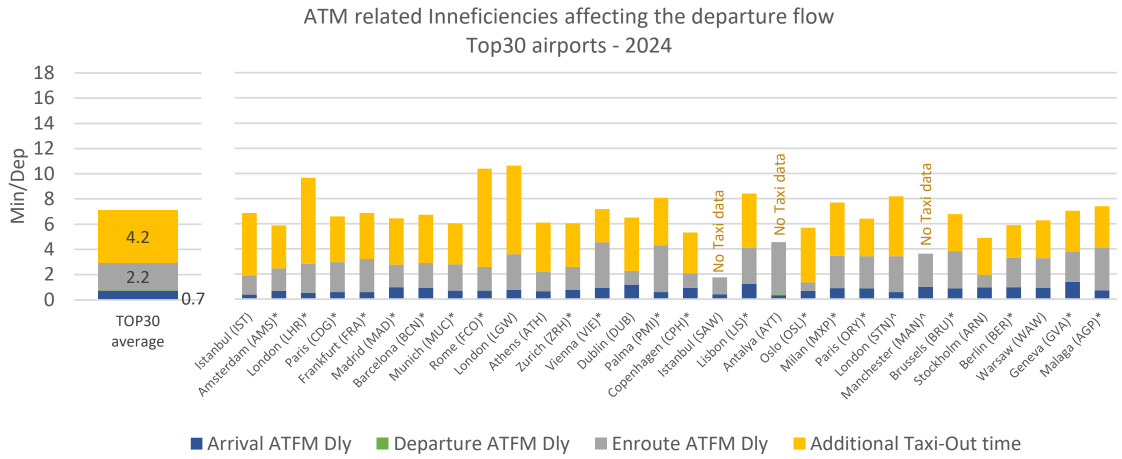
Figure 6-6: Combined view of inefficiencies impacting the arrival flow at T30 airports in 2024

The impact of network restrictions on arrivals varies across the T30 airports. For example, airports such as Oslo, Stockholm, Istanbul, Heathrow, Madrid, and Lisbon experienced lower enroute ATFM delays, averaging 1.3 min/arr or less. In contrast, arrivals at Antalya, Gatwick, Vienna, Stansted, Manchester, and Palma faced delays of 3 min/arr or more. This impact of the network restrictions is directly linked to the dominant routes and airport pairs served by traffic at these airports, together with their geographical location.

Figure 6-6 also highlights the airports most affected by combined inefficiencies impacting arrival operations, and potentially arrival punctuality: Heathrow and Gatwick lead with combined inefficiencies of around 15 min/arr, followed by Lisbon at 12 min/arr and Athens at 11 min/arr.

For departures from the T30 airports (Figure 6-7), the additional taxi-out time had on average a stronger impact than ATFM delays, despite an increase in en-route ATFM delays in 2024 affecting departures from these airports (2.2 min/dep in 2024 vs 2 min/dep in 2023).

Departures from Gatwick and Rome suffered the highest combined delays in their departure flow, exceeding 10 min/dep. However, it is important to note that additional taxi-out time does not affect departure punctuality, as punctuality compares actual vs. scheduled off block time.

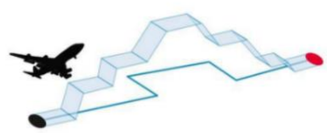


Source: NM and APDF data;PRU Analysis

Figure 6-7: Combined view of inefficiencies impacting the departure flow at T30 airports in 2024

Across the T30 airports, there were nearly zero ATFM regulations on departures. In the absence of departure regulations, the management of the departure flow can be done by Air Traffic Control (ATC) implementing pre-departure delays (before leaving the parking stand). Another strategy involves organising aircraft queues before they enter the runway for departure, which would show in the additional taxi-out times. Due to lack of data or data quality issues, pre-departure delay could not be added to the analysis.

6.2.5 VERTICAL FLIGHT EFFICIENCY DURING CLIMB AND DESCENT



This section evaluates vertical flight efficiency during climb and descent. Reducing intermediate level-offs and diversions during climb and descent saves substantial amounts of fuel and CO_2 and reduces noise levels in the vicinity of airports. In general, the lower the level segment, the higher the additional fuel consumption. The detected inefficiencies are inter alia related to airspace design, procedure design, airline operating procedures, and tactical ATC interventions. Each cause has its specific impact and reducing each individual impact requires actions from the different stakeholders.

Figure 6-8 shows the average time flown level at the T30 European airports at aggregated level between 2015 and 2024 and by airport in 2024.

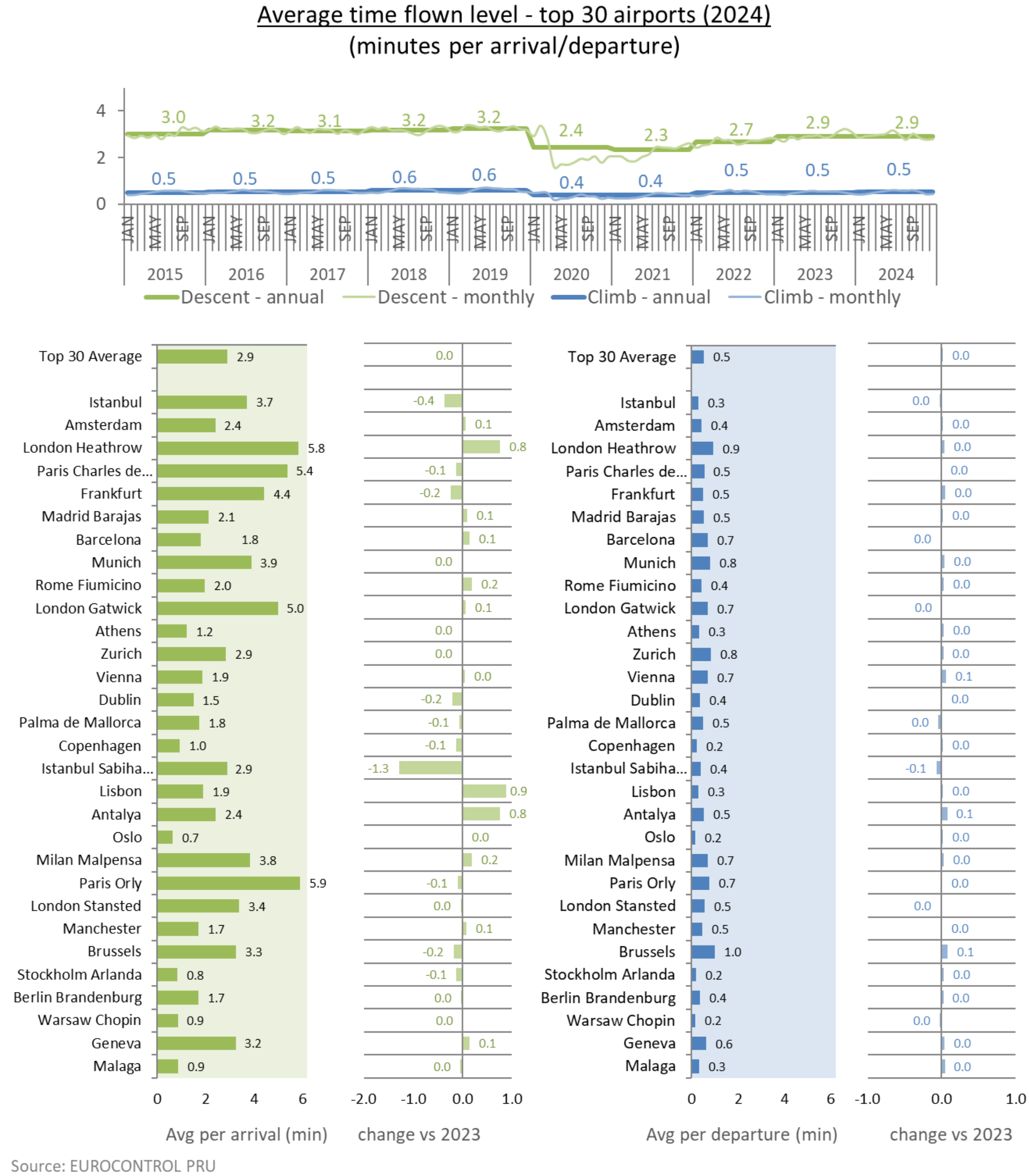


Figure 6-8: Average time flown level during climb and descent at the top 30 airports in 2024

Overall, there are no major changes compared to 2023, especially for the climb phase. However, significant increases of the average time flown level per flight during the descent are observed for London Heathrow, Lisbon and Antalya.

For London Heathrow, the increase in traffic and the greater use of holding stacks explain this rise. The same evolution is seen in the ASMA results (see 6.2.1).

The amount of observed level flight has increased significantly for arrivals to Lisbon since the implementation of Point Merge on 16/05/2024. Especially at the altitudes of the sequencing legs, the amount of level flight has increased with respect to before the implementation. The increase of level flight during the descent to Antalya is only seen during the months May, June and July and can't be related to a change in traffic since the amount and evolution of traffic was like in 2023.

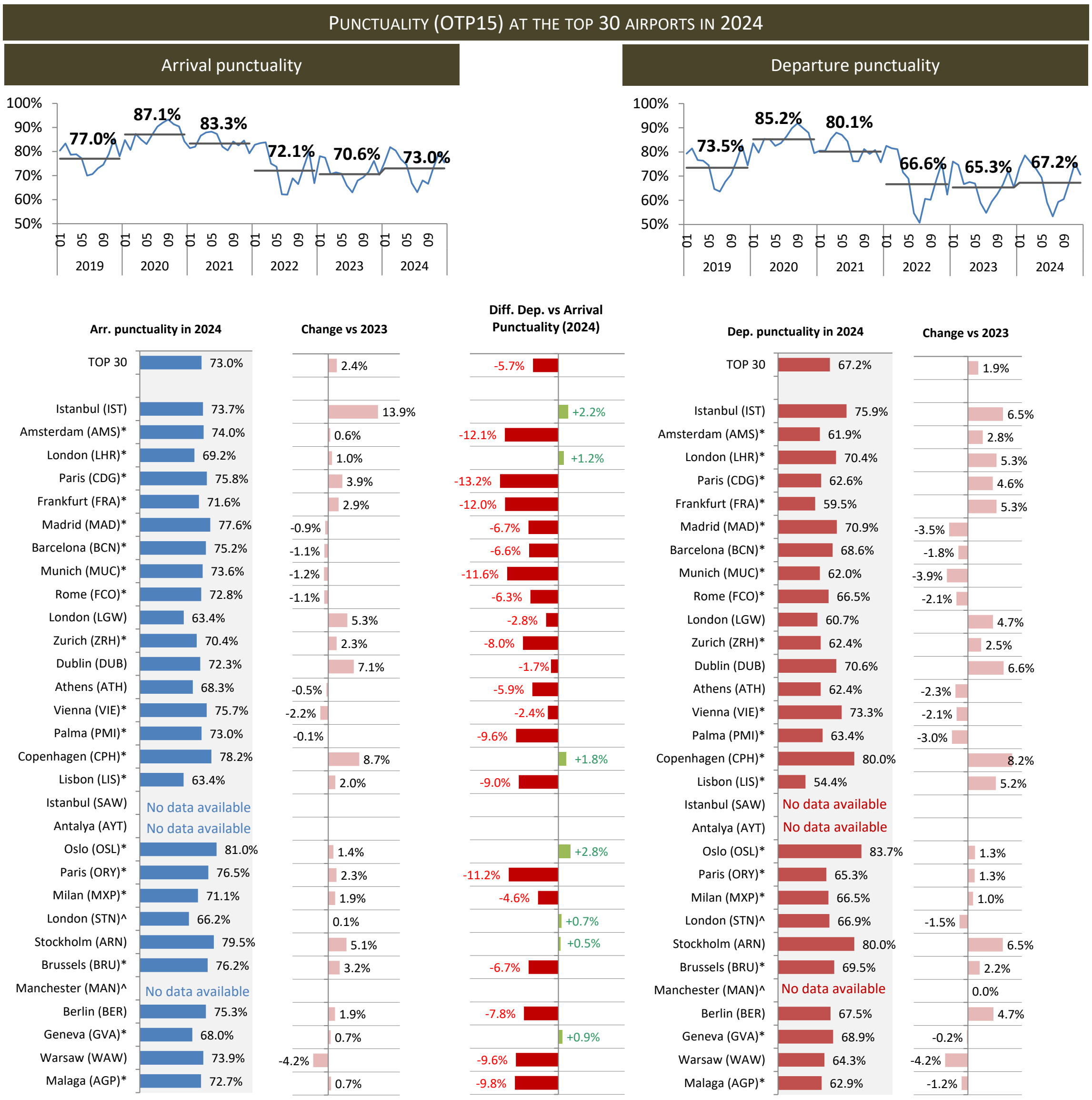
The only significant decrease of the average time flown level per flight during the descent is seen for arrivals into Istanbul Sabiha Gokcen despite a slightly higher number of flights than in 2023. The observed improvement is most likely related to the opening of the second runway at the end of 2023.

6.3 PUNCTUALITY

6.3.1 PUNCTUALITY AT THE T30 AIRPORTS (OTP15)

Airports and airlines typically prioritise punctuality when assessing their operational performance. Nevertheless, punctuality acts as a "thermometer" that merely reflects the outcome of a multifaceted and interconnected system involving numerous stakeholders. It is not designed to measure independent performance.

Punctual flights are those that leave or arrive at the stand with less than 16 min delay with respect to their schedule. Annual departure and arrival punctuality per airport is shown in Figure 6-9.



Source: APDF data;PRU Analysis

Figure 6-9: Arrival and departure punctuality at the top 30 airports (2024)

Punctuality in 2024 for airport arrivals and departures at the T30 airports improved but remained notably worse compared to 2019. Nearly one-third of departures from these airports were delayed by more than 15 minutes. The situation was particularly severe during the summer, with departure punctuality dropping to just 53% in July 2024.

Globally, at the T30 airports, departure punctuality was nearly 6% worse than the arrival punctuality. This highlights not only how turnaround processes failed to improve arrival punctuality but also how ATFM regulated departures added extra minutes to turnaround times. At airport level, only a few airports achieved better departure than arrival punctuality.

Oslo performed best, with both arrival and departure punctuality exceeding 80%, and departures 2.8% better than arrivals. The lowest punctuality was recorded at Gatwick and Lisbon for arrivals (63.4%) and Lisbon for departures (54.4%).

6.3.2 DAILY VIEW OF THE T30 AIRPORTS (SUMMER)

Summer departure punctuality at European Top 30 airports below 60%

Figure 6-10 shows the daily punctuality levels in summer 2024, 2023 and 2019. Departure punctuality (orange line) is usually lower than arrival punctuality (blue line). This is affected by many factors including airline schedule buffers or the decision to wait for connection passengers.

The summer season (June to September) experienced a slight decline in punctuality compared to 2023, with average arrival punctuality at 66.1% and departure punctuality at 58%, both still reflecting extreme delays.

The gap between departure and arrival punctuality remained consistent with 2023 levels and considerably wider than in 2019.

Notably, there were several "bad days" with departure punctuality dropping below 50%, with the worst being 19th July, due to the CrowdStrike-related IT outages.

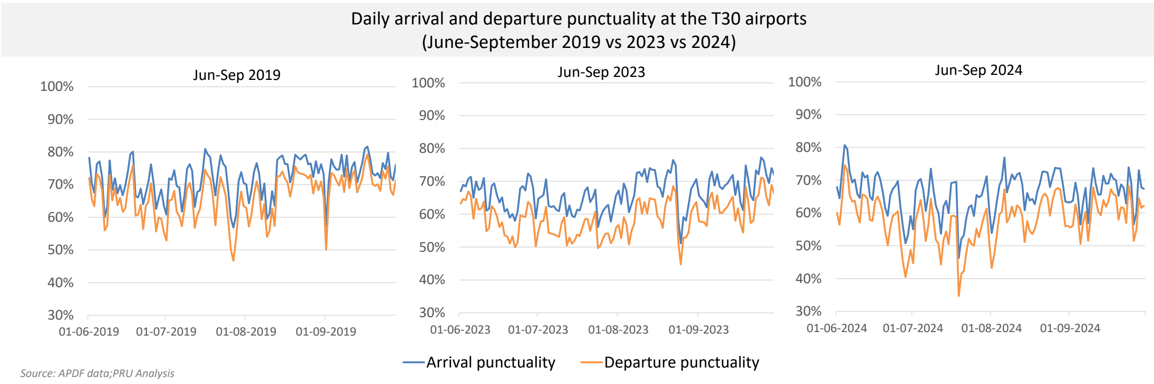


Figure 6-10: Daily evolution of arrival and departure punctuality at the T30 airports (Jun-Sep 2019-2023-2024)

6.3.3 SUMMER ARRIVAL VS DEPARTURE PUNCTUALITY PER AIRPORT AND IMPACT ON THE NETWORK.

Figure 6-11 shows the punctuality at the T30 airports at aggregated level during summer (June to September). The size of each airport bubble represents its traffic to illustrate the potential disruptive impact on the network.

The results for summer 2024 are depicted by the red bubbles, showing a similar cloud in general as the previous year (green bubbles).

At airport level the evolution is despair, some improving (Copenhagen, Paris CDG, Cologne, Istanbul) and some deteriorating (Madrid, Munich, Athens) and many not showing any significant change.

Major hubs such as Frankfurt, Paris CDG, Istanbul, and Amsterdam saw varying degrees of improvement in departure punctuality over the summer.

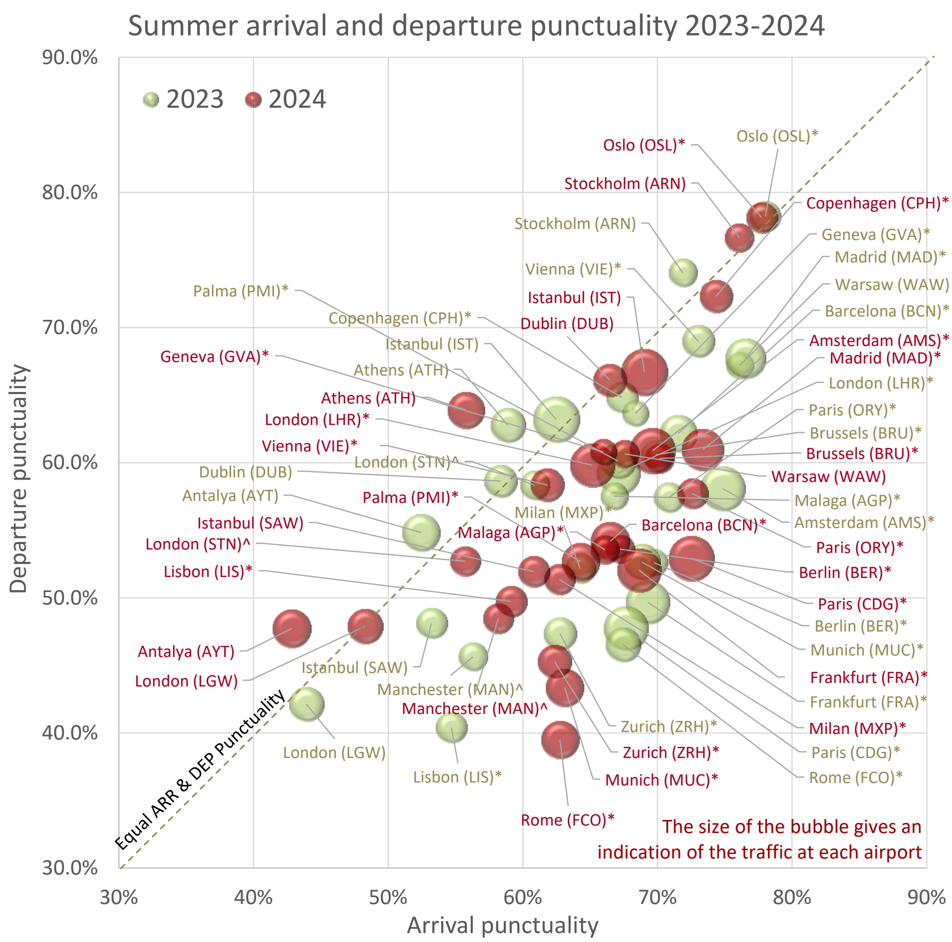


Figure 6-11: Arrival vs Departure punctuality at top30 airports (Summer)

A consistent gap between arrival and departure punctuality persists, with most bubbles still positioned below the 45° diagonal line.

6.3.4 DEPARTURE DELAYS (AIRLINE DATA): THE DRIVERS BEHIND THE LOW DEPARTURE PUNCTUALITY

Most airlines report the reasons and corresponding duration of the departure delays, which allows an analysis of the drivers behind the low levels of punctuality. Figure 6-12 shows the breakdown of the average delay per departure and the evolution since 2019[27].

In 2024, the average pre-departure delays at the T30 airports were 17.8 (min/dep), similar to the previous two years and more than 4 minutes higher than in 2019. These delays peaked during the summer months, with average values of 28 min/dep in July and over 23 min/dep in both June and August.

Reactionary delays, represented in grey, were the largest contributor, increasing by 27% compared to 2019. These delays often result from the late arrival of the aircraft or waiting for resources such as crew, passengers, cargo, or baggage. Reactionary delays tend to accumulate throughout the day as disruptions compound.

27 Delay minutes and reasons as reported by the airlines according to the IATA AHM730 delay codes and grouped per category.

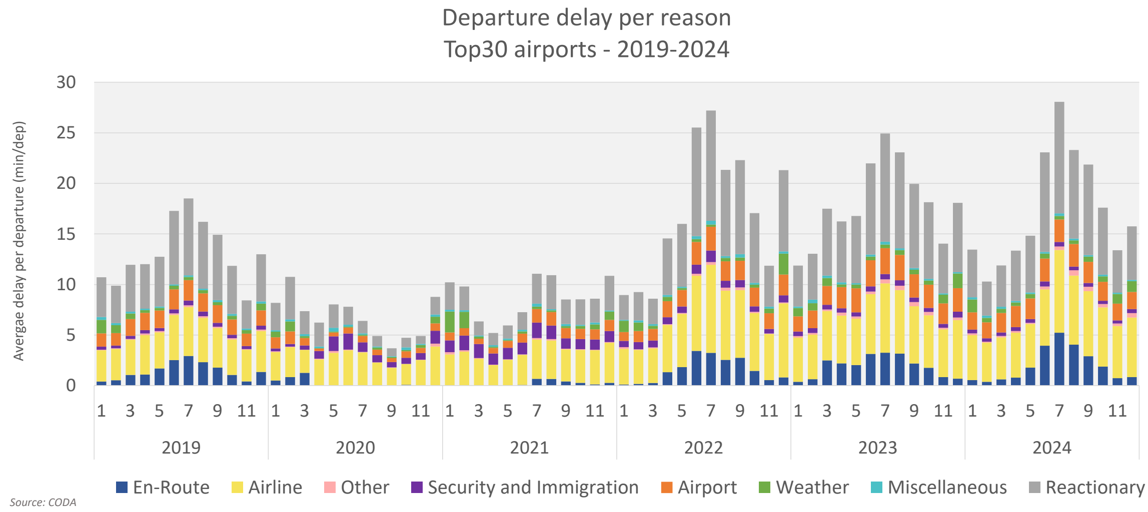


Figure 6-12: Breakdown of the pre-departure delay per reason for the top 30 airports

Airline-related delays, shown in yellow, were the second most significant driver of pre-departure delays and were 44% higher than in 2019. These include issues such as late passengers or baggage, aircraft and ramp handling challenges, crew availability, and technical or flight planning problems.

Airport-related delays, depicted in orange, averaged 2 min/dep, which is 20% higher than in 2019. However, these delays have improved by 11% compared to 2023.

Finally, delays associated with security and immigration (purple) continued to decrease for the third consecutive year in 2024, now approaching pre-COVID levels.

Post-COVID staffing issues at airports largely resolved

Offering a deeper understanding of delays connected to airport operations, Figure 6-13 illustrates delays associated with terminal and apron processes. The breakdown of these delays is presented based on IATA codes.

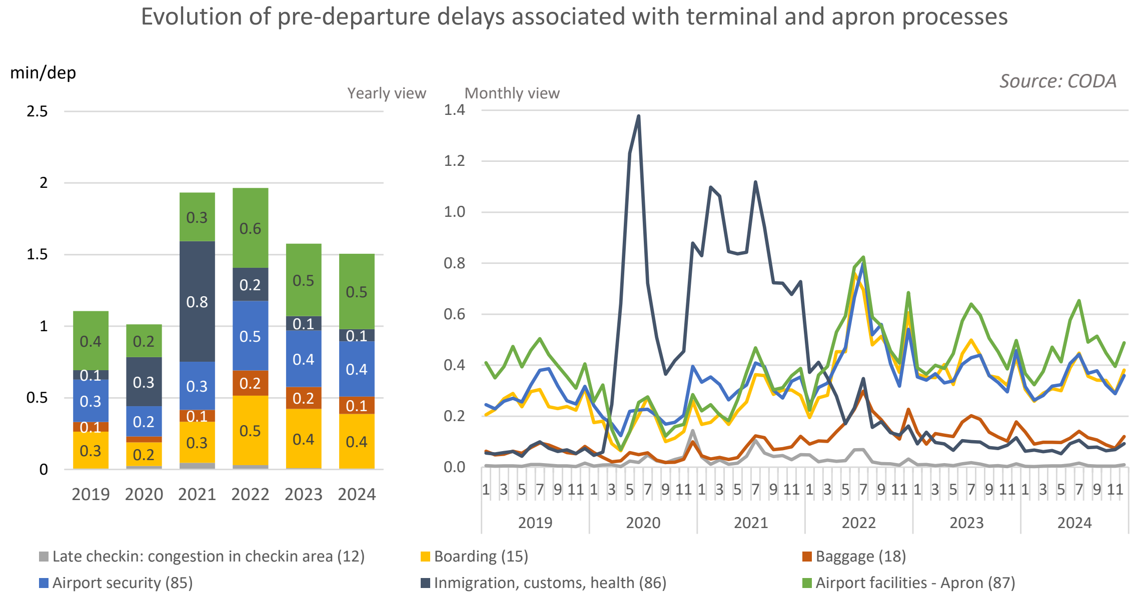


Figure 6-13: Pre-departure delays associated with terminal and apron processes - AHM730 Codes (top 30 airports)

Airport delays in 2024 caused by baggage handling, boarding, and apron facilities have clearly improved compared to the previous three years, though they remain higher than in 2019. This suggests that the issues airports faced in post-COVID years, like staff shortages and COVID restrictions, are now largely resolved.

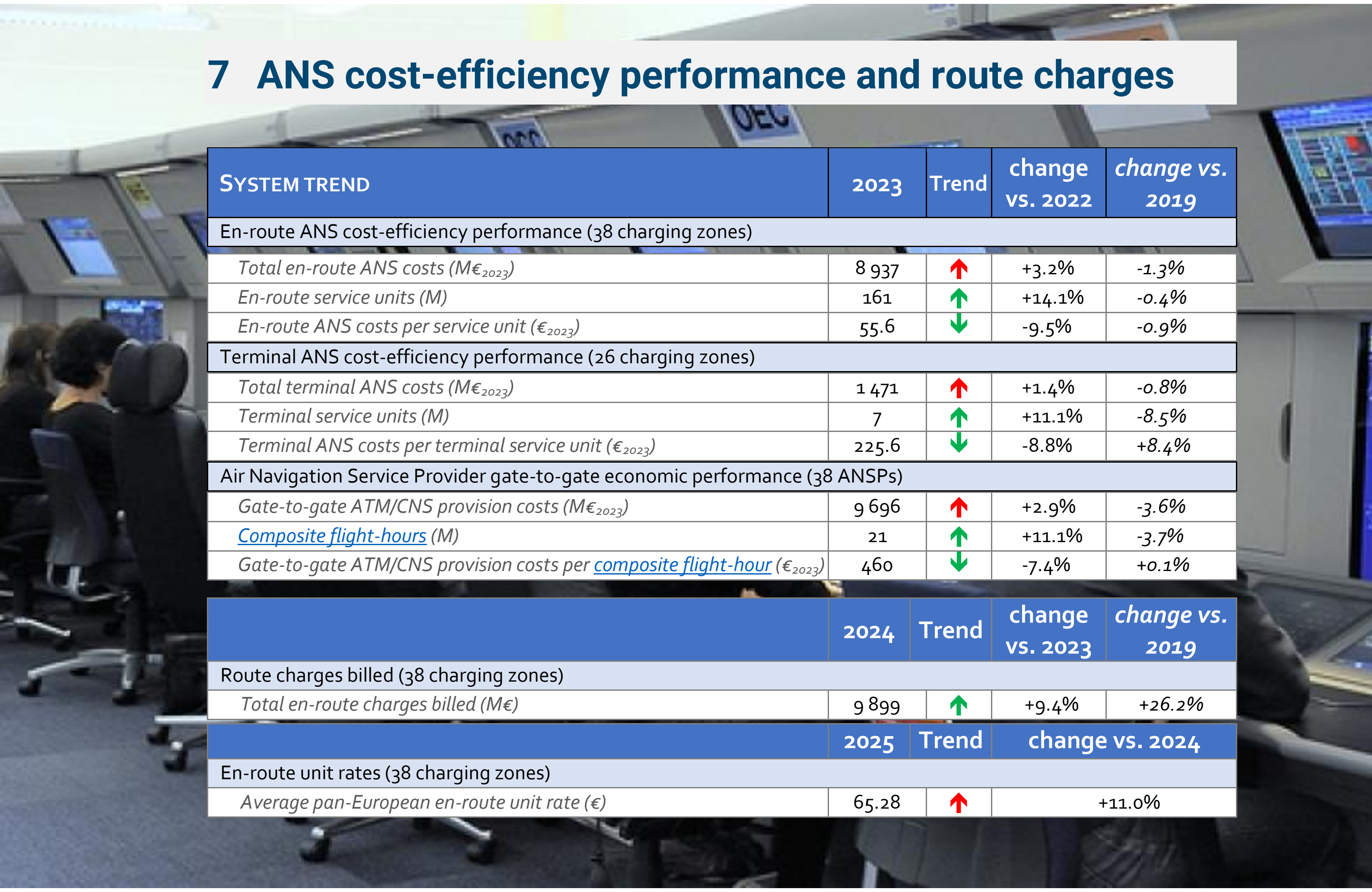
The seamless integration of various airport processes and stakeholders is essential for optimising available resources. Airport Operations Centers (APOCs) play a vital role in centralising and efficiently managing airport operations. While most major airports have an APOC or AOCC (Airport Operations Control Center), their implementations can vary significantly.

As part of its Transformation Support Strategy initiative (see also Chapter 2.4), the PRC conducted a study on APOCs, exploring their diverse implementations across European airports and the associated performance benefits. The findings of the Airport Operations Centres Performance study will be published shortly.

The new Entry Exit System (EES), initially planned for launch in 2022, has faced multiple delays. The European Commission has now announced a phased rollout set to begin in 2025. Once the proposal is approved and an official start date is confirmed, Member States will have six months to implement the EES.

The EES is an automated IT system designed to register travellers from non-EU countries each time they cross an EU external border. Its impact will vary across European airports, depending on the proportion of non-EU passengers they handle.

Airport operators have raised concerns about potential disruptions during the implementation phase, potentially leading to significant increases in processing times and related delays at border checkpoints.



7 ANS cost-efficiency performance and route charges

SYSTEM TREND	2023	Trend	change vs. 2022	*change vs. 2019*
En-route ANS cost-efficiency performance (38 charging zones)				
Total en-route ANS costs (M€$_{2023}$)	8 937	↑	+3.2%	*-1.3%*
En-route service units (M)	161	↑	+14.1%	*-0.4%*
En-route ANS costs per service unit (€$_{2023}$)	55.6	↓	-9.5%	*-0.9%*
Terminal ANS cost-efficiency performance (26 charging zones)				
Total terminal ANS costs (M€$_{2023}$)	1 471	↑	+1.4%	*-0.8%*
Terminal service units (M)	7	↑	+11.1%	*-8.5%*
Terminal ANS costs per terminal service unit (€$_{2023}$)	225.6	↓	-8.8%	*+8.4%*
Air Navigation Service Provider gate-to-gate economic performance (38 ANSPs)				
Gate-to-gate ATM/CNS provision costs (M€$_{2023}$)	9 696	↑	+2.9%	*-3.6%*
Composite flight-hours (M)	21	↑	+11.1%	*-3.7%*
Gate-to-gate ATM/CNS provision costs per composite flight-hour (€$_{2023}$)	460	↓	-7.4%	*+0.1%*

	2024	Trend	change vs. 2023	*change vs. 2019*
Route charges billed (38 charging zones)				
Total en-route charges billed (M€)	9 899	↑	+9.4%	*+26.2%*
	2025	**Trend**	**change vs. 2024**	
En-route unit rates (38 charging zones)				
Average pan-European en-route unit rate (€)	65.28	↑	+11.0%	

This chapter provides a pan-European view, covering 39 States[28] operating 38 en-route charging zones [29] that are part of the Multilateral Agreement for Route Charges. This includes the 29 States[30] which in 2023 were subject to the requirements of the Single European Sky (SES) Performance Scheme as well as the United Kingdom (commonly referred to as "States operating under economic regulation" in this chapter) and also 9 EUROCONTROL Member States which are referred to as "States operating under full cost-recovery" (see section 7.1 for more details).

Section 7.1 and Section 7.2 present a detailed analysis of cost-efficiency performance at pan-European system level for en-route and terminal ANS, respectively. These sections analyse ANS cost-efficiency performance in 2023, which is the latest year for which actual cost data are available, and present a performance outlook for the coming years.

Section 7.3 provides information on the route charges billed in 2024 at a system and individual charging zone level as well as an analysis of the airline groups which paid the most in route charges.

Section 7.4 analyses 2025 national chargeable en-route unit rates and provides an overview of their components.

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28 This is different from the 41 EUROCONTROL Member States in 2023 since: (1) Ukraine is a EUROCONTROL Member State integrated into the Multilateral Agreement relating to Route Charges in 2021 but is excluded from this report due to ongoing war, and (2) Monaco en-route costs are included in the French cost-base.

29 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 zones for Spain (Spain Cont. and Spain Canarias).

30 Comprising the 27 Member States of the European Union (EU) in 2023, plus Switzerland and Norway.

Finally, section 7.5 presents high-level key indicators extracted from the ATM Cost-Effectiveness (ACE) benchmarking analysis as well as from the ANSP financial dashboard produced by the EUROCONTROL Aviation Intelligence Unit [31].

Note that, for consistency purposes, the cost-effectiveness analysis presented in sections 7.1, 7.2, and 7.5 are expressed in real terms and in 2023 Euros as explained in more detail below.

The year 2022 marked the end of a period of relatively low inflation which had been prevailing in most European States in the past decade.

Although average inflation rates reduced considerably in 2023 (EU-27 inflation stood at 6.4%) after a strong increase in 2022 (EU-27 at 9.2%), higher-than-usual inflation remained a significant issue for some States, as illustrated in Figure 7-1.

For instance, while inflation in 2023 exceeded 10% for seven States, in 2022 it was 18 States that reported double-digit inflation figures.

Presentation of financial time-series data in PRR

Presentation and comparison of historical series of financial data from different States poses problems, especially when different currencies are involved, and inflation rates differ. The timeseries comparisons can therefore be distorted by transient variations in exchange rates.

For this reason, the PRC has adopted following approach in its Performance Review Reports for allowing for inflation and exchange rate variation. The financial elements of performance are assessed, for each year, in national currency. They are then converted to national currency in 2023 prices using national inflation rates. Finally, for comparison purposes in 2023, all national currencies are converted to Euros using the 2023 exchange rates.

This approach has the virtue that analysis of time series is not distorted by transient changes in exchange rates over the period. It does mean, however, that the performance figures for any State and charging zone in a given year prior to 2023 are not the same as the figures in that year's PRR report and cannot legitimately be compared with another States' and charging zones' figures for the same year.

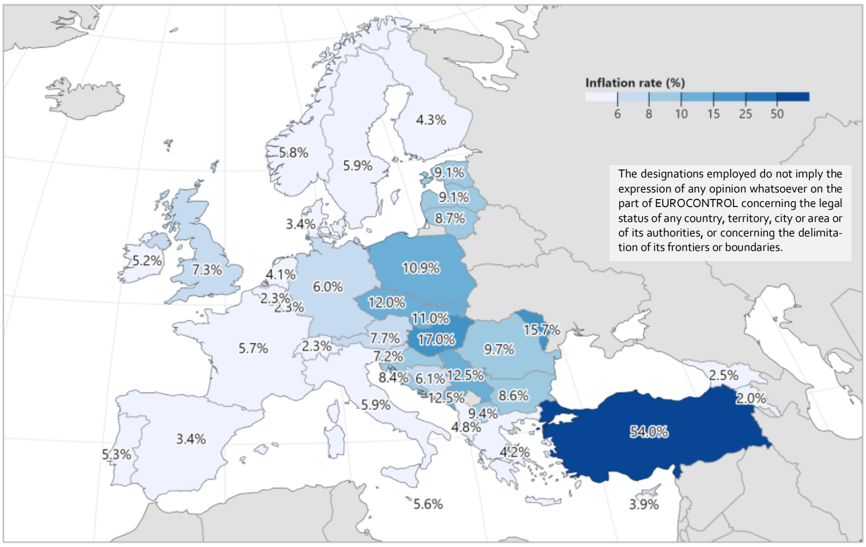


Figure 7-1: 2023 annual inflation rates in Europe

This exceptionally high inflation has an impact on the analysis presented in this report (see grey box). In particular, this affects the comparison of changes in costs and unit costs between 2022 and 2023 in real terms.

For this reason, the analysis of 2022-2023 variations in en-route costs and, correspondingly, the unit costs in real terms should be interpreted with caution.

According to the inflation forecast provided by the IMF[32], this effect on cost-efficiency analysis is expected to be temporary. Indeed, the inflation forecasts from 2024 onwards are considerably below 2023 levels for all States included in the analysis.

[31] For more details, see: https://ansperformance.eu/economics/finance/.

[32] Based on IMF World Economic Outlook database, October 2024.

7.1 EN-ROUTE ANS COST-EFFICIENCY PERFORMANCE IN 2023

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 2023 (with the exception of Portugal Santa Maria).

Figure 7-2 shows the nine EUROCONTROL States which were part of the EUROCONTROL Multilateral Route Charges System in 2023 and operate under a full cost-recovery regime (i.e. Albania, Armenia, Bosnia-Herzegovina, Georgia, Moldova, North Macedonia, Serbia, Montenegro and Türkiye).

Figure 7-2 also shows 29 EUROCONTROL States which are bound by the regulations of the SES Performance and Charging Scheme. These States operate under the "determined costs" method as defined in the Performance and Charging Regulation [22].

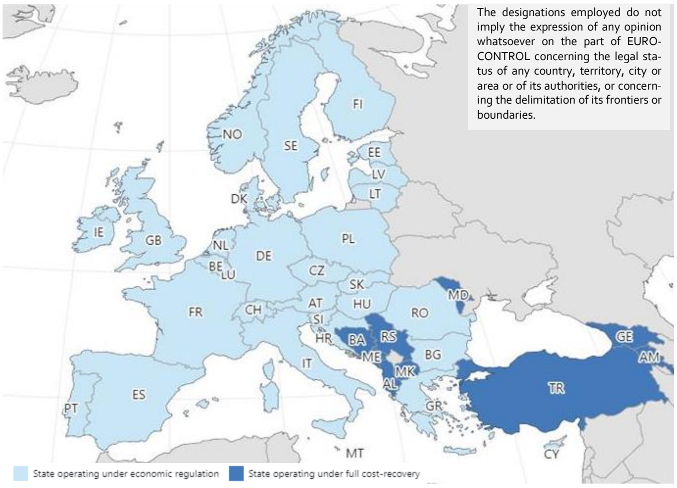


Figure 7-2: Geographical scope of en-route cost-efficiency performance analysis

The UK operates under a national economic regulation regime framework which shares similarities[33] with the one applied by States operating under SES Regulations. Consequently, for the purposes of this analysis, the UK is considered as part of the States subject to economic regulation.

The analysis provided in this section is based on data submitted by the States in November 2024 in the context of the Enlarged Committee for Route Charges.

7.1.1 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 2018-2023 period[34].

En-route unit costs in 2023 were the lowest ever recorded

Figure 7-3 shows that **at pan-European level in 2023, traffic (expressed in total en-route service units – TSUs) grew by +14.1%, while en-route ANS costs also increased by +3.2% reaching the 2018 level. As a result, the en-route unit costs in 2023 reduced by -9.5% to €55.6 per TSU – the lowest level to-date.**

	2018	2019	2020	2021	2022	2023	2023 vs 2022	2018-23 CAGR
Total en-route ANS costs (M€2023)	8 931	9 052	8 849	8 351	8 661	8 937	3.2%	0.01%
Total en-route service units (M TSUs)	157	161	68	87	141	161	14.1%	0.5%
En-route ANS costs per TSU (€2023)	56.9	56.1	129.6	96.4	61.4	55.6	-9.5%	-0.5%

Figure 7-3: Real en-route ANS cost per TSU for pan-European system (€2023)

The aggregated trends in en-route costs, TSUs and unit costs are analysed for States operating under economic regulation and those operating under a full cost-recovery regime below.

33 High-level comparison of the two regulatory systems is provided on pg. 59 of the PRR 2022 .

34 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].

For the States operating under economic regulation, the en-route unit costs decreased continuously between 2021 and 2023 at an average rate of -24.9% p.a., in real terms. This cost-efficiency improvement reflects the fact that an increase in the en-route cost-base (+2.3% p.a.) was more than compensated by significant TSU growth (+36.2% p.a.).

The massive reduction in TSUs in 2020 and the resulting reduction in revenues put considerable pressure on costs. As a result, for these States en-route costs reduced by -1.9% and -6.5% in 2020 and 2021, respectively. However, after reaching their lowest point in 2021, en-route ANS costs began growing steadily with a reported increases of +2.4% in 2022 and +2.2% in 2023, although despite these increases they remained -4.1% below the 2019 level.

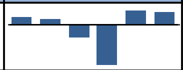
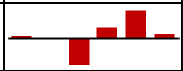
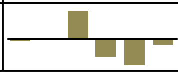
States operating under economic regulation	2022-23 change		2018-23 trends	2019-23 change
Total en-route ANS costs (M€2023)	+€171M	+2.2%		-4.1%
TSUs	+15M	+13.8%		-2.5%
En-route unit costs (€2023)	-€6.2	-9.3%		-1.6%

Figure 7-4: Changes in en-route costs, TSUs and unit costs for States operating under economic regulation (€2023)

Similarly, for States operating under full cost-recovery, the collapse in TSUs in 2020 resulted in a number of cost-efficiency measures which resulted in a -6.6% reduction in en-route cost-base. This trend was reversed in 2021 and 2022 with annual increases in costs of +12.9% over the period.

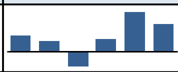
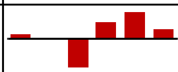
States operating under full cost-recovery	2022-23 change		2018-23 trends	2019-23 change
Total en-route ANS costs (M€2023)	+€105M	+13.8%		+35.5%
TSUs	+5M	+21.5%		+12.0%
En-route unit costs (€2023)	-€2.2	-6.3%		+21.0%

Figure 7-5: Changes in en-route costs, TSUs and unit costs for States operating under full cost-recovery (€2023)

The trend of growing en-route ANS costs for these States continued in 2023 (+13.8%), however, since the strong traffic recovery also resulted in a +21.5% increase in TSUs, the resulting en-route unit costs fell by -6.3% and amounted to €32.6 per TSU. Compared to 2019, however, the unit costs were some +21.0% higher reflecting mainly significant growth in en-route ANS costs for these States (+35.5%) between 2021 and 2023.

These results for the States operating under full cost-recovery are heavily influenced by the trends recorded for the Turkish charging zone which represents more than two thirds of the total costs and TSUs for these States in 2023. More details on the variation in en-route ANS costs for Türkiye are provided in the sub-sections below.

7.1.2 BREAKDOWN OF EN-ROUTE COSTS

Figure 7-6 presents the breakdown of en-route ANS costs into their main components. It shows that operating costs accounted for some 84% of the en-route cost-base in 2023 (staff costs for 60% and other operating costs for 24%) while capital-related costs comprised some 16% (depreciation accounting for 10% and cost of capital for 6%).

Figure 7-7 presents the changes in the main components of en-route ANS costs between 2022 and 2023 as well as over the 2019-2023 period.

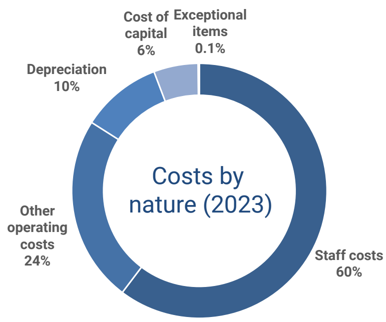


Figure 7-6: Breakdown of 2023 en-route ANS costs

Between 2022 and 2023, the increase in en-route ANS costs in real terms (+€276M) was driven mainly by growth in staff costs (+€199M) and other operating costs (+€92M) while, taken together, the capital-related costs remained mostly unchanged (-€1M).

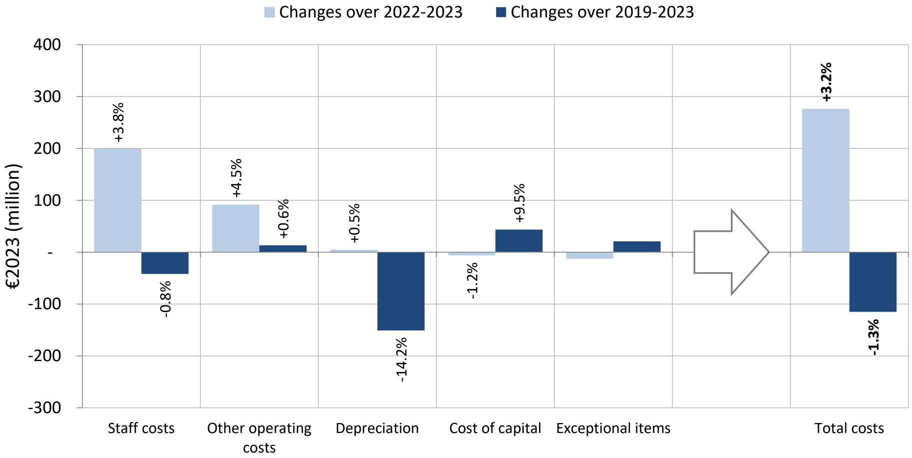


Figure 7-7: Changes in en-route cost categories over 2022-2023 and 2019-2023 periods (€2023)

En-route costs grew in 2023, but stayed below 2019 mainly due to lower depreciation

Despite the significant increases in 2023, staff costs and other operating costs were relatively close to their 2019 levels in real terms (-€42M and +€13M, respectively). Depreciation costs reduced significantly between 2019 and 2023 (-14.2%, or -€151M) while the costs of capital increased (+9.5%, or +€44M). These pan-European trends mask significant differences observed between the States operating under economic regulation and those operating under a full cost-recovery regime.

Figure 7-8 shows the changes in en-route ANS costs categories for States operating under economic regulation between 2019 and 2023. In real terms, en-route ANS costs for these States reduced by -4.1% (or -€342M) over this period, reflecting reductions across most cost categories with the most significant decreases recorded in depreciation (-14.4%, or -€142M) and staff costs (-2.3%, or -€118M).

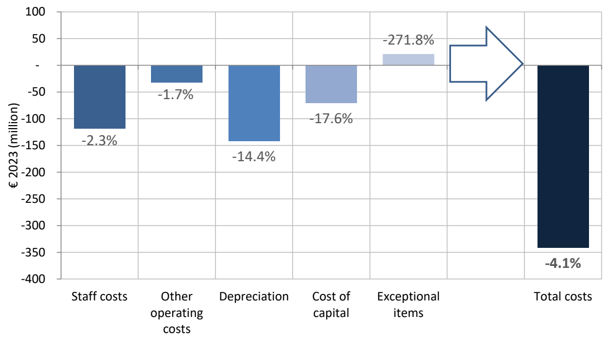


Figure 7-8: Changes in en-route cost categories for States operating under economic regulation between 2019 and 2023 (€2023)

These reductions are driven heavily by six charging zones which recorded significant reductions in their cost-bases in absolute terms over this period, including France (-€102M, or -6.6%), Italy (-€90M, or -11.8%), Czech Republic (-€49M, or -25.7%), Austria (-€42M, or -16.0%), Germany (-€36M, or -3.4%) and Poland (-€34M, or -13.6%). Detailed analysis shows that for most of these charging zones the decreases in their cost-bases mainly reflect savings in staff, other operating and depreciation costs.

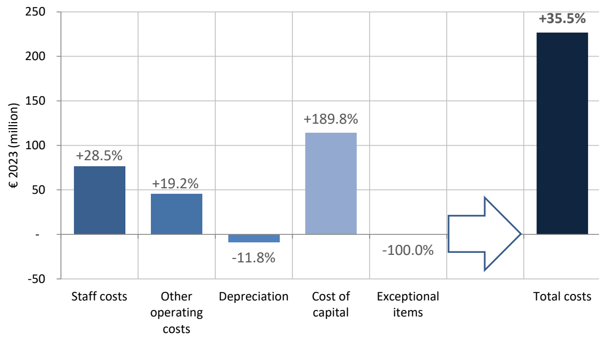


Figure 7-9: Changes in en-route cost categories for States operating under full cost-recovery between 2019 and 2023 (€2023)

As shown in Figure 7-9, en-route ANS cost of States operating under full cost-recovery increased significantly (+35.5%, or +€227M) between 2019 and 2023.This reflects increases in staff costs (+28.5%, or +€76M), other operating costs (+19.2%, or +45M) and the cost of capital (+189.8%, or +€114M). The trends for these States are heavily influenced by variations for Türkiye which represents some 70% of the total en-route ANS costs for this group. If Türkiye was excluded from the sample, the full cost-recovery States would report a reduction in en-route costs of some -11% (or -€36M) over this period.

7.1.3 ACTUAL EN-ROUTE UNIT COSTS AT CHARGING ZONE LEVEL IN 2023

Figure 7-10 presents the level of en-route unit costs[35] for each individual charging zone as well as changes in en-route ANS costs between 2022 and 2023 in real terms (see dashes on the right side).

Some of the results are heavily influenced by inflation effects and should be interpreted with caution.

In 2023, en-route unit costs ranged from €274.2 for Moldova to €19.7 for Malta, a factor of almost 14 between these two charging zones. This large gap should be seen in the light of the particular traffic situation in Moldova following the outbreak of war in Ukraine, with TSUs in 2023 being some -80% below 2019.

In 2023, en-route costs per TSU reduced for 31 en-route charging zones out of the 38 included in the analysis. For five charging zones, en-route unit costs decreased by more than -15% in 2023, including Malta (-38.5%), Georgia (-34.1%), North Macedonia (-17.6%), Austria (-17.6%) and Spain Continental (-16.9%). For most of these charging zones the observed reduction reflects a combination of growth in TSUs and a reduction in the en-route cost-base in real terms. In the case of Georgia, however, the reduction reflects entirely the substantial increase in TSUs (+64.1%) which more than compensated the growth in costs (+8.1%).

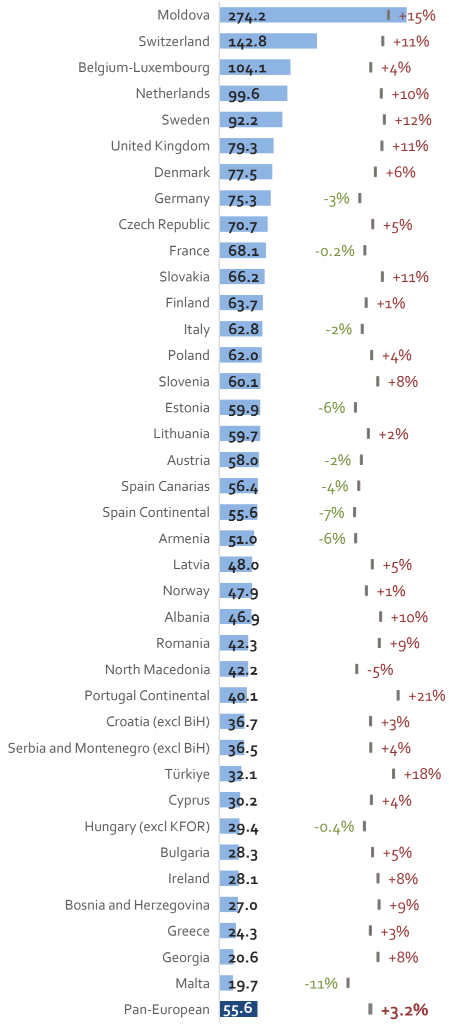


Figure 7-10: Actual en-route ANS costs per TSU in 2023 and changes in costs between 2022 and 2023 (€2023)

En-route unit costs in 2023 grew for seven charging zones, with three of these recording an increase exceeding 5%, including Moldova (+12.8%), Portugal Continental (+8.2%) and Switzerland (+7.6%). For these charging zones the increases reflect significant growth in en-route ANS costs.

The number of TSUs grew in 2023 for all the charging zones included in this analysis for the first time since 2020. At the same time, en-route ANS costs also increased for the majority of the charging zones (27 out of 38) in 2023, with the largest increases in relative terms recorded for Portugal Continental (+20.7%, or +€28M) and Türkiye (+17.8%, or +€95M). In the case of Portugal Continental, the increase is mainly driven by growth in staff costs (+21.5%), explained by overtime payments, salary indexation and higher pension costs, and depreciation costs (+50.9%) reflecting the implementation of

[35] The actual unit costs reflected refer to the ratio of actual en-route costs and TSUs recorded for 2023 and should not be confused with the chargeable unit rate which is analysed in section 7.4.

previously delayed investments. While for Türkiye, the costs grew across all categories in 2023 with the largest increases in staff costs (+27.9%), reflecting the effect of measures implemented by the Government to address the falling purchasing power of public sector employees, and other operating costs (+11.3%).

En-route costs reduced for 11 charging zones in 2023 with the largest reductions, in relative terms, recorded for Malta (-10.8%, or -€2M), Spain Continental (-6.6%, or -€49M) and Estonia (-6.1%, or -€2M). In the case of Malta and Spain Continental, these reductions reflect lower staff and other operating costs while Estonia reported significant reductions in depreciation and the cost of capital.

7.1.4 Pan-European en-route ANS cost-efficiency performance outlook for 2024-2029

Caution is needed when interpreting the planned changes in this section, as the data submitted by States under SES legislation in November 2024 for the Enlarged Committee for Route Charges may differ from the final National performance plans (NPPs) for RP4. These figures may change after review by the European Commission and the PRB during the performance plan assessment.

The objective of this section is to provide information on forecast changes in en-route unit costs at pan-European system level for the period 2024-2029. The analysis in this section is based on the forward-looking data reported in the en-route reporting tables submitted by the EUROCONTROL Member States in November 2024 in the context of the Enlarged Committee for Route Charges.

For the outlook in this section, it is therefore important to highlight that:

- For the States subject to SES regulations, the data might differ from the latest National Performance Plan (NPP) figures for the fourth reference period (RP4) covering 2025-29 period.
- Forward-looking information for the Italian en-route charging zone is excluded from the analysis in this section for confidentiality reasons.
- For the UK, the forward-looking data reflects the determined cost and TSU data included in the adopted business plan for NR23 covering the 2023-27 period. For this reason, the UK data is excluded when considering trends over the entire 2023-29 period.
- For Türkiye, which has already been experiencing significant inflationary pressures in the past years[36], the forecast inflation figures remain very high over the entire 2023-29 period. This has a large impact on the forecast costs when expressed in real terms and, due to the weight of Türkiye in the sample, significantly affects pan-European trends. For this reason, forecast figures for Türkiye are excluded from the analysis in this sub-section.

To account for these limitations, Figure 7-11 is split into two parts: i) 2023-27 period including 36 charging zones and ii) 2023-29 period comprising 35 charging zones since data for the UK is not available beyond 2027.

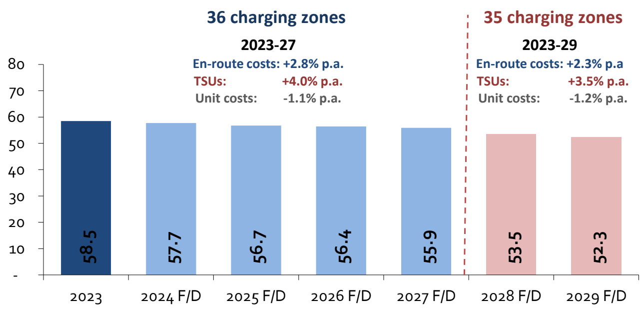


Figure 7-11: Pan-European en-route cost-efficiency outlook 2023-2029 (€2023)

[36] It should also be noted that as of 2024, Türkiye decided to establish its cost-base and corresponding national unit rates in Euros in response to the extraordinarily high inflation (some 72% in 2022 and 54% in 2023). This option, foreseen in the EUROCONTROL Principles for Establishing Cost-base [24], allows States experiencing significant inflationary pressures to alleviate the impact of inflation on its ANS provision.

Between 2023 and 2027, en-route service units are expected to increase at a much faster rate (+4.0% p.a.) than en-route ANS costs (+2.8% p.a.). As a result, en-route unit costs are projected to reduce by some -1.1% annually over this period.

In 2029 en-route unit costs are projected to be -7.3% lower than in 2023

When considering 35 charging zones over the full 2023-29 period, en-route ANS costs are planned to increase (+2.3% p.a.) while TSUs are forecast to grow at an annualised rate of +3.5%. Should these projections materialise, the en-route unit costs are foreseen to be some -7.3% lower by 2029 than they were in 2023. These average trends, however, vary considerably at charging zone level.

Figure 7-12 shows the annualized planned and forecast performance at individual charging zone level for en-route ANS costs, TSUs and unit costs between 2023 and 2029[37].

Between 2023 and 2029, the unit costs are projected to decrease for 26 out of 36 charging zones. For most of these charging zones, these cost-efficiency improvements reflect the fact that TSUs are planned to grow at a faster pace than en-route costs.

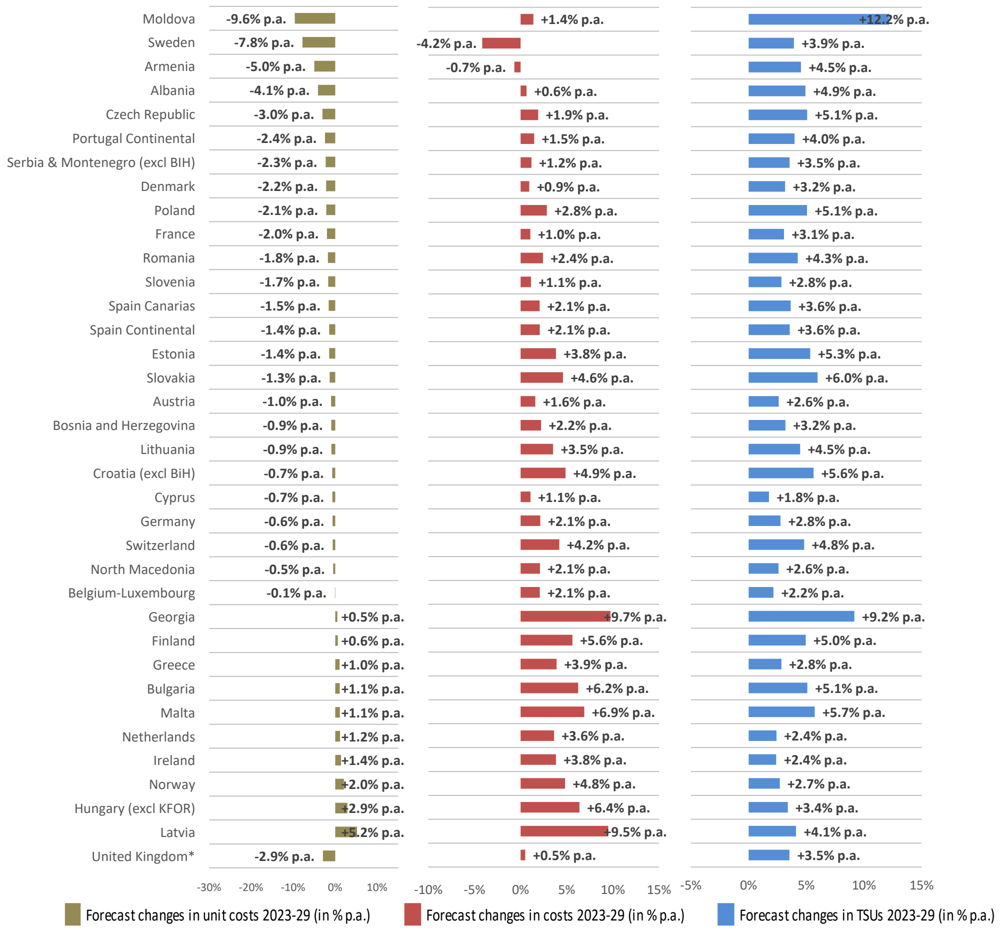


Figure 7-12: En-route cost-efficiency outlook over 2023-2029 at individual charging zone level (€2023)

While the TSUs are forecast to grow for all the charging zones included in this analysis, only Sweden (-4.2% p.a.) and Armenia (-0.7% p.a.) plan to reduce their en-route cost-base in real terms over this period. For Armenia this reflects mainly the inflation effect since costs in nominal terms are expected to increase consistently during the period. In the case of Sweden, the apparent reduction in costs

37 The data for the United Kingdom reflects 2023-2027 period.

mainly results from the fact that its 2023 cost-base was exceptionally high reflecting increase in pension costs following indexation.

7.2 TERMINAL ANS COST-EFFICIENCY PERFORMANCE IN 2023

The analysis of terminal ANS cost-efficiency in this section refers to the States which were required to report data on ANS costs and unit rates in accordance with the SES Regulations [22] in 2023 (see Figure 7-13).

Financial figures are expressed in Euros and in real terms throughout this analysis. The terminal cost-efficiency KPI is computed as the ratio of terminal ANS costs with terminal navigation service units (TNSUs)[38].

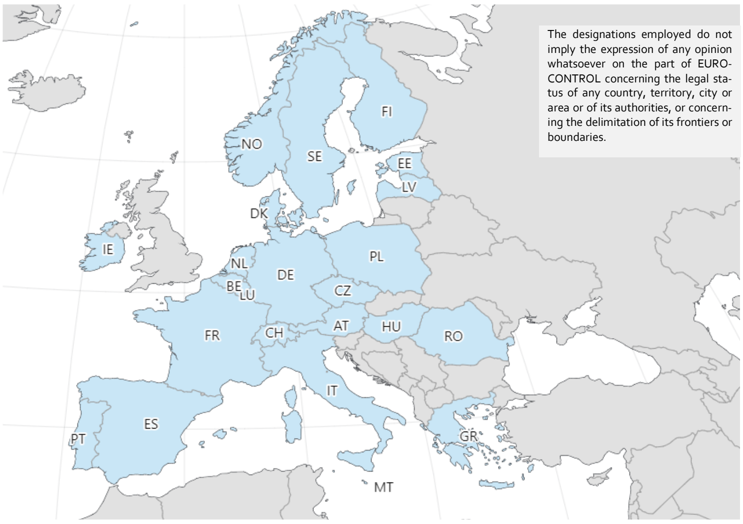


Figure 7-13: Geographical scope of terminal ANS cost-efficiency analysis in 2023

The adoption of the Performance and Charging regulation [22] in 2020 introduced significant changes[39] to the reporting requirements of terminal ANS data for the States subject to this legislation. The analysis of terminal ANS cost-efficiency performance in 2023 includes 26 terminal charging zones (TCZs) comprising 144 airports reported by 23 States (generally one zone per State, but two for Italy, Poland and France).

Furthermore, for the States which subsidise part of their terminal ANS costs charged to the users of terminal air navigation services (Greece, Belgium and Spain) the unit costs presented in this analysis do not consider these State subsidies.

7.2.1 TRENDS IN ACTUAL TERMINAL ANS COST-EFFICIENCY PERFORMANCE AT EUROPEAN SYSTEM LEVEL

Figure 7-14 shows the changes in terminal ANS costs, TNSUs and unit costs between 2018 and 2023 at European system level comprising 26 TCZs.

In 2023, TNSUs grew significantly (+11.1%) while terminal ANS costs also increased (+1.4%). As a result, the terminal costs per TNSU reduced by -8.8% compared to 2022 but remained some +8.4% higher than in 2019.

	2018	2019	2020	2021	2022	2023	2023 vs 2022	2018-23 CAGR
Total terminal ANS costs (M€2023)	1 453	1 483	1 465	1 434	1 451	1 471	1.4%	0.3%
Total terminal service units ('000 TNSUs)	6 965	7 129	3 013	3 650	5 869	6 523	11.1%	-1.3%
Real terminal unit cost per TNSU (€2023)	**208.6**	**208.0**	**486.0**	**392.9**	**247.3**	**225.6**	**-8.8%**	**1.6%**

Figure 7-14: Real terminal ANS cost per TNSU at European System level (€$_{2023}$)

[38] TNSUs are computed as a function of aircraft maximum take-off weight ((MTOW/50)$^{\alpha}$)

[39] The high-level overview of these changes is provided on p. 63 of the PRR 2021

7.2.2 TERMINAL ANS 2023 COST-EFFICIENCY PERFORMANCE AT TERMINAL CHARGING ZONE LEVEL

Figure 7-15 presents a composite view of the terminal ANS unit costs for the 26 TCZs (the number of airports in each TCZ is indicated in brackets). The left side of the figure provides information on the level of terminal ANS unit costs in 2023, while the right-hand side shows the changes in terminal ANS costs between 2022 and 2023.

In 2023, the average terminal ANS costs per TNSU amounted to €225.6 at European system level. Terminal unit costs ranged from €475.7 for Switzerland, to €100.7 for France TCZ 1.

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 TCZ, the use of different cost-allocations between en-route and terminal ANS, differences in the number of TNSUs across TCZs and the scope of ANS provided.

For instance, the Luxembourg TCZ with the fifth highest terminal unit cost in 2023 only includes one airport and represents some 1% of the total terminal ANS costs and traffic (in terms of TNSUs) at European system level. Similarly, while Poland TCZ 2 reflects the information relating to 14 airports, including regional airports, only the five main airports are included in the two Italian TCZs, highlighting the significant differences in size and scope of the TCZs.

The number of TNSUs grew across the majority of the TCZs in 2023 - with the exception of the Estonia and Luxembourg TCZs, both of which recorded slight reductions in TNSUs of around -1% each.

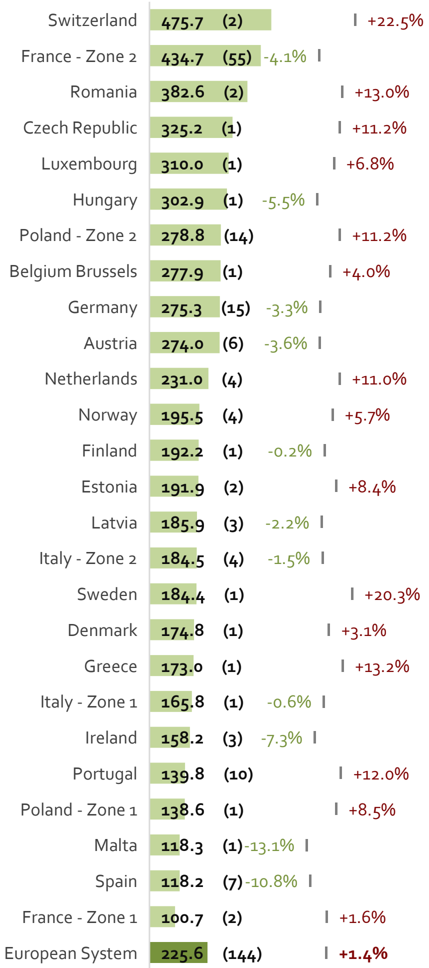


Figure 7-15: Actual terminal ANS costs per TNSU in 2023 and changes in costs between 2022 and 2023 (€2023)

Terminal ANS costs also increased for the majority of the TCZs (15 out of 26) with eight of these TCZs recording increases exceeding +10%, with the largest recorded for Switzerland (+22.5%) and Sweden (+20.3%). At the same time, terminal costs reduced for 11 TCZs with largest reductions reported for the Malta and Spain TCZs (-13.1% and -10.8% respectively).

As already explained in the introduction to this chapter, some of these results are heavily influenced by the inflation effect and should be interpreted with caution.

7.2.3 EUROPEAN TERMINAL ANS COST-EFFICIENCY PERFORMANCE OUTLOOK FOR 2024-2029

Caution is needed when interpreting the planned changes presented in this section since the figures presented here might differ from the information in the final adopted NPPs for RP4. These figures are therefore subject to change following the review process undertaken by the European Commission and the PRB as part of the assessment of theses national performance plans.

Significant changes in the scope of terminal ANS reporting expected as of 2025

Figure 7-16 summarises the evolution of the composition and scope of terminal ANS reporting in Europe over the previous reference periods. It shows a number of differences planned for the RP4 in terms of number of SES States reporting, TCZs established as well as the number of airports included in these zones.

		RP1	RP2	RP3	RP4
Number of	*SES States reporting*	29	30	23	21
	Charging zones	33	38	26	26
	Airports covered	230	174	144	189

Figure 7-16: Changes in composition and scope of terminal ANS reporting in Europe

The differences between the scope of terminal ANS reporting in RP3 and that planned for RP4 include:

- Two additional TCZs established by Romania comprising three and five airports respectively, as well as the inclusion of an additional airport in the existing TCZ1 as of 2025.
- Changes in the composition of the two Italian TCZs where TCZ1 will include four additional airports previously reported in TCZ2 while TCZ2 will comprise 44 new airports.
- Changes in the composition of the French TCZ2 which will include 52 airports (55 previously).
- Latvia and Estonia decided to no longer establish a TCZ since none of their airports fall within the mandatory reporting bracket.

It should also be noted that the planned figures for the two Italian TCZs are excluded from the analysis due to confidentiality reasons. For these reasons, the scope of the forward-looking analysis in this section differs significantly from the rest of the terminal ANS analysis in this chapter.

Figure 7-17 summarises the planned terminal cost and TNSU figures submitted by the States subject to the SES legislation for the period from 2023 to 2029 covering 24 TCZ comprising 140 airports.

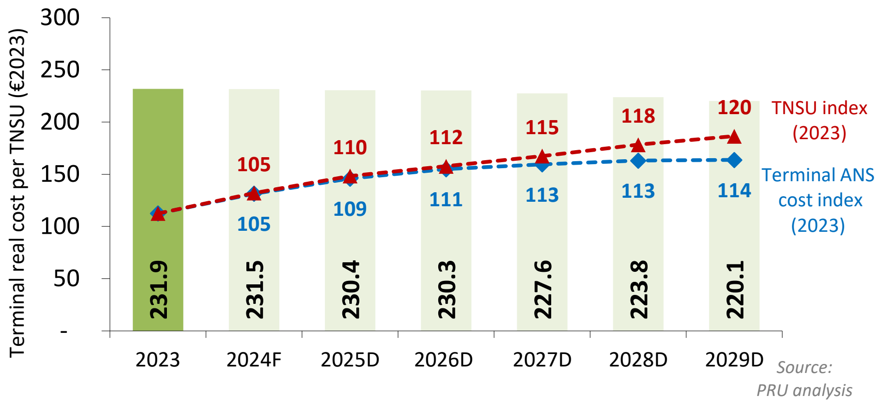


Figure 7-17: European terminal cost-efficiency outlook 2023-2029 (€2023)

Between 2023 and 2029, terminal ANS costs are planned to increase by +2.2% p.a., while TNSUs are projected to grow by +3.0% annually. If these projections materialise, the resulting terminal ANS unit costs will reduce by -5.1% to reach €220.1 by the end of the period.

7.3 DEVELOPMENT OF ROUTE CHARGES BILLED IN 2024

The pan-European ATM system is primarily financed through the collection of en-route charges via the EUROCONTROL Route Charges System and managed by the EUROCONTROL Central Route Charges Office (CRCO) which is tasked with the billing, collection and disbursement of route charges for the contracting Member States.

Route charges billed reached some €10 billion in 2024 – the highest level on record

In 2024, the CRCO has billed[40] some €9.9 billion of route charges, significantly exceeding both the amounts billed in 2023 (€9.0) billion and in 2019 (€7.8 billion), reflecting a combination of strong TSU growth and, on average, higher en-route unit rates for 2024. It should be noted, however, that while the billed amounts have grown considerably since 2020, this recovery has not been consistent across the different charging zones.

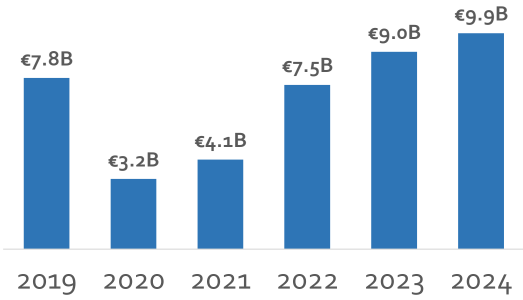


Figure 7-18: Changes in route charges billed between 2019 and 2024, in nominal €

Figure 7-19 shows the changes in the route charges billed between 2023 and 2024 (left hand-side of the figure) as well as between 2019 and 2024 (right-hand side of the figure) at a charging zone-level.

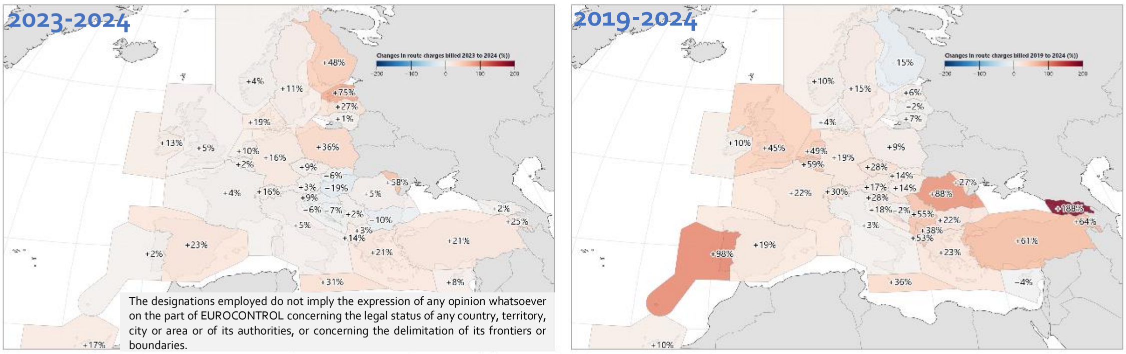


Figure 7-19: Changes in route charges billed over 2023 – 2024 and 2019 – 2024 at a charging zone level

In 2024, the amounts billed grew for 33 of the 38 charging zones in Europe, with most significant increases recorded in Northern Europe (+75% for Estonia and +48% for Finland) as well as for Moldova (+58%). However, these increases should be interpreted with caution since these States have been particularly affected by changes in traffic flows following the beginning of the war in Ukraine. For instance, despite this substantial increase in route charges billed, Finland still billed considerably below pre-crisis level (-15% compared to 2019) while Estonia only moderately exceeded the 2019 level (+6%).

The right-hand side of Figure 7-19 shows that the level of route charges billed was still below 2019 levels for three other charging zones including Latvia (-2%), Bosnia and Herzegovina (-2%) and Cyprus (-4%).

It should be recognised, however, that a multitude of factors should be considered when interpreting the evolution of route charges for individual charging zones. For instance, due to the nature of the charging regime, States subject to full cost-recovery are more flexible when reacting to changes in

40 The amounts billed to airspace users reflected in this analysis do not necessarily imply collection or disbursement of these amounts.

traffic shifts since, for these States, latest traffic forecasts are taken into account when setting the national unit rates.

Figure 7-20 shows the top 20 airline groups [41] in terms of route charges billed in 2024 as well as the change compared to 2023 (see percentage above each bar). The picture is rather fragmented, with the top 5 airline groups representing some 30% of total route charges billed in 2024.

The Ryanair Group operated by far the highest number of flights in Europe in 2024 and paid some 11% of the total route charges; almost double the amount of the easyJet Group which ranks second.

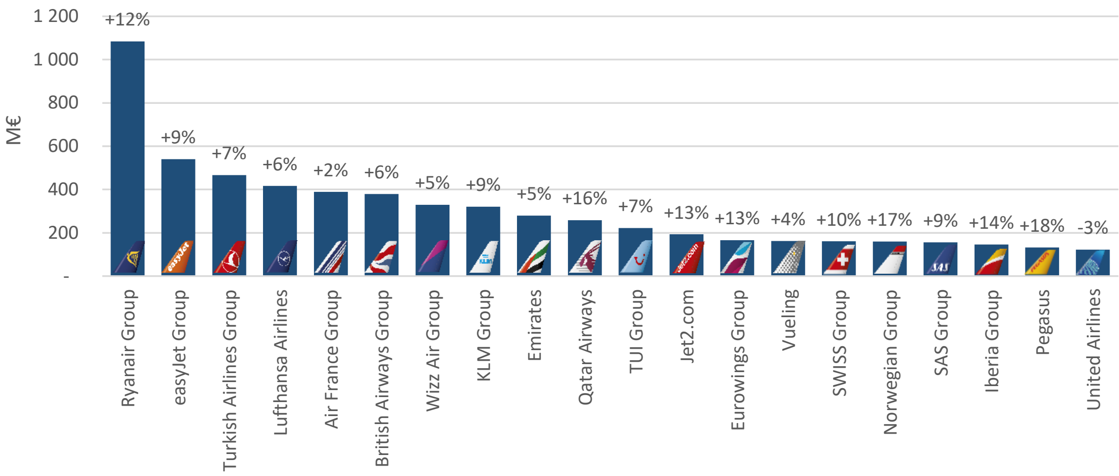


Figure 7-20: Top 20 airline groups in terms of route charges billed in 2024

The amounts of route charges billed grew significantly in 2024 across the majority of the largest airline groups, owing to continuing traffic recovery, with the most significant growth recorded for Pegasus (+18%), Norwegian Group (+17%) and Qatar Airways (+16%). At the same time, the amount of route charges billed for United Airlines, which ranks twentieth in Figure 7-20, reduced by -3% in 2024 – the only reduction across the major airline groups.

[41] Groups refer to Level 1 grouping as defined here: https://www.eurocontrol.int/directory/airline-groups-lookup

7.4 DEVELOPMENT OF EN-ROUTE UNIT RATES FOR 2025

When analysing the variations in the national unit rates it is important to recognise that they also include amounts carried over from previous years which are to be charged or reimbursed to the airspace users on top of the chargeable cost-bases for a given year as detailed in the grey box.

For the States operating under economic regulation, the revenue losses for 2020 and 2021 resulting from the collapse in traffic levels due to the COVID-19 pandemic (some €6B) are to be charged to airspace users through adjustments to the unit rates, starting from 2023 and spread over 5 to 7 years[42] [43].

The differences between en-route unit costs and unit rates

En-route unit cost is a key performance indicator used by the PRC in the context of performance monitoring in this report and reflects the ratio of actual en-route costs and actual TSUs at a charging zone level for a given year.

En-route unit rate reflects the value used for charging purposes based on planned/forecast en-route costs and TSUs. It also includes under/over recoveries from previous years (carry-overs) and other revenues (if applicable) which are deducted.

The States operating under SES regulations, 2025 unit rates are based on the determined cost and TSU figures submitted in November 2024 in the context of the Enlarged Committee for Route Charges which are subject to review and approval by the European Commission. Should these figures change following this assessment, the difference will be charged/reimbursed to the airspace users later during the period, as was already the case during previous reference periods.

The States which are not bound by the SES or national economic regulation regimes, but which are part of the EUROCONTROL Multilateral Route Charges System, apply the "full cost-recovery method". In this case, all gains/losses compared to forecast revenues are returned/charged to airspace users usually in the year n+2 but this can be postponed and/or spread over a period of up to five years[44]. For instance, Türkiye has decided to spread the under-recoveries from the years 2020 and 2021 over five and three years, respectively. At the same time to minimise the effects on airspace users in 2024 Moldova, which has been experiencing a very significant traffic downturn due to the war in Ukraine, has decided to carry-over losses from 2020 – 2022 period to be recovered from 2026 onwards.

Unit rates grew for 26 charging zones

Figure 7-21 provides a summary of national chargeable en-route unit rates[45] for the years 2024 to 2025 for the 38 en-route charging zones included in this analysis. It shows that between 2024 and 2025 unit rates grew for 26 out of 38 en-route charging zones included in this analysis. As already indicated, some of these increases should be interpreted with caution, since, for the States subject to SES regulations, the planned cost and TSU figures underpinning the 2025 unit rate are still subject to approval

42 The UK adopted a similar approach by spreading the under-recoveries as foreseen in the Decision of the enlarged Commission No. 21/169, which was taken to reflect these exceptional measures in the EUROCONTROL principles.

43 It should be noted that, differently from the other States operating under economic regulation, Norway decided to internalise these revenue losses for 2020-21 period and not to charge them to the airspace users, while Estonia and Finland decided to not include these adjustments in their 2025 and 2026 unit rates and resume the recovery of these amounts as from 2027.

44 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 [24], the Commission Implementing Regulation (EU) 2019/317 [22] and the Commission Implementing Regulation (EU) 2020/1627 [25].

45 National chargeable unit rates for 2024 and 2025 are expressed in nominal terms but in Euros 2024 for comparison purposes, therefore, the 2024 unit rates reflected in this analysis for countries operating outside of the Euro zone might differ from those adopted by the Enlarged Committee for Route Charges. These unit rates do <u>not</u> include the administrative unit rate for billing and collection of route charges by the CRCO.

by the European Commission. With this in mind, the largest increases in the 2025 unit rates were recorded for:

- Estonia (+72%, from €50.53 to €86.88), reflecting a combination of a downward revision in the traffic forecast for 2025 as well as inclusion of carry-overs of traffic risk sharing and traffic adjustments from 2023 (€9.5M and €4.6M respectively). It should be noted that the 2025 unit rate does not include the portion of losses from the 2020-21 period since Estonia also decided to postpone the recovery until after 2026.
- Poland (+59%, from €58.52 to €93.32), resulting from i) a combination of much higher determined cost-base and a downward revision in the traffic forecast for 2025 included in the provisional RP4 performance plan, ii) an inflation adjustment and iii) traffic and traffic risk-sharing adjustments reflecting much lower TSUs in 2023.
- The Netherlands (+44%, from €95.15 to €136.88) resulting from a much higher determined cost-base for 2025 proposed in the provisional RP4 performance plan and, to a lesser degree, the inclusion of traffic risk-sharing and traffic adjustments reflecting lower than planned TSUs in 2023.

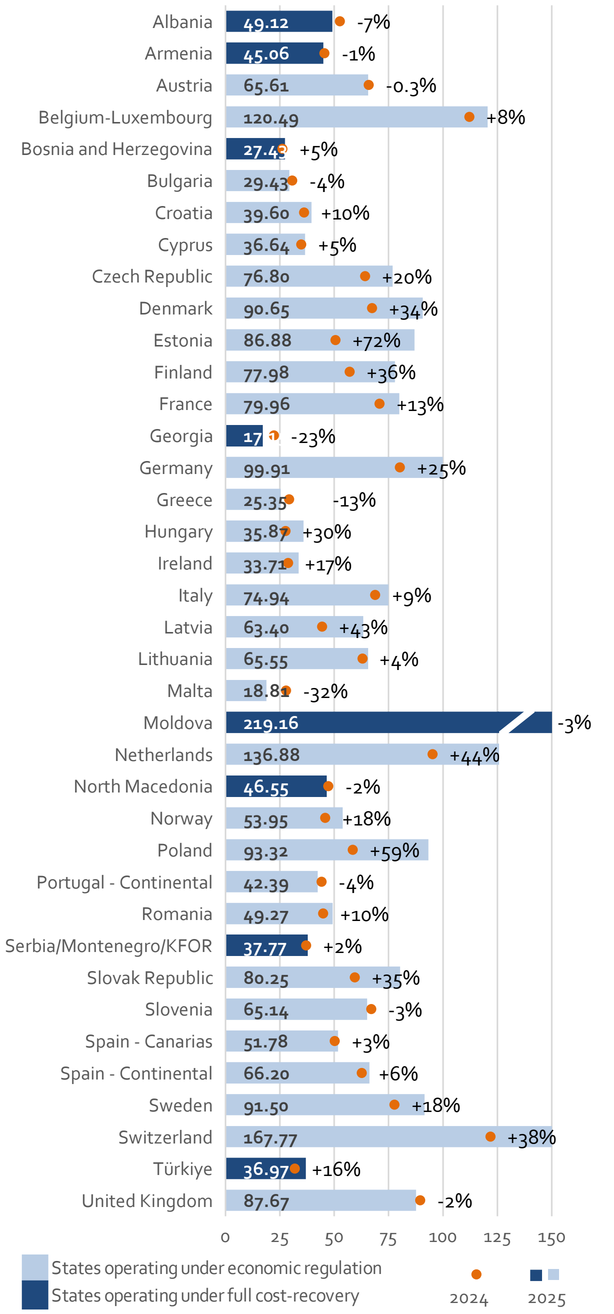


Figure 7-21: Comparison of National en-route Unit Rates between 2024 and 2025 (in nominal terms, in EUR 2024)

In 2025, unit rates reduced for 12 en-route charging zones, with the largest decreases recorded for:

- Malta (-32%, from €27.87 to €18.81) reflecting a combination of lower determined costs and an upward revision in the traffic forecast for 2025 included in the provisional RP4 performance plan.
- Georgia (-23%, from €22.24 to €17.15) reflecting entirely the use of significantly higher traffic forecast to establish the 2025 unit rate since the nominal cost-base is projected to grow by some +37% in 2025.
- Greece (-13%, from €29.27 to €25.35) resulting mainly from the significant upward revision of traffic forecast for 2025 included in the RP4 performance plan with planned TSUs some +19% above those planned for 2024.

The national unit rates can be affected by a range of different factors and their level and trends might significantly differ from the cost-efficiency indicator (en-route unit costs) which is presented in

Section 7.1. It is, therefore, important to analyse the composition of unit rates to better understand the nature of the amount which is ultimately charged to airspace users.

Figure 7-22 shows the aggregated composition of the 2025 average en-route unit rate at a pan-European level combining the chargeable costs, TSUs and adjustments carried-over to 2025 from previous years for the 38 en-route charging zones included in this analysis.

It is important to recognise that the majority of the adjustments carried-over from previous years indicated in Figure 7-22 are applicable only to the States operating under economic regulation. For the States operating under full cost-recovery, due to the nature of the cost-recovery regime, only the difference between the actual and forecast costs and traffic (identified separately as "*Balance carried-over to 2025**" in Figure 7-22) and deductions of other revenues are reported (under "*Other revenues*" together with the States operating under economic regulation in Figure 7-22).

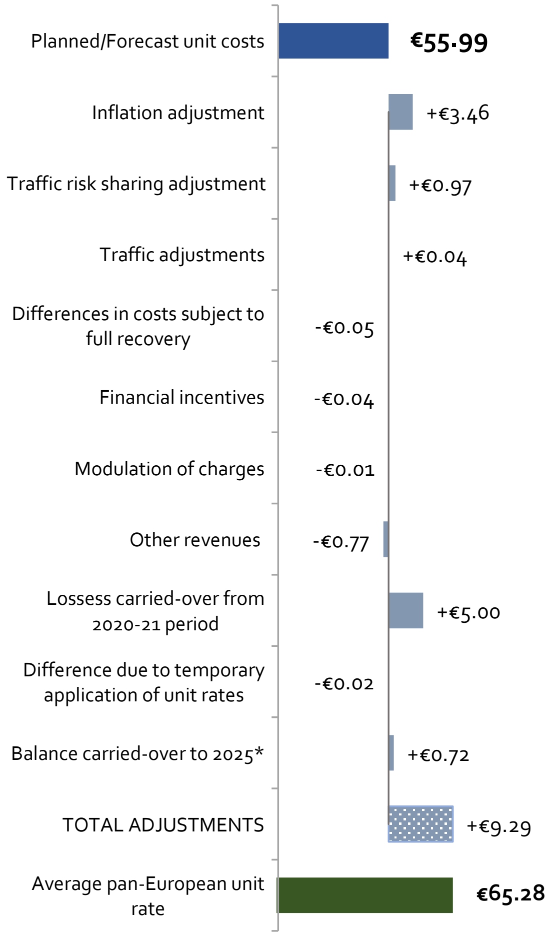


Figure 7-22: Composition of 2025 average pan-European en-route unit rates (in nominal terms, EUR 2024)

The **2025 average pan-European unit rate (€65.28) was some +€9.29 above the planned/forecast unit costs for the year. This is mainly due to i) the adjustment linked to the recovery of revenue losses carried over from 2020-21 for States operating under economic regulation (+€5.00)**[46]**, and ii) the inflation adjustment (+€3.46) reflecting the difference between the actual and planned (forecast) inflation index for the States operating under economic regulation.** Combined, these two adjustments reflect some 13% of the average pan-European unit rate.

The portion of losses from 2020-21 period to be recovered in 2025 amounted to €0.9B (some 8% of total)

Overall, for the States operating under economic regulation, **the portion reflecting the losses incurred in the 2020-21 period which was carried over and included in 2025 unit rates is equal to some €899M**. The majority of these losses, which amount to some €6.0 billion in total, are expected to be fully recovered over a period of 5 to 7 years.

The majority of European States experienced considerable inflationary pressures in 2022 and 2023. While these inflation-driven cost increases are difficult to quantify when assessing the evolution of national unit rates, **for the States subject to economic regulation, the growth in inflation is directly reflected in the unit rates through the inflation adjustment. This adjustment represents some €623M included in 2025 unit rates.**

Figure 7-17 summarises the shares of inflation adjustment and the carry-over of losses incurred in the 2020-21 period included in the 2025 en-route unit rates[46] for the States subject to economic regulation with the percentages indicating the combined share of these two adjustments in the unit rate.

While, on average, these two adjustments combined represent around 14% of the 2025 unit rates for the States subject to economic regulation, these shares vary significantly across the States ranging from some 22% for Hungary to some 1% for the UK.

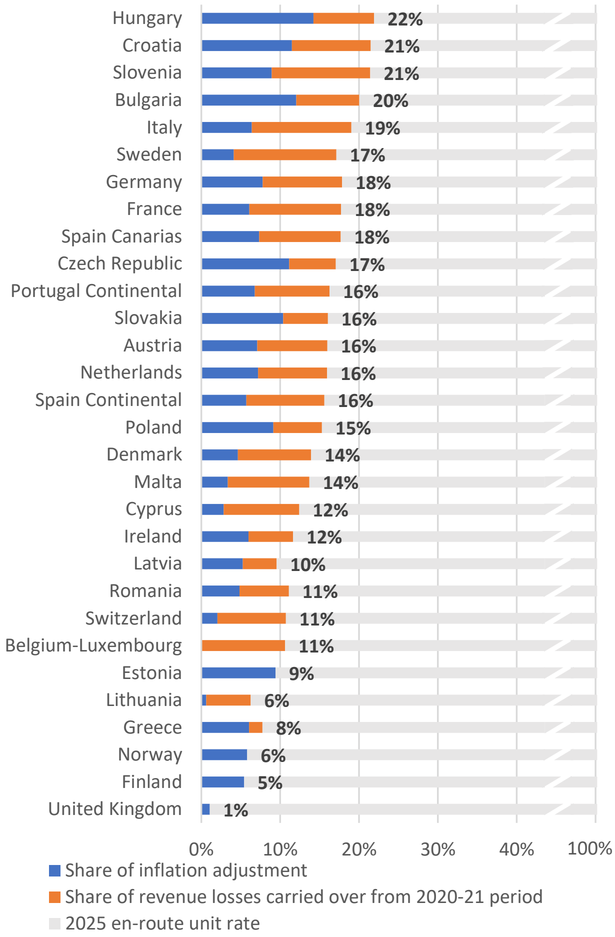


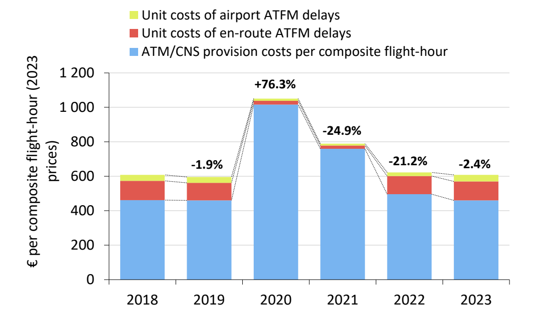
Figure 7-23: Share of inflation adjustment and revenue losses carried over from 2020-21 period in 2025 en-route unit rates

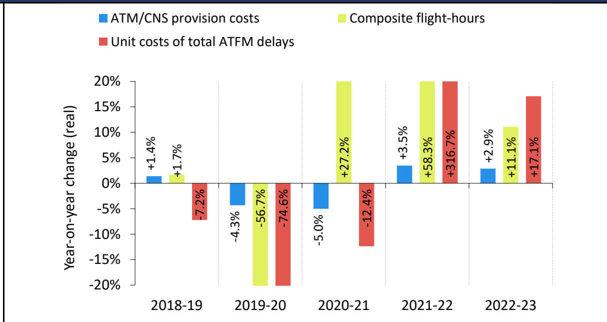
[46] It should be noted that the adjustment for revenue losses carried over from the 2020-21 period in 2025 unit rates does not include the amounts for: i) Norway since it decided not to charge these carry-overs to the airspace users, ii) the United Kingdom, which is instead charging the amounts stemming from 2020-21 period through the traffic risk-sharing adjustment in line with the applicable local regulations, and iii) Estonia and Finland both of which decided to postpone the amounts due to be recovered in 2025 and 2026 until 2027 onwards.

7.5 ANSPs GATE-TO-GATE ECONOMIC PERFORMANCE IN 2023

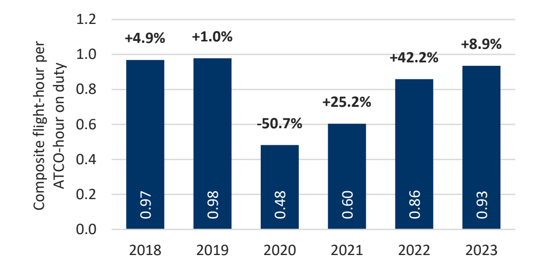
This section reflects data from the ATM Cost-Effectiveness (ACE) Benchmarking exercise as available at the time of publication and may be updated once the final ACE data is available.

Trends in unit economic costs at pan-European system level [47]

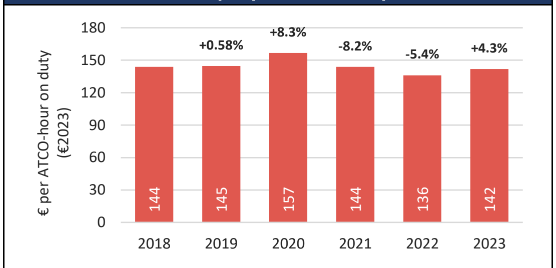




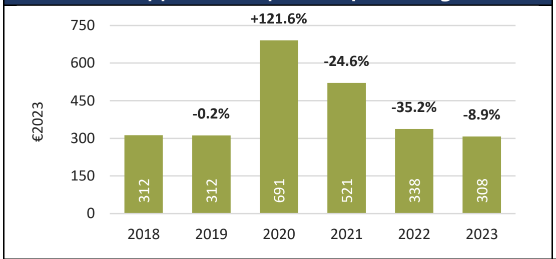
Trends in ATCO-hour productivity



Trends in ATCO employment costs per ATCO-hour



Trends in support costs per composite flight-hour



Compared to 2022, the **economic costs per composite flight-hour** at pan-European system level fell by -2.4%, amounting to €607 (a similar value to that recorded in 2018). This overall reduction results from a -7.4% decrease in the unit financial costs while the unit costs of ATFM delays rose by +17.1%.

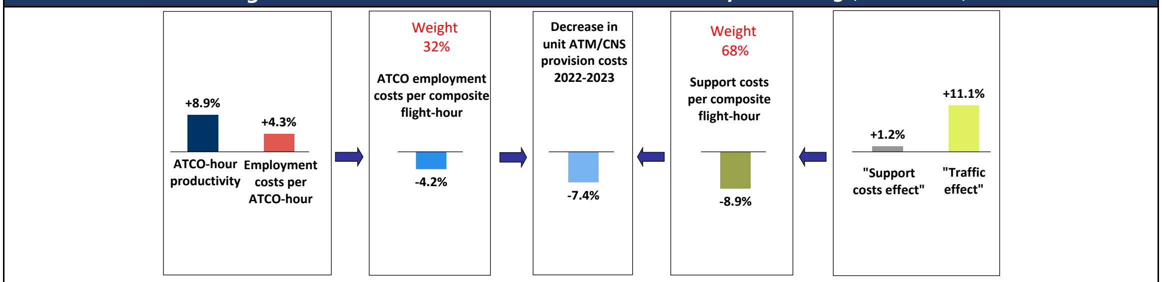
Unit ATM/CNS provision costs fell by -7.4% in 2023, reflecting the fact that composite flight-hours rose much faster (+11.1%) than ATM/CNS provision costs (+2.9%). The resulting unit ATM/CNS provision costs in 2023 (€460) were similar to pre-crisis levels.

ATCO-hour productivity increased by +8.9%, reaching 0.93 composite flight-hours per ATCO-hour on duty. This productivity level is similar to that recorded in 2017.

ATCO employment costs per ATCO-hour grew by +4.3% in 2023 reflecting the fact that ATCO employment costs (+6.4%) rose faster than ATCO-hours on duty (+2.0%).

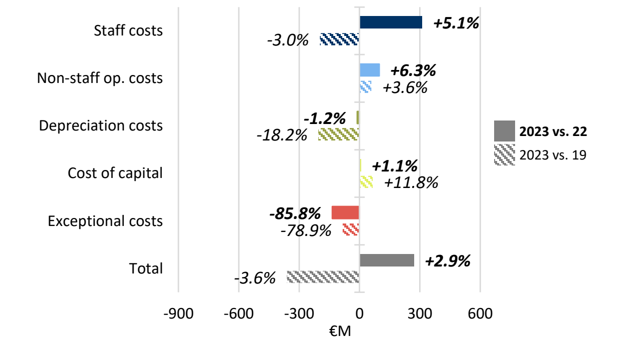
Unit support costs fell by -8.9% compared to 2022, reaching €308, reflecting the fact that composite flight-hours rose much faster (+11.1%) than support costs (+1.2%).

Changes in the financial cost-effectiveness indicator, 2022-2023 (real terms)



47 The costs of 1 minute of ground ATFM delays is approximated at 127 EUR in this analysis. Details on the methodology and sources used to compute economic costs are available in the Annex II of the ATM Cost-Effectiveness (ACE) Benchmarking Report (2025 Edition).

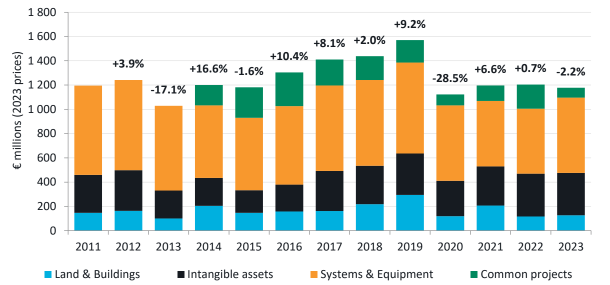
Trends in ANSPs gate-to-gate ATM/CNS provision costs



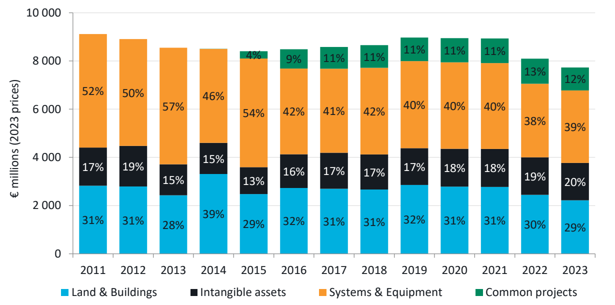
Trends in ANSPs gate-to-gate ATM/CNS staff

Staff categories	Change over 2022-2023	in FTEs
ATCOs in OPS	+1.0%	+168
ATCOs on other duties	+6.4%	+141
Ab-initio trainees	+10.9%	+88
On-the-job trainees	+9.8%	+115
ATC assistants	+0.9%	+17
OPS support (non-ATCOs)	+2.8%	+110
Technical support staff for op. maint., monit. and control	+1.3%	+111
Technical support staff for planning and development	+0.7%	+21
Administration	+1.1%	+96
Staff for ancillary services	+0.5%	+9
Other Staff	+1.3%	+34
Total number of staff	**+1.8%**	**+910**

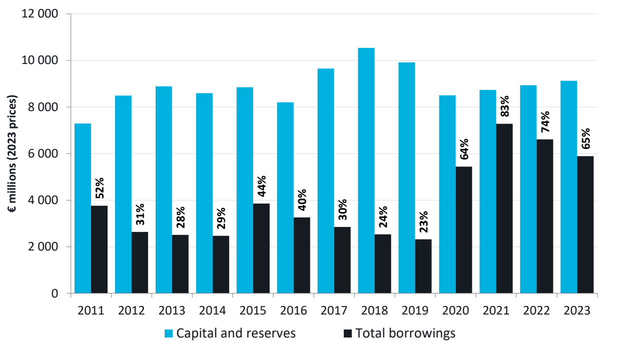
Trends in ANSPs capital expenditures



Trends in the composition of ANSPs fixed assets



Trends in ANSPs borrowings and reserves



Total **ATM/CNS provision costs** rose by +2.9% in 2023, mainly reflecting increases in staff costs (+5.1% or +€312M) and non-staff operating costs (+6.3% or +€98M). However, ANSPs cost-bases remained some - €361M (-3.6%) lower than in 2019 (see striped bars) owing to the significant cost-savings achieved by ANSPs at system level in 2020 and 2021.

The **number of ATM/CNS staff** rose by +1.8% (+910 FTEs) in 2023 – the first increase recorded since 2020. While the staff numbers grew across all the staff categories compared to 2022, the main increases were reported in the number of ATCOs in OPS (+168 FTEs), ATCOs on other duties (+141 FTEs) and on-the-job trainees (+115 FTEs).

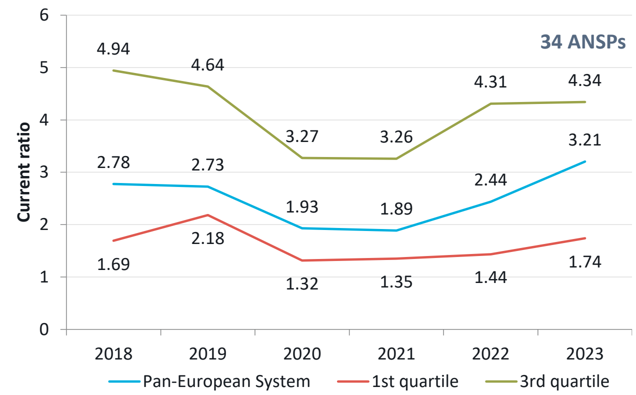
Between 2011 and 2019, **capital expenditures** grew by +3.5% annually peaking at some €1.6B in 2019. The outbreak of the COVID-19 pandemic resulted in cancellation, revision or postponement of some capex projects by most of European ANSPs. This was reflected in a significantly lower level of capital expenditures at pan-European system level between 2020 and 2023 (some -9% lower, on average, compared to 2011-19 period).

As a result of these reductions in capital expenditures, the **level of fixed assets in operation** was lower than over the 2011-19 period.

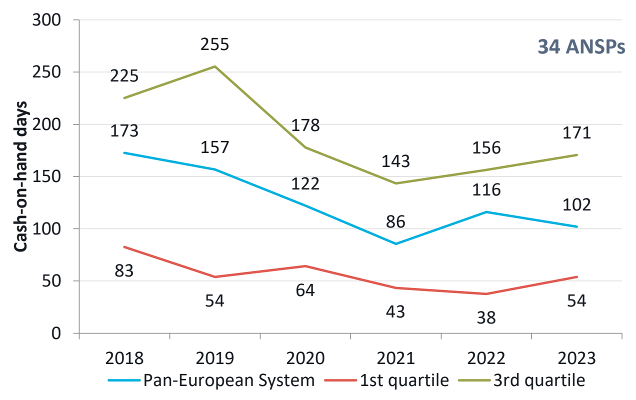
Capital and reserves represented some 40% of the total liabilities in 2023, while they represented, on average, some 47% between 2011 and 2019.

The level of **total borrowings** reduced by some -11% and amounted to €5.9 billion in 2023 representing some 29% of total liabilities (up from 16%, on average, over 2011-19 period). However, despite this reduction the level of ANSP financing through debt remained significantly higher (65%) than at any point between 2011 and 2019 (23%-52% depending on year).

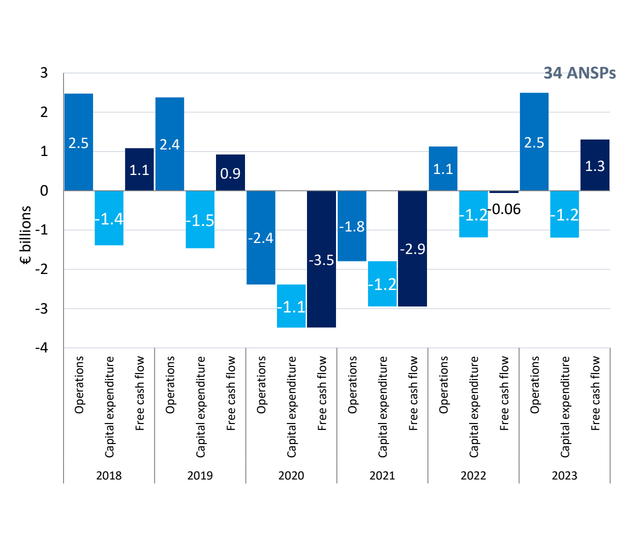
Trends in ANSPs current ratio



Trends in ANSPs cash-on-hand days



ANSP cash flow (in nominal €)



The current ratio, cash-on-hand days and cash-flow indicators have been calculated at pan-European system level, using data published in the ANSPs' financial statements. They are therefore consistent with the information published at individual ANSP level in the EUROCONTROL Aviation Intelligence Unit ANSPs Financial Dashboard.[48]

Following the positive shift in 2022, which marked the end of three years of continuous decline, the average **current ratio** of pan-European ANSPs continued to improve in 2023. However, it should be noted that after reaching their lowest levels in 2020-21 the ANSPs in the first quartile experienced a proportionally weaker recovery compared to the pan-European average. This suggests that while overall improvements are evident, some ANSPs continue to face liquidity challenges, highlighting disparities across the Pan-European system.

In 2023, the average **cash-on-hand days** reduced slightly to 102 days, down from 116 in 2022. This is still well below pre-pandemic level of 157 days in 2019.

Following the unprecedented drop in traffic and resulting loss of revenues in 2020, the net cash flow from operating activities turned negative (-€2.4 billion, compared to +€2.4 billion in 2019). Since then, there has been a progressive recovery. In 2023, the **free cash flow** from operations reached €2.5 billion. After accounting for capital expenditures (€1.2 billion), the resulting free cash flow of €1.3 billion significantly exceeded the value recorded in 2019.

For more information on our ATM Cost-Effectiveness (ACE) benchmarking reports, definitions and data, please visit https://ansperformance.eu/economics/ace-overview/

48 The ANSP Financial Dashboard produced by the EUROCONTROL Aviation Intelligence Unit collects the data from ANSPs' most recent financial statements and validate them with the ANSPs. For more details, see: https://ansperformance.eu/economics/finance/.

8 Annex 1 – Analysis of Area Control Centres

The Annex with the detailed analysis of the most constraining Area Control Centres (ACCs) can be downloaded @ https://www.eurocontrol.int/sites/default/files/2025-03/eurocontrol-performance-review-report-2024-annex.pdf

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EUROCONTROL

For any further information please contact:

Performance Review Unit, 96 Rue de la Fusée,
B-1130 Brussels, Belgium

pru-support@eurocontrol.int