EUROCONTROL

# Performance Insight

## 20 years of performance-oriented approach for ATM in Europe – a success story?

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**Measuring European Aviation Performance**

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## BACKGROUND

This PRC Performance Insight document, has been prepared by the EUROCONTROL Performance Review Unit (PRU) for the Performance Review Commission (PRC).

The PRC conducts independent measurement, assessment and review of the performance of the Pan-European Air Navigation Services (ANS) system, including its contribution to the efficiency of Pan-European aviation. The PRC strives to identify future improvements and makes recommendations as appropriate.

The PRC maintains open and transparent dialogue with relevant parties, including but not limited to States, Air Navigation Service Providers, Airspace Users, Airports, social dialogue partners, civil-military organisations, international and national organisations, etc. The PRC conducts research into the development of performance measurement. This includes, inter alia, investigating how performance could best be described/measured in the long-term, developing and testing proposals for future indicators and metrics and contributing to future improvements in performance.

The PRC disseminates the results of its analysis to relevant parties, provided that no sensitive data are involved, in order to demonstrate the PRC's commitment to transparency and to promote the application of PRC analysis.

The PRC produces independent ad-hoc studies, either on its own initiative and/or at the request of relevant parties. The PRC's website address is: https://www.eurocontrol.int/air-navigation-services-performance-review

## NOTICE

The PRU has made every effort to ensure that the information and analysis contained in this document are as accurate and complete as possible. Should you find any errors or inconsistencies we would be grateful if you could please bring them to the PRU's attention by sending an email to: PRU-support@eurocontrol.int.

## Introduction and background

Key points in this section

- Creation of a Single European market for aviation in 1992 but ATM is lagging behind.
- Delay crisis at the end of the 90s triggered a performance-based approach for ATM.
- Creation of PRC and EUROCONTROL "light touch" performance review system in 1998.
- SES legislations (2004) + legal provisions for a "hard touch" performance scheme as of 2012 including binding targets.

Historically, air transport has developed under the auspices of national authorities with largely monopolistic national carriers and services and publicly owned and managed infrastructure.

The deregulation of aviation in Europe 30 years ago created a single market removing commercial restrictions for European airlines operating within the European Union (EU), effectively allowing them to freely set fares and to operate freely on intra EU routes. At the same time, the EU grew from 12 States in 1989 to 27 States in 2008 bringing free movement and an open aviation area which, together with the rise of low-cost airlines and internet booking, stimulated substantial growth in air traffic.

Before the outbreak of the pandemic in 2020, traffic in Europe had more than doubled since 1990 to reach 11.1 million flights in 2019.

Particularly high growth rates were observed between 1990 and 2000, which resulted in severe delays towards the end of the 1990s when the European Air Traffic Management (ATM) system could no longer keep up with deploying sufficient capacity to accommodate the increasing demand.

Many things have changed since then to improve European ATM performance but, despite all efforts, delays soared again in 2018/19 causing major disruptions to passengers and some of the problems were not new.

### Why this PRC performance insight?

The objective of this PRC performance insight edition is to look at the major developments and trends in terms of ATM performance over the past 20 years before the start of the COVID crisis in 2020[1].

Did the performance-oriented approach in ATM work as foreseen? How did the system change and what does it mean for the future? What lessons can be learned?

Following a brief description of the institutional background, the first part illustrates some trends in terms of changes in air traffic demand in the European ATM system over the past 20 years.

The second part highlights some of the network wide initiatives to improve the performance of the ATM network.

The last part of the paper evaluates how ATM performance has changed over time and what lessons could be learned from the past with a view to further improve ATM performance in the future.

The key findings are that:

- Focus on performance clearly yielded benefits but has not delivered the improvements anticipated.
- Increased network focus and less fragmentation is key to realising future performance improvements.
- A balanced approach is necessary to avoid one performance area improving at the expense of others.
- Delivering future performance requires transformational change not just evolution.

### A performance-oriented ATM in Europe

Prompted by the unacceptably high delays, the European Civil Aviation Conference (ECAC) adopted in February 1997 a strategy to introduce a performance-oriented approach in European ATM [1].

In 1998, the first "light touch[2]" performance review system addressing all aspects of ATM was established by EUROCONTROL and the

1 Although not part of this analysis the outbreak of the COVID-19 pandemic in 2020 and the resulting dramatic effects for aviation are addressed in complementary PRC publications [26].

2 Performance improvements rely mainly on transparency, peer pressure and States' goodwill.

Performance Review Commission (PRC) was created to independently monitor ATM performance, set Pan-European targets and advise EUROCONTROL States to ensure the effective management of the ATM system.

Inspired by the initiatives in Europe, the International Civil Aviation Organisation (ICAO) also started to work at global level on the development of performance indicators to better understand where improvements are needed. The work of the PRC supported the development of the ICAO Manual on Air Navigation services Economics and the joint work between the FAA and EUROCONTROL later supported the development of indicators for the Global Air Navigation Plan (GANP).

### Single European Sky (SES)

In 1999, the single European sky (SES) was launched by the European Commission (EC) to improve the performance of air traffic management (ATM) and air navigation services (ANS) through better integration of European airspace. With ATM lagging behind, it was a major step forward that the States and the European Parliament recognised the importance of expanding EU aviation policy into the ATM-domain.

The first legislative package (SESI) was drafted in 2001 and adopted in 2004 [ [2], [3], [4], [5]]. The regulations established a framework, comprising a set of common binding rules on ATM safety, on the provision of ATM services, on airspace management and on interoperability within the network. The SES high level goals envisaged that, compared to 2004, the post 2020 ATM system should provide a 3-fold increase in capacity, a 10-fold increase in safety, a 10% reduction in environmental impact, and a reduction in cost to airspace users of 50%. Harmonisation and standardisation were regarded as important steps in achieving less fragmentation and reducing costs.

The SESAR (Single European Sky ATM Research) Joint Undertaking was set up in 2007 to stimulate innovation and cooperation with the industry and to manage the technological and industrial dimension of the SES, i.e. the development and deployment of the new European ATM system.

Within the framework of the EU aviation strategy and the SES, the European Air Traffic Management (ATM) Master Plan is the main planning tool for ATM modernisation across Europe. It defines the development and deployment priorities needed to deliver the Single European Sky ATM Research (SESAR) vision in a coordinated and timely fashion. The Master Plan also details performance ambitions and is regularly updated, through collaboration between all stakeholders, to respond to the evolving aviation landscape.

### A legally binding performance scheme

Encouraged by the success of the EUROCONTROL "light touch" performance scheme, the EU made legal provision for an EU-wide performance scheme which came into force in August 2010 [6] as one element of the SES II legislative package.

The SES performance scheme places focus on planning and accountability for performance, binding target setting (Safety, Cost-Efficiency, Capacity and Environment), monitoring, incentives and corrective actions at both European and national levels. It is coupled with a new Charging regime [7], replacing "full cost recovery" by a system of "determined costs" and risk sharing set at the same time as performance targets.

The first reference period (RP) covered the years 2012-2014. From 2015 onwards, each reference period covers five calendar years.

With the SES performance scheme building on the existing indicators developed within the EUROCONTROL scheme, a key rationale for the EC was to achieve synergies (common procedures, tools, data feed) between the SES performance scheme (29 States in RP1) and the existing EUROCONTROL performance review system (39 Member States in 2012) to keep costs to a minimum.

The EUROCONTROL scheme complements the SES work by providing a wider performance view on all EUROCONTROL States and by carrying out research and development into the longer-term evolution of ANS performance review, including benchmarking with regions outside Europe.

## How did demand change over time?

Key points in this section

- Strong relative growth in Eastern Europe - but from a smaller base
- Higher dispersion across the network with a higher number of airport pairs.
- Further increase of traffic in summer and more traffic on weekends.
- Change of aircraft type and size over time with more and more aircraft requesting higher flight levels.
- Observations to a large extent driven by strong growth of "low cost" segment.
- Peak system load remains concentrated in the core area which forms the crossing point of several traffic flows.

Before the pandemic cut back traffic in 2020 to the level of 1989, flights in the ECAC area had more than doubled compared to 1990 (+109%).

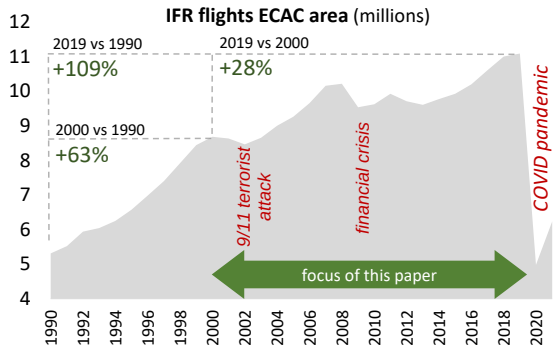


Figure 1: Traffic growth over the past 30 years

Strong growth can be observed between 1990 and 2000 (+63%), following the deregulation of the European air transport market.

Between 2000 and 2019, traffic grew by +28% which corresponds to an additional 2.4 million flights using the ATM system in 2019.

Overall, the analyses in the remainder of this paper focus on changes over the past 20 years (before the pandemic), since the introduction of a performance-based approach in ATM in Europe in the late 1990s.

Subject to data availability, the individual analysis periods in the paper may vary slightly.

Without a doubt, over the past 20 years, there has been a shift towards more international flights. Between 2000 and 2019, the relative share of international flights increased from 58.7% to 70.6%. At the same time, domestic traffic within ECAC States decreased notably.

| Flights (ECAC area) | 2000 | 2019 | Δ (pp) |
|---|---|---|---|
| **Total IFR flights** | **8.7** | **11.1** | |
| within ECAC | 86.0% | 77.5% | -8.5% |
| *domestic (within State)* | 40.3% | 27.6% | -12.7% |
| *International ECAC* | 45.7% | 49.9% | +4.2% |
| Internat. to/from ECAC area | 13.0% | 20.7% | +7.7% |
| Overflights | 1.0% | 1.8% | +0.8% |

Figure 2: Breakdown of flights in the ECAC area

Of the flights to and from the ECAC area, the highest growth over the past 20 years was on routes to China and the Middle East, followed by Russia and the Asia/ Pacific region. It illustrates the growing importance of Middle East hubs.

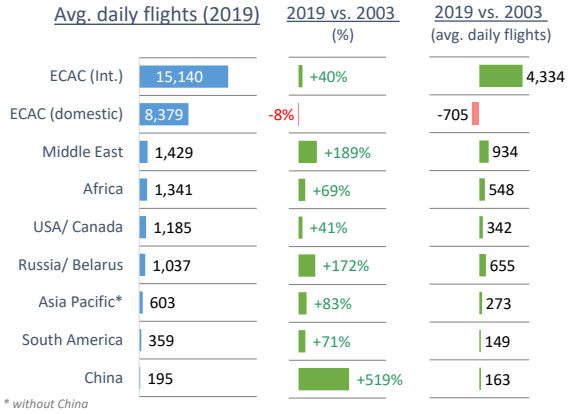


Figure 3: Flights to/from the ECAC area by region

The growth was not equally distributed among the network. Although from a lower base, the map below shows that the highest growth rates were observed for Eastern Europe where traffic more than doubled in several States.

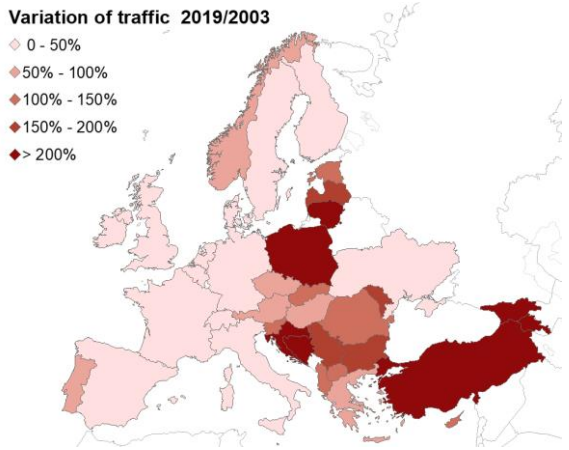


Figure 4: Traffic growth by State (2019 vs 2003)

Before the COVID crisis, the provision of sufficient airport capacity was considered as one of the key challenges for future air transport growth. The Challenges to Growth study [8] warned in 2018 about the airport capacity shortage expected in 2040, when 1.5 million flights will not be able to fly, despite the capacity plans for the airports.

Based on all departures in the ECAC area, the center of gravity of European traffic moved gradually towards the south-east over the last 20 years which is likely to continue with the opening of the Istanbul Grand Airport in April 2019.

Traffic in general gets more dispersed across the network with more services to smaller airports away from congested hub airports.

| Departures | 2000 | % dep. | 2019 | % dep. | Δ |
|---|---|---|---|---|---|
| >150k | 8 | 20.2% | 9 | 19.7% | +1 |
| [75k,150k) | 20 | 26.3% | 23 | 26.4% | +3 |
| [10k,75k) | 112 | 35.6% | 134 | 39.2% | +22 |
| [1k,10k) | 362 | 17.9% | 361 | 14.7% | -1 |
| | 502 | | 527 | | +25 |

Figure 5: ECAC airports by IFR departures

A notable growth can be observed at airports with less than 75k departures whereas there was only one additional airport with more than 150k departures.

The shift towards more but less concentrated services over time is also confirmed by the analysis of average daily flight on ECAC airport pairs in Figure 6.

| Avg. daily flights on airport pair (bi-directional) | 2000 | % traffic | 2019 | % traffic |
|---|---|---|---|---|
| [>25 | 8 | 2.4% | 1 | 0.2% |
| [15,25) | 43 | 6.8% | 35 | 4.5% |
| [10,15) | 63 | 6.5% | 73 | 5.8% |
| [5,10) | 324 | 19.2% | 364 | 16.6% |
| [1,5) | 2,071 | 40.7% | 3,036 | 43.5% |
| >1 | 62,490 | 24.3% | 61,490 | 29.4% |

Figure 6: Airport pairs by avg. daily flights

Airport pairs with more than 15 daily flights decreased between 2000 and 2019 while those with lower frequencies generally increased notably during that time.

Figure 7 shows a comparison of the busiest air routes on the peak days in 2000 (top) and 2019 (bottom). Both, peak traffic load and average daily traffic increased notably over the analysis period, but the distribution of the busiest flows stayed rather similar over the past 20 years.

A significant concentration of traffic exists in the area delimited by London, Paris, Frankfurt and Amsterdam. The area includes major European hubs, and it is also the crossing point between traffic from Northern Europe to the South West and traffic from Central Europe to the West.

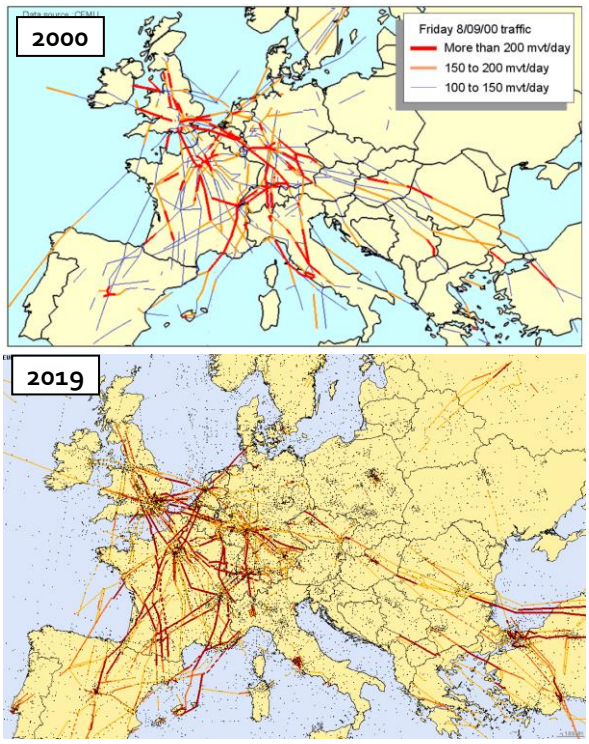


Figure 7: Route network utilisation (peak days)

Another concentration of traffic exists over Switzerland, the Eastern part of France and the Southern part of Germany, as this area corresponds to the cross-roads of major traffic flows (South-North and East-West). New areas with major traffic flows include the area around Istanbul, Madrid and Bordeaux.

Over the years, the difference between week and weekend traffic has decreased. While in 2000 the average traffic level was 28.2% higher on weekdays than on weekends, the ratio was only 9.7% in 2019.

At monthly level, there was a further increase of traffic in the summer with the peak month moving from September to July. While in 2000 the traffic in summer was 9% higher than average, the ratio increased to 14.6% in 2019.

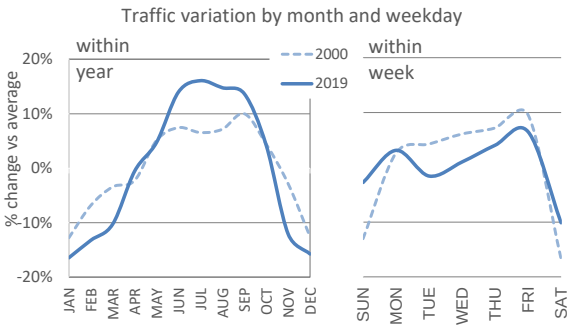


**Figure 8: Traffic variation by month and weekday**

The highest variation between summer and winter is observed in typical holiday regions such as South-East Europe where the relatively low traffic in winter contrasts sharply with the high demand in summer.

The emergence of low-cost carriers (LCCs) following the liberalisation of the European air transport market clearly contributed to the observed traffic trends over the past 20 years.

Their market share increased from virtually zero to 31% in 2019, which corresponds to 9.600 average daily flights

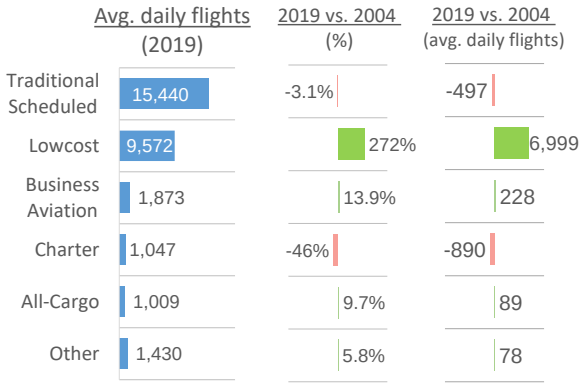


**Figure 9: Market segments (2019 vs 2004)**

At the outset, the growth of the LCCs was concentrated in Western Europe but with the enlargement of the European Union in 2004, LCCs progressively expanded into Central and Eastern Europe, stimulating strong growth in those emerging markets.

Although some LCCs have started to operate at large European hub airports, they tend to operate at less congested secondary airports and may decide to enter and exit new markets at comparatively short notice which can introduce unforeseen changes in traffic patterns and airport loads.

Over the past years there was also a strong growth in narrow bodies (+84.5%) which is to a large extent also driven by the growth of LCCs typically operating one aircraft type (B737, A320). At the same time, there was a decrease in the use of smaller regional jets (-44%) and Turboprop (Commuter) aircraft (-34.7%).

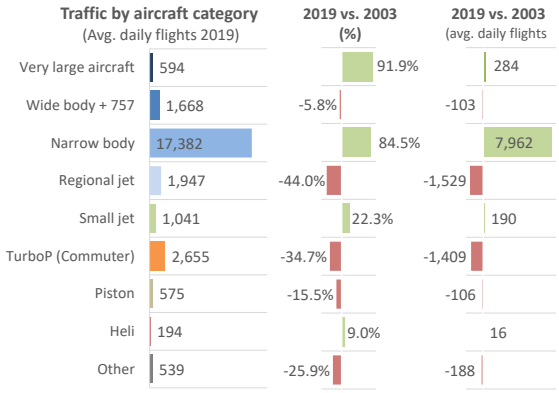


**Figure 10: Change in aircraft categories in the ANS system (2019 vs. 2003)**

The change in the composition of the aircraft mix also reflected on the requested flight levels between 2003 and 2019 which show a clear increase in demand in upper flight levels. Fewer Turboprop aircraft and the parallel strong growth of the narrowbody fleet clearly contributed to this trend.

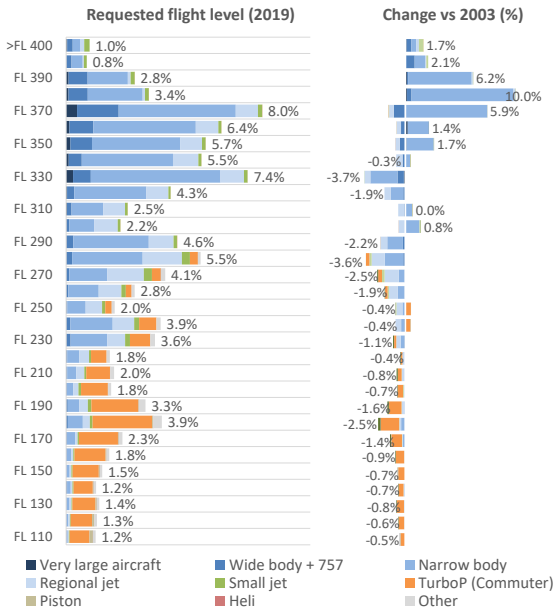


**Figure 11: Change in requested FL (2019 vs. 2003).**

## How did the ATM network change?

Key points in this section

- Despite its international nature, ATC is still predominantly organised by administrative boundaries rather than operational needs.
- The operational concept as well as the processes and technology in Europe essentially remained the same over the past 20 years (slow tech. change in ATM with no striking new technologies to improve capacity).
- Many local initiatives improved safety, flight efficiency, capacity and cost efficiency over time but despite these efforts, the network remains fragmented in many ways.
- The successful introduction of RVSM in 2002 was per design a network wide initiative. Other initiatives such as FRA were implemented locally at various shapes and times which prevented network wide leverage.
- Despite local improvements, the recent crises have shown that the network benefits from a strong network management function, ranging from the planning to the tactical phase.
- Especially in high-density areas such as the core area a wider approach to airspace design (geographical, technological) in line with traffic flows is needed.

The operational ATM concept as well as the processes and technology in Europe remained essentially the same over the past 20 years. Substantial technological change is usually comparatively slow, given the high safety requirements, the coordination effort needed to harmonise standards and the relatively small ATM supplier market.

The following section illustrates some of the main network wide initiatives aimed at improving ATM performance in Europe.

It goes without saying that, in addition to the selected examples in this section, there were numerous local and regional projects and initiatives which greatly enhanced the operational, economic and safety performance of ATM in Europe.

### Reduced Vertical Separation Minimum (RVSM)

A genuine system wide capacity improvement was the introduction of the **Reduced Vertical Separation Minimum (RVSM)** in the entire ECAC region about 20 years ago (Jan. 2002) which was part of a wider ICAO strategy to establish RVSM in all global regions.

It required all stakeholders in the network to change at the same time as it introduced an additional six flight levels between flight level FL 290 and FL 410 by reducing the vertical separation between those flight levels from 2000 ft. to 1000 ft.

The six additional flight levels created by RVSM increased airspace capacity In Europe by up to 20% and thus helped reducing delays and lowering fuel consumption.

### Defragmentation of ATM in Europe

Despite its international nature, air traffic in Europe has been traditionally managed at national level in a fragmented and quasi monopolistic environment. Hence, many issues revolve around the level of operational, technological and institutional fragmentation[3] and its impact on ATM performance in terms of operations and costs.

Acknowledging the need to organise ANS according to traffic flows, EUROCONTROL was entrusted already back in 1974 with the provision of air traffic services in the upper airspace above parts of four States (Belgium, Germany, Luxembourg and the Netherlands).

The Maastricht Upper Area Control Centre (MUAC) was part of a broader pan-European vision to create several similar facilities across the continent to ensure a common, consolidated and more efficient approach. In 1997, the Central European Air Traffic Services (CEATS) Upper Area Control Centre project comprising eight

3 "Fragmentation" refers to the division of ANS provision into smaller decision-making or operational units than would result from considerations of optimum scale. In Europe, this has mainly arisen from the organisation of ANS at the State level. However, fragmentation also arises through smaller than optimal operational units within national ANSPs.

States was launched but terminated again in 2008 when the financial crisis hit Europe.

It nonetheless paved the way to the later formation of **Functional Airspace Blocks (FABs)** aimed at reducing the level of fragmentation and to organise European airspace according to traffic flows rather than national boundaries. The goal was to achieve enhanced cooperation (airspace management and economy of scales through integration of services), thereby lowering the cost of ANS. A report commissioned by the PRC in 2006 estimated the costs of fragmentation to be around 20-30% of the total en-route costs [9].

In the context of the SES II legislative package, all EU member States were required to become part of a FAB by 2012 to reduce the level of fragmentation. The resulting nine FABs covering 31 states are shown in Figure 12.

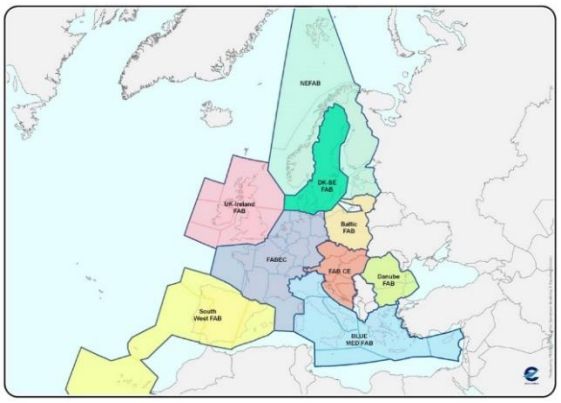


**Figure 12: Functional airspace blocks (2019)**

In 2017, the European Court of Auditors [10] concluded in a special report evaluating the key components of the Single European Sky (SES) initiative, that the formation of FABs has failed to defragment European airspace as they have not been fully implemented due to a *"lack of commitment on the part of the Member States. Concerns linked with preserving sovereignty, the legacy ANSPs, their revenues and their workforce have a strong impact in the Member States preference for keeping the current status quo"*.

Current FABs *"essentially provide a forum for cooperation between stakeholders of neighbouring States but have proved ineffective in targeting fragmentation, whether at the levels of airspace management, service provision or procurement of technical equipment."*

Figure 13 provides a high-level comparison of key system figures between 2003 and 2019. In the analysis, there were 37 different en-route ANSPs of various geographical areas in Europe[4] (and a similar number of different regulators).

| | 2003 | 2019 | Δ vs 2003 |
|---|---|---|---|
| Flight hours controlled (M) | 11.6 | 17.4 | +51% |
| En-route Service Units (M TSUs)* | 85 | 149 | +76% |
| Nr. of civil en-route Air Navigation Service Providers | 37 | 37 | - |
| Area Control Centres (ACCs) | 71 | 62 | -13% |
| Number of Air Traffic Controllers (ATCOs in OPS) | 16,107 | 17,778 | +10% |
| Number of sectors (at maximum configuration) | 609 | 752 | +23% |
| Number of airports with ATC services | 426 | 403 | -5% |
| Total staff (without inter. MET) | 56,460 | 56,056 | -1% |
| Total en-route ANS cost (M€2020)* | 6,580 | 7,283 | +11% |

* 30 en-route charging zones

**Figure 13: Key system figures in a nutshell**

Although not driven by the FAB initiative, there was some consolidation of service provision at national level over the past years which reduced the number of Area Control Centers (ACCs) from 71 to 62 between 2003 and 2019.

To accommodate the increased traffic over the years, the number of sectors (+23% vs. 2003) and the number of Air Traffic Controllers (ATCOs) increased over time (+10% vs 2003).

The level of fragmentation in Flight Data Processing (FDP) systems (2016) in Europe is shown in Figure 14 [11].

While on the one hand competition can reduce the price and stimulate innovation, the number of different FDPs in use can affect performance in terms of interoperability issues and high customisation and maintenance costs. Particularly in view of the increasing level of digitalisation in ATM the interoperability and interfaces will gain in importance over the coming years.

Although some ANSPs have established partnerships (COOPANS, COFLIGHT, iTech),

4 For consistency purposes 37 ANSPs are included in the analysis (excl. Sakaeronavigatsia). Furthermore, complete dataset is not available for ARMATS, PANSA and SMATSA, for these ANSPs the 2003 figures are estimated, based on pan-European average growth rates.

there appears to be further potential for reducing procurement, development and maintenance costs if ATM systems are jointly developed as part of common initiatives or based on open or commercial off-the-shelf software.

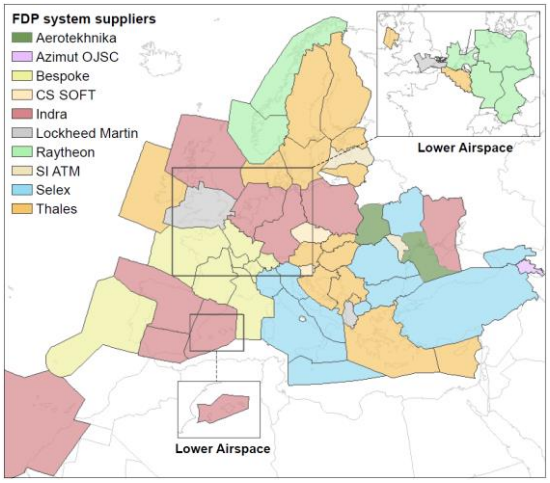


**Figure 14: FDP system suppliers by ANSP (2016)**

## Airspace management and route design

In the amalgamated European ATM system, airspace management and route design has traditionally been the prerogative of the States and therefore organised according to national preferences.

Relying mainly on local physical infrastructure the airspace was divided in an increasing number of sectors to safely manage the rising traffic. Similarly, the route network was largely designed on ground-based navigation aids.

Building on the work of EUROCONTROL to improve the European air route network through a Collaborative Decision Making (CDM) process, the development of a European Route Network Design function was formalized by the EC in the SES context[5] in 2011.

A major step away from a rigid route network was the start of the implementation of **Free Route Airspace (FRA)** concept in Europe. FRA allows airspace users to freely plan a route between defined points instead of following predetermined routes.

5 EU Regulation 677/2011 [12] defines the tasks of the Network Manager. The main ones are: the provision of ATFCM services, development of an integrated European Route Network Design, central function of radio frequency allocation, coord. improvements to SSR code allocation, and support for network crisis management.

FRA was successfully implemented in Portugal in 2009 and mandated by EC legislation in 2011 [12]. Although it took more than 10 years, FRA has now been fully or partly implemented in most parts of Europe (Figure 15).

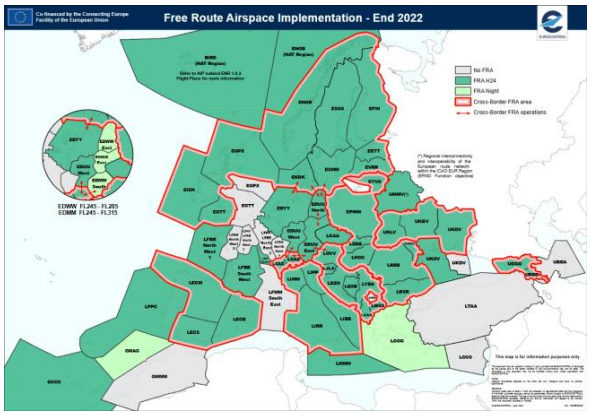


**Figure 15: FRA implementation status – End 2022**

Although some constraints remain, the operational and economic benefits of FRA are estimated to be substantial. EUROCONTROL estimates that flight inefficiency in the network reduced from 3.6% in December 2007 to 2.0% in December 2021, partly due to initiatives like FRA [13].

Although initiatives such as SES and SESAR have led to better interoperability and harmonisation, there is clearly a need for further action to improve performance. The existing limits of the current geographically organised service provision at national level were underlined and highlighted in the Airspace Architecture Study [14] in 2019.

## The European network management function

To counter the high delays and to protect their airspace from overload, various European States established their own ATFM units in the 1980s. It soon emerged that the only solution was to carry out flow management centrally to make the best possible use of the available airspace. EUROCONTROL was entrusted to set up the Central Flow Management Unit (CFMU) and to take gradually over the different components for providing an efficient and safe flow management between 1989 and 1996.

The CFMU turned progressively towards providing not just flow management services but supporting European capacity management and airspace design as well.

In 1999, EUROCONTROL implemented the European capacity assessment and planning process to support network wide capacity planning. Based on stakeholder collaboration, the anticipated requirements and the capacity plans are published annually in the Network Operations Plan (NOP).

In 2011, the network function was strengthened in the SES context with the creation of a European Network Manager (NM) [12] [15]. This evolution foresees a more proactive role in ATFM, ATC capacity enhancement, airspace structure development and the support to the deployment of technological improvements across the ATM network for the NM.

Despite the strengthening of the role, the NM position is notably weaker than the role of the Air Traffic Control System Command Center (ATCSCC) in the U.S. In Europe, the processes remain largely dependent on voluntary cooperation at national level.

The timely deployment of sufficient capacity remains the responsibility of the State and the ANSPs. The PRC raised its concern on several occasions that more focus should be put on a stronger capacity planning and deployment process [16] [17] [18]. In several cases capacity plans were not sufficient and/or frequently postponed which contributed to the serious capacity shortfall observed in 2018/19.

Paradoxically, the shortcomings in local capacity planning were then to some extent mitigated by the NM together with several ANSPs which helped to implement flow measures (re-routing, level capping) to offload traffic from the constrained ACCs, albeit leading to longer flight distances.

The economic and operational benefits of a strong, centrally managed and coordinated, ATM network was clearly visible during the capacity crisis in 2018/19 but also during the COVID-19 crisis as of 2020. However, there appears to be a need to further strengthen the entire process from the capacity planning phase to the management of the flows on the day of operations.

### Balancing airspace user requirements

To best satisfy both civil and military demand for airspace, EUROCONTROL has developed rules and standards for the sharing of airspace known as "Flexible Use of Airspace" (FUA) since 1984. It was formalised as part of SES legislation, applicable to the EU member states, in EU Regulation 2150/2005 [11].

Figure 16 shows the location of special use airspace (SUA)[6] above FL 300 in Europe[7].

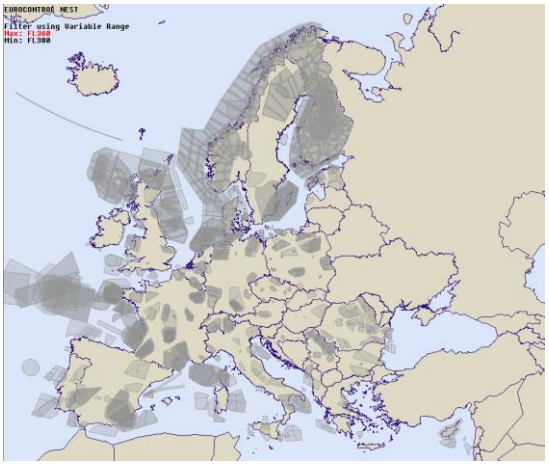

**Figure 16: Shared civil/military airspace (>FL300)**

Airspace is no longer designated as "civil" or "military" but considered as one continuum and allocated according to user requirements.

The application of FUA principles and practices has been a major enabler for ATC capacity increases and flight efficiency improvements in Europe over the past years. However, the application of FUA can differ notably by State.

A PRC review of civil/military co-operation and co-ordination procedures in 2016 suggested scope for improvement in terms of information flows across the network and in terms of strategic impact assessment when the airspace is shared [19].

Even though the work in the States has notably improved the shared use of airspace over the past 20 years, more work is needed to best accommodate the increasing needs of all

6 Defined airspace wherein activities must be confined because of their nature (often military).

7 Based on Aeronautical Information Publication (AIP) data available from the European AIS Database (EAD).

stakeholders, in terms of volume and time whilst maximising the use of the airspace.

Moreover, in addition to traditional civil and military airspace users, technological innovation has also stimulated new entrants, who also require access to the finite airspace – the increasing demand may necessitate a paradigm approach to how airspace is managed in the future.

### Integration of airports in the ATM network

The full integration of airports as nodes in the European air transport network has been identified as crucial - even more so as airport capacity is considered to be one of the main bottlenecks in the future.

The implementation of Airport Collaborative Decision Making (A-CDM) at European airports is a good step in this direction as it encourages airport partners and the NM to work transparently and collaboratively, exchanging relevant accurate and timely information.

While A-CDM helps to optimise local aircraft turn-around and pre-departure processes, it also allows the exchange of more accurate departure information with the European ATFCM network, leading to improved predictability and utilisation of resources.

In 2017, Munich was certified as the first fully A-CDM implemented airport. The number has grown to a total of 32 fully certified A-CDM airports across Europe with positive effects for the entire network.

For smaller airports where there is no justification for a full A-CDM implementation the possibility to integrate with the ATFCM Network is offered by the Advanced ATC Tower concept, sharing a very small sub-set of A-CDM information with the network.

A more recent initiative is the development of an Airport Operations Plan (AOP), linked with the Network Operations Plan (NOP) of the Network Manager to ensure a better integration of airports in the ATM network.

### A common standard for sharing information

Information sharing and situation awareness at local and network level are enablers to increased digitalisation and to further improve ATM performance. Although there is already a significant collection of data sets in European aviation today it is still not efficiently used and shared. A better use is facilitated through initiatives such as the system wide information management (SWIM) protocols, business to business (B2B) interfaces and a better use of ADS-B data.

The System Wide Information Management (SWIM) concept – to be implemented by the end of 2024 - consists of standards, infrastructure and governance enabling the management of ATM related information and its exchange between qualified parties via interoperable services.

SWIM enables seamless information access and interchange between all providers and users of ATM information and services and is considered a key enabler for the realisation of the Digital European Sky.

## How did the ATM network perform?

Key points in this section

- Key policy was to decrease delays and deliver more capacity at lower costs.
- Increased focus on ATM performance and a higher level of cooperation and transparency supported by a regulatory framework resulted in improved ATM performance over the past years.
- However, performance improvements were below anticipation and European targets were almost never achieved - partly due to shortcomings in a limited number of service providers.
- Unit rates essentially reduced continuously since 1990 but the provision of capacity shows cyclic shortcomings which appears to be linked to cost management and which subsequently cancels out cost efficiency improvements.
- The observed cyclic patterns suggest an unbalanced approach towards performance between cost and capacity management.
- Although European targets were not met, en-route flight efficiency improved over time due to local initiatives such as FRA. Interconnectivity among service providers becomes more and more of an issue as it hinders the realisation of network wide benefits.

Most performance schemes (including the SES performance scheme) monitor or set targets in the key performance areas of safety, environment, airspace capacity and cost efficiency.

Safety is the primary objective of ATM and therefore usually evaluated separately from the other performance areas.

Insufficient capacity has a negative impact on service quality (high delays, etc.) and on airspace users' costs (cost of delays); while the provision of capacity higher than demand may contribute towards higher than necessary ANS charges (underutilisation of resources).

Figure 17 illustrates the interplay between cost-efficiency, operational performance and capacity provision.

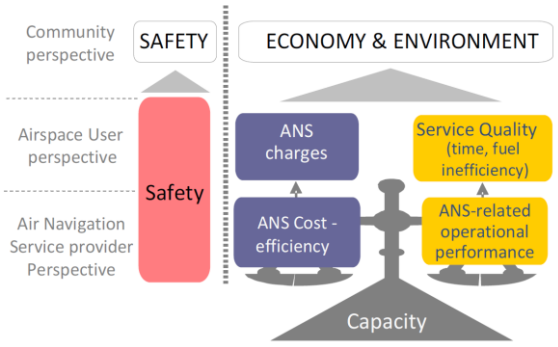


Figure 17: Different views on ATM performance

### Safety

20 years ago, safety information existed in a number of States but even basic safety data were not uniformly available across Europe.

Analysis of safety performance at European level in 1998 has yielded the conclusion that there were significant variations in the scope, depth, consistency and availability of ATM safety data across the ECAC area.

To address this shortcoming and to define and support the achievement of consistent safety levels in the ECAC area, EUROCONTROL developed Safety Regulatory Requirements (ESARRs), which also define a harmonised occurrence reporting and assessment scheme applicable to all member States. The majority of the ESARR requirements have since then been transposed into EC law.

For many reasons safety has improved over the past decades, including better equipment, more efficient operations, and additional safety defenses and mitigation tools. Within the SES performance scheme, safety is ensured through regulatory requirements.

Although the now established monitoring of 'lagging' indicators - coordinated by European Union Aviation Safety Agency (EASA) - measures reported safety events and provides some insights in historic performance, there is still a difficulty in getting sufficient meaningful and useful safety data for performance review purposes.

There is a challenge to drive improvement in the safety area through performance monitoring whilst at the same time maintaining appropriate confidentiality of safety data and ensuring

transparency of safety information for the general public.

To ensure continued high levels of safety in Europe, it is furthermore important to think also about the challenges ahead in a dynamically evolving ATM environment (new entrants and technologies, increasing digitalisation, etc.) and how best to measure them.

## Capacity

Following the high delays at the end of the 1990s, a Pan-European target for en-route ATFM delay was adopted in 2001 by the EUROCONTROL Provisional Council on the PRC's recommendation. The objective was to progressively reduce ATFM en-route delay to 1 minute per flight in summer by 2006 and to maintain the level for the coming years.

The start of the SES performance scheme in 2012 then introduced binding annual EU-wide capacity targets gradually reducing delay to 0.5 minutes per flight in 2014 and to maintain this level until 2019 (end of RP2).

Figure 18 shows the en-route ATFM delays and the corresponding delay targets since 1999.

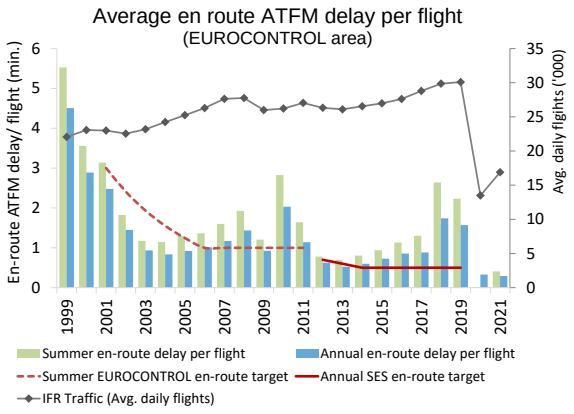


**Figure 18: En-route ATFM delays and targets**

Except for the period between 2002 and 2005 (following RVSM implementation), the system wide capacity targets were not achieved.

It is important to point out that the vast majority of the European ANSPs were able to provide sufficient capacity. However, in a limited number of ACCs there were capacity gaps building up between 2004 and 2010 and again between 2013 and 2019 which substantially impacted the entire network.

## Environment

Flight efficiency has been identified as a major ATM performance issue as it not only has financial but also environmental implications.

The ANS performance debate focuses mainly on improving operational efficiency. For every tonne of fuel reduced, an equivalent amount of 3.15t of $CO_2$ is avoided [20].

In 2007, the PRC proposed an initial Pan-European flight efficiency target to reduce average route extension per flight by two kilometer per year. However, the target became obsolete with the start of the SES performance scheme in 2012 which set EU-wide targets on a new metric (expresses as a percentage of the route extension) and on improved data sets which makes a time series analysis over the past 20 years difficult.

Figure 19 shows the evolution of horizontal en-route flight efficiency in Europe between 2009 and 2021 for flight plans (blue) and actual trajectories (red). It also shows the EU-wide SES targets in RP2 as a dotted line.

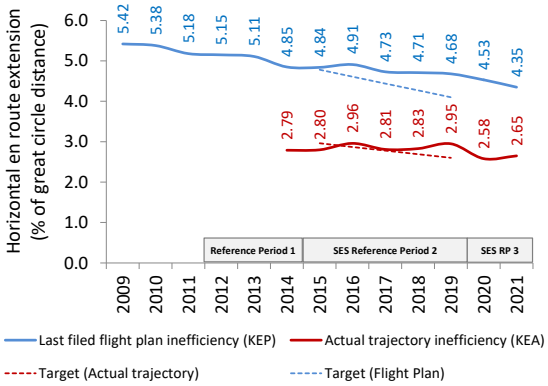


**Figure 19: Horizontal en-route flight efficiency**

Although there has been a continuous efficiency improvement in filed flight plans since 2009, the EU wide flight efficiency targets have never been achieved. The notable gap between the filed flight plans and actual flown trajectories suggests that flight efficiency is improved for the flight, mainly because of more direct routings given by ATC on a tactical basis.

The continued implementation of FRA by the end of 2022 is expected to bring further benefits, but PRC analysis highlighted that the interface between adjacent States becomes more and

more of an issue. In 2019, already more than 50% of the inefficiency was related to interconnectivity issues which requires an increased focus on the cross-border cooperation and timely coordinated implementation to realise the full benefits across the network.

## Economic performance

One of the main objectives of the SES performance scheme was to reduce ANS service provision costs in Europe.

Figure 20 combines capacity and cost efficiency performance. It shows the long-term trend in en-route ANS costs[8], traffic, and en-route ATFM delays for a consistent set of 30 charging zones between 2003 and 2021.

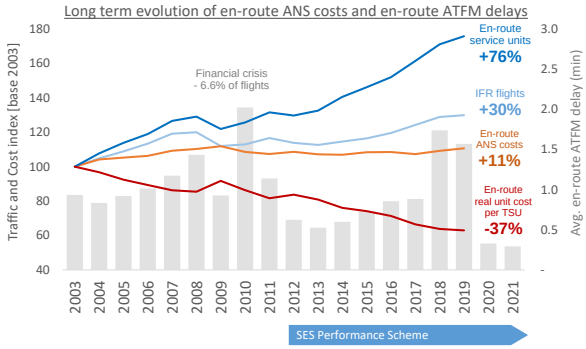


**Figure 20: Long term perspective (2003-2019)**

The analysis shows that cost-efficiency in European ATM has been improving since 2003.

Between 2003 and 2019, the significant growth in en-route Service units[9] (+75.8% vs 2003) outpaced the increase in en-route ANS costs (+10.7% vs 2003) which resulted in an effective 37% reduction in unit ANS costs by 2019.

However, the average changes mask different trends and cycles prior to the impact of COVID-19 crisis on the aviation industry.

**1998-2004**: High delays at the end of the 1990s resulted in the introduction of performance-oriented ATM and a 1-minute en-route ATFM delay target in 2001. The introduction of RVSM in 2002 added 20% capacity and greatly contributed to ease the capacity situation.

**2004-2008:** Between 2003 and 2008, the robust traffic growth outpaced the growth of en-route costs (+2.0% p.a.). This period shows a continuous reduction of en-route unit costs (-3.1% p.a.) but en-route ATFM delays started to increase again.

**2009-2013:** In 2009, the adverse effects of the economic recession impacted the industry resulting in a notable traffic drop (-6.6%). In the meantime, en-route cost-bases continued to grow (+1.5%) reflecting the rigidity of the industry to adjust costs downwards in the very short-term. As a result, en-route unit costs increased in 2009 for the first time since 2003, effectively cancelling out a significant part of the en-route cost-efficiency improvements achieved over the previous years. The limited degree of flexibility to quickly adjust to changing conditions is partly due to the cost structure which is largely fixed in the short term but also due to the lack of incentives provided by the prevailing funding system at that time (full cost recovery).

From 2010 onwards, in response to the traffic downturn, several States implemented cost containment measures, which contributed to the -3.0% p.a. decrease in en-route unit costs observed over the 2009-2012 period already before the start of the SES performance scheme in 2012.

**2013-2019**: Substantial improvements were achieved over the 2012-2019 period since en-route costs increased only slightly (+0.3% p.a.) while en-route Service Units rose by +4.4% p.a. leading to a significant reduction of en-route unit costs (-4.0% p.a.).

The observed trend should be seen in the context of the cost-containment measures already initiated in 2009-2010 which continued to generate savings years after their implementation, and for the States operating under SES regulations, the implementation of the performance scheme and the incentive mechanism which contributed to maintain a downward pressure on costs.

8 For a consistent set of 30 en-route charging zones.

9 Service Units are used for charging purposes based on aircraft weight factor and distance factor. The higher increase compared to the number of flights is due to an increase in average flight length and aircraft mass.

It is worth pointing out that there was a notable difference between the States included in the SES performance scheme since 2012 and those States still applying the full "cost recovery" method. Despite continuous traffic growth, the cost base in SES States remained stable which resulted in a continuous reduction of unit costs between 2012 and 2019. In non-SES States, the cost base increased further in line with the traffic which resulted in almost constant unit costs.

With traffic continuing to grow again in 2013, the capacity situation worsened and en-route ATFM delays increased first gradually and then soared at the end of the 2nd reference period of the SES performance scheme in 2018/19. An increasing share of en-route ATFM delay was attributed to ATC capacity and staffing which suggests substantial shortcomings in capacity planning and deployment.

The more detailed data in the ATM Cost-Effectiveness (ACE) benchmarking reports [21] shows that between 2013 and 2019, traffic at EUROCONTROL level increased by +22.1% while ATCO hours on duty grew by only +2.9%.

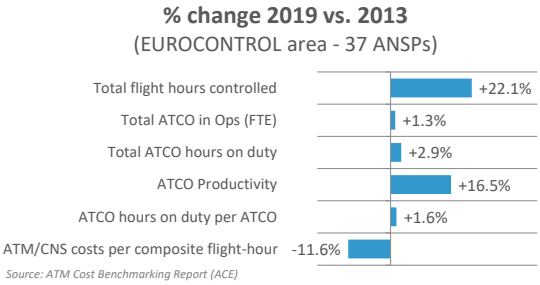


**Figure 21: Evolution of staff related figures (2013-2019)**

Hence, overall cost efficiency and ATCO productivity (+16.5% vs 2013) improved notably during that time.

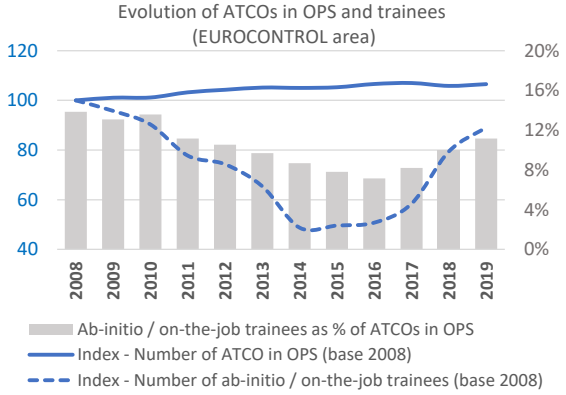


**Figure 22: Evolution of ATCOs and trainees in the EUROCONTROL area (2008-2019)**

At the same time, the intake of ATCO trainees reduced most likely as the result of the cost containment or optimisation measures implemented by ANSPs following the traffic downturn in 2009 (see Figure 21).

Additionally, it is clearly visible that planned capital expenditures have been delayed, although these were included in the cost base which resulted in a substantial surplus for many ANSPs in Europe in those years (Figure 23) [22] [23].

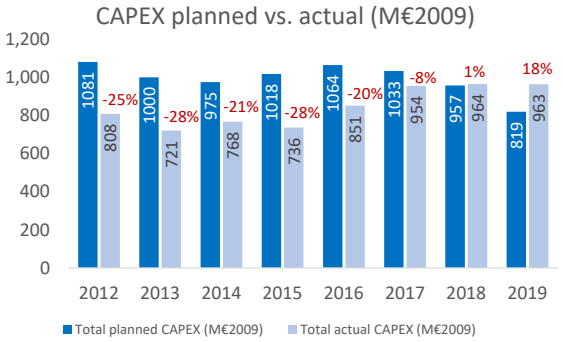


**Figure 23: Planned vs actual CAPEX (2012-2019)**

Between 2012 and 2017, capital expenditures were some 25% below plan which means that projects have not been executed as foreseen.

Both, reduced recruitment and the delay of planned projects generated savings for the ANSPs but are likely to have contributed to the widening capacity gap since 2013 which culminated in the capacity crisis in 2018/19 and which caused substantial additional costs to airspace users due to unacceptably high delays.

## What are the lessons learned?

The foundation laid by States more than 20 years ago enabled required progress towards a single European ATM system but - even after two decades - still lacks full political commitment to yield the possible benefits of a true network wide approach in ATM.

The introduction of a performance-oriented approach in ATM and the later introduction of the SES performance scheme in 2012 led to an increased focus which improved ATM performance in the EUROCONTROL area in all areas - but not at the anticipated pace and level.

***Focus on performance clearly yielded benefits but has not delivered the improvements anticipated***

The higher focus on performance and the increased level of transparency over the past 20 years triggered many good local and regional initiatives which helped improving ATM performance in the context of increasing traffic (+28% 2019/ 2000).

However, despite all those initiatives over the past 20 years, the airspace architecture in Europe, the ATM operational concept, as well as the processes and technology have not changed much and are still largely in line with national boundaries instead of operational needs and traffic flows (non-optimal organisation of airspace).

Some areas such as the core area will clearly require a wider approach to airspace design to accommodate future traffic growth and to align operations to traffic flows instead of national boundaries.

***Increased network focus and less fragmentation is key to realising future performance improvements***

The fragmentation of ATM provision in Europe remains an issue in many ways (operational, technological and institutional). Although local performance improvements are visible, there is a need to move more towards a true network-oriented approach to leverage further performance benefits (airspace interfaces, capacity provision, duplication of services, data and information flows, etc.).

For instance, the local implementation of Free Route Airspace has clearly brought notable flight efficiency benefits, but more than half of the measured inefficiencies today are attributable to interconnectivity issues which requires a wider (cross-border) approach (disconnect between local service provision and airspace user requirements to optimize the entire flight trajectory).

The European Network Manager (NM) has shown the benefits of network wide coordination of capacity planning and flow management. Similar to a "supply chain manager", there is a need to strengthen the role and to better empower the NM to manage the European ATM network for the benefit of all stakeholders (infrastructure, capacity, ATFM, etc.).

With airports expected to become more and more a constraint to growth it will be important to also integrate them fully as nodes in the ATM network in terms of capacity planning but also to increase situation awareness for all stakeholders on the day of operations.

***A balanced approach is necessary to avoid one performance area improving at the expense of others***

The long-term analysis suggests a disconnect between performance areas (cost-efficiency vs capacity provision) at some service providers (delays increase while costs go down) - even with the SES performance scheme and binding targets already in place.

The resulting delays can quickly erase cost-efficiency improvements as capacity shortages have a significant impact on airspace users and passengers in terms of delays and associated costs. When delays soared again due to the lack of en-route capacity in 2018/19, a high-level estimate suggests that en-route ATFM delay costs to airspace users were equivalent to 25% of the total en-route ANS provision costs. This underlines the importance of finding a balanced approach in performance management which considers all key performance areas equally instead of focusing entirely on one area.

In view of the observed trends in the long-term analysis, there appears to be a need to refine

some processes to ensure such a balanced approach to ATM performance through a strong monitoring (incl. planned investments and the deployment), transparency and clearer accountabilities.

Although the dynamics of the COVID crisis are operationally and economically completely different, there is a risk to repeat the mistakes made following the financial crisis in 2009 in terms of capacity planning and deployment, particularly with the pressure on cost savings still high. The high delays in summer 2022 are a clear sign that some service providers were not prepared to scale up operations in time to accommodate the recovering demand.

Without a doubt, the focus of ANS performance in the coming years will be on the ability to adjust operations and costs in line with demand, while at the same time preparing for the future in terms of safety, capacity provision, technological transformation and environmental sustainability.

***Delivering future performance requires transformational change not just evolution***

The current geographical and operational setup of the ATM system will limit the flexibility in capacity provision in the context of increasing traffic and new entrants over the coming years.

A more flexible approach in providing capacity in time (rostering, etc.) and space (virtualization) and hence additional efficiency gains are expected to come from the further digitalisation and automation of the industry (especially as drones proliferate).

Although it is understood that there are a number of issues that need to be overcome (safety, confidentiality, liability, standards, etc.), the better sharing of trajectory and airspace data will enable the better use of data-driven technologies like Artificial Intelligence (AI) or virtualization of service provision in support of planning (utilization of resources), decision making and scalability.

To ensure the best possible benefit for the European network, the transformation of the industry needs to be closely coordinated at European level.

Given the importance of transformation and environmental sustainability over the coming years, the independent PRC will put an increased focus on the transparent monitoring and review of the industry's progress towards the challenging political and societal performance ambitions and targets.

Should you wish to comment on this publication, or to contact the PRC,
please email us @: pru-support@eurocontrol.int.

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