SESSYS

(Single European Sky SYStems)

December 2023

December 2023

The structural weaknesses of a fragmented European Air Traffic Management (ATM) system are widely recognised and the subject of decades of political efforts by the European Commission to find a solution.

The latest proposal of SES regulations, aimed at strengthening Europe's role, was rejected by the Member States.

One would have thought that these weaknesses could have become unbearable with the COVID19 crisis that has generated a "financing wall".

With the return of traffic to what it was before the crisis, there is a risk that the European Air Navigation Providers (ANSPs) consider that they can return “back to normal”.

This document proposes a targeted set of concrete recommendations on pan-European functions and technical systems, so that the European ATM system can move out of this detrimental fragmentation.

This text is not an official document of the Air and Space Academy.

It was written by Pierre Andribet, Marc Baumgartner and Jean-Marc Garot members of the Air and Space Academy.

.

Executive summary

This paper proposes a focused set of recommendations for pan European functions and technical domains, whose viability was affirmed in prior analyses (principally within the SESAR Joint Undertaking):

- **Establishing a stronger Network Manager** with clear authority for key areas such as:
    - *design of airspace.*
    - *Capacity and Traffic Flow Management*
    - *Overall optimization of the operational, environmental, and economic efficiency of the network*

This organization could be like the US Air Traffic Control System Command Centre (ATCSCC)

- **Streamlined and modernized CNS Infrastructure: Adopting a "CNS-as-a-service" model**, aimed at optimizing Communication, Navigation, and Surveillance (CNS) infrastructure.
- **Reorganization of Air Navigation Services:** Based on proven principles of service-oriented architectures widely used in other industries, definition of a new organisation of the ATM system in Europe and its economic model by establishing ATM data server service providers. These providers would handle radar data, flight plan data, weather data, and aeronautical data, with only the working positions connected to these servers remaining in ATC centres,

It will allow altogether a better cost control, the pooling at European level of financial risks such as those encountered in the recent crisis that the aviation industry has suffered, better operational efficiency, and through operational harmonization, greater mobility possibilities for staff.

This will also make it easier to modernize the system and finally allow it to adopt 21st century technology, thereby offering European manufacturers the possibility of developing a more competitive system at the international level.

In addition, this rationalisation of ATM is an essential element of the contribution of ATM to the EU Green Deal.

The European Commission's endorsement of these recommendations presents a pivotal opportunity to reinvigorate the Single Sky initiative. A seamless transition demands an infrastructure manager to assume the helm. The EUROCONTROL Agency emerges as the preeminent candidate, armed with the requisite expertise and global outlook to guide this transformative undertaking.

Table of Contents

1 Foreword

In her 2000 foreword to the High-Level Group report, Commissioner Loyola de Palacio highlighted the fragmented European ATM system's shortcomings, including unprecedented delays, inefficiencies, and a lack of coordination. Despite maintaining high safety standards, the report emphasized the need for a unified system to address these issues.

Several reports have underscored the structural weaknesses of a fragmented European air traffic management (ATM) system, including the European Court of Auditors' special report[1] and the EC Wise Person Group report [2].

The European Commission's recast of SES II regulations proposal, called SES II+, to strengthen the role of Europe, has been rejected by the States, halting the reform of European ATM.

One might have expected that these weaknesses would become intolerable in the wake of the COVID-19 crisis, which triggered a "financing wall" (an estimated deficit of €8.6 billion[3] at the end of 2021 expected to be recovered through a significant increase in route charges for at least the next 7 years).

The authors of this paper had hoped for a "Reinvention of European air traffic control based on the covid-19 pandemic experience"[4]. However, at least in Western countries, the States have largely rescued their Air Navigation Service Providers (ANSPs).

As traffic levels approach pre-crisis levels, there is a danger that the European ATM system will consider it can go “back to normal” (as fragmented as ever) despite the lingering financial implications of the crisis, the persistent efficiency shortfalls, and the ATM system's challenge to contribute to decarbonization goals.

2 Solutions at hand

This paper outlines a set of recommendations to propel the European air traffic management (ATM) system towards true efficiency, encompassing:

- **Establishing a stronger Network Manager:** Like the United States' Air Traffic Control System Command Center (ATCSCC), a centralized authority should oversee air traffic movement across Europe. This centralized network manager would harmonize traffic flows, optimize resource allocation, and enhance overall system efficiency.
- **Streamlining and modernizing CNS Infrastructure:** Embracing a "CNS-as-a-service" model, where Communication, Navigation, and Surveillance (CNS) infrastructure is managed and provided as a unified service. This approach would streamline CNS operations, reduce complexity, and enable more efficient utilization of infrastructure resources.
- **Reorganizing Air Navigation Services:** A fundamental reorganization of the ATM system in Europe, encompassing both its structure and economic model. This reorganization would establish ATM

[1] Special report n° 11/2019 “*the EU’s regulation for the modernisation of air traffic management has added value – but the funding was largely unnecessary*”

[2] *Report of the Wise Persons Group on the future of the Single European Sky 2019*

[3] EUROCONTROL think paper#14 The future of Air Navigation services

[4] Utilities Policy, Volume 75, April 2022, 101343

data server service providers, who would be responsible for collecting, processing, and disseminating air traffic data, enhancing the overall efficiency and reliability of the system.

These proposed solutions aim to address the persistent inefficiencies and fragmentation that plague the European ATM system, paving the way for a more integrated, streamlined, and cost-effective air traffic management network.

2.1 Establishing a Stronger Network Manager

Ensuring efficient Demand and Capacity Balance (DCB) across time and space is crucial for optimizing the operational, economic, and environmental performance of the European air traffic management (ATM) network.

Today, the Network Manager possesses the necessary tools and data to optimize DCB at the European level, enabling them to determine the optimal trade-offs between occasionally conflicting objectives, such as reducing greenhouse gas emissions while minimizing delays.

However, the current regulatory framework impedes the Network Manager's ability to implement these optimal solutions:

- **Weak capacity supply management**: The current framework only allows for the "acceptance" of ANSP capacity plans, with inadequate penalties for non-compliance.
- **Detrimental weakness in capacity and demand management**: This weakness results in excessive ground delays and an increased environmental impact of the ATM system.

To effectively achieve the goals of the Single Sky initiative and the European Green Deal, the Network Manager should be granted the following three essential pan-European roles:

- **Airspace organization authority**: The Network Manager should be granted the authority to organize airspace, including the boundaries between Flight Information Regions (FIRs) and route networks, enabling a top-down optimization of airspace utilization across Europe.
- **Powerful Capacity and Traffic Flow Management (ATFCM) function**: The Network Manager should be empowered with a robust ATFCM function, enabling them to effectively manage air traffic flows and optimize capacity allocation, minimizing delays and maximizing overall network efficiency.
- **Overall optimization of network efficiency:** The Network Manager should be responsible for comprehensively optimizing the operational and economic efficiency of the network, incorporating environmental performance considerations into these optimizations, even if it necessitates trade-offs with other performance objectives.

2.1.1 A European airspace design and management authority

Optimizing airspace design and its management is crucial for achieving the environmental and operational objectives of the Single Sky while considering the needs of airspace users.

Numerous solutions to the main airspace design challenges (10 hot spots) have been identified and documented for years, as outlined in the Airspace Architecture Study (SJU, 2019). It is therefore essential to empower the Network Manager with the authority to manage airspace as close to the optimum as possible, while adhering to safety and security requirements:

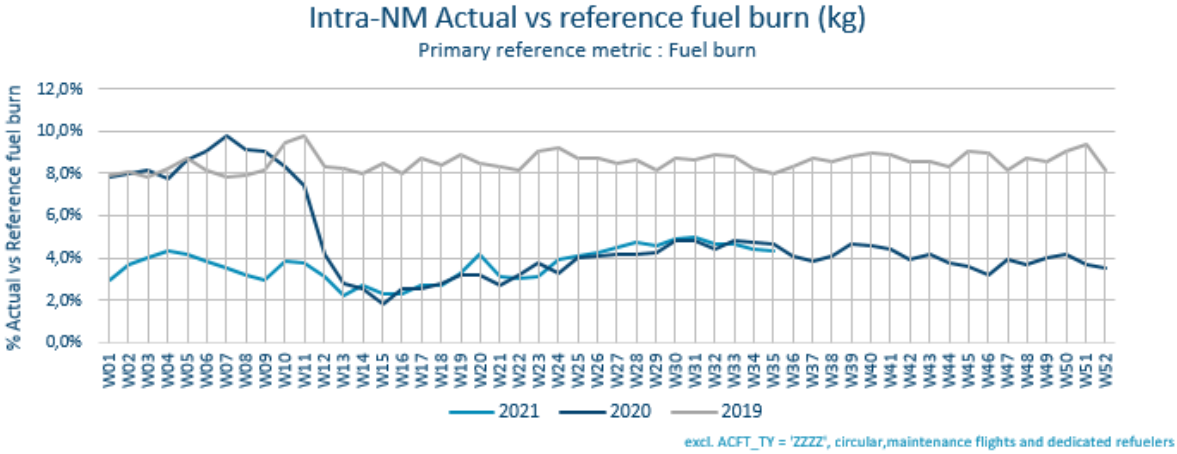
- **Requirement for the Network Manager to publish the optimal airspace structure**, with States justifying any deviations (including relocating or removing restricted areas that significantly disrupt optimal traffic flows).
- **Alignment of sectorization with operational needs**, with States responsible for organizing reciprocal delegations of service across borders when necessary.
- **Completion of the Free Route Area by the target date of 2024**.

- **Limitation of route restrictions to only those operationally necessary**.
- **Granting the Network Manager final decision-making authority** on arbitration matters related to the structure of European airspace.

This top-down approach to airspace design will have a significant impact on capacity and delay reduction, but more importantly, it will significantly reduce the environmental impact of air traffic management (ATM).

During the COVID-19 pandemic, the unprecedented decline in air traffic resulted in the removal of 1 200 route restrictions. As shown in the following figure, this allowed for the achievement of half of the ambitious environmental performance targets for ATM (up to 10%) at virtually no cost. Only around 50 restrictions were reinstated, and these savings persisted throughout the summer of 2021 despite traffic returning to winter 2019-20 levels. This demonstrates the indispensable role that effective airspace management plays in meeting the European Union's environmental efficiency objectives for air navigation services (ANS).

Figure 1: Additional fuel burn indicator and traffic



2.1.2 A powerful Capacity Traffic Flow and Emission Management (ATFCEM) function

The Network Manager should be empowered with a robust ATFCEM function, enabling them to proactively manage air traffic flows and optimize capacity allocation, minimizing delays, maximizing overall network efficiency, and reducing environmental impact.

At the planning level, the Network Manager should have the authority to achieve a better balance between capacity and demand by:

- Reallocating airspace: If an ANSP is expected to be saturated, the Network Manager could delegate airspace management to a neighbouring ANSP with less congestion.
- Overseeing ATCO staff planning: This would help ensure that adequate staffing levels are in place to handle traffic demand.

At the tactical level, the Network Manager should play a role like the U.S. Air Traffic Control System Command Center (ATCSCC), with the final say on dynamic demand and capacity balancing (DCB) measures. This would allow the Network Manager to intervene quickly and effectively to address any potential disruptions or bottlenecks in the network.

In terms of demand management, the Network Manager should have the authority to impose controlled trajectory changes on selected flights, including both horizontal and vertical adjustments. This would enable the Network Manager to:

- **Avoid congestion areas**: By rerouting flights away from congested areas, the Network Manager can help to reduce overall delays.
- **Minimize environmental impact**: By optimizing flight paths, the Network Manager can help to reduce fuel burn and CO2 emissions.

By strengthening the ATFCEM function of the Network Manager, the European ATM system can achieve its full potential in terms of efficiency, sustainability, and user satisfaction.

2.1.3 Environmental, operational, and economic optimization of the network

Currently, the Network Manager optimizes flow management delays solely based on traffic and declared capacity. However, to achieve a truly efficient and sustainable ATM system, the Network Manager should play an active role. It should minimize not only delays but also the environmental impact and cost of ATC services for users.

This optimization should consider a set of factors, including:

- **The "cost of capacity,"** directly linked to the cost of controllers (approximately €2.8 billion in 2019): By optimizing capacity allocation, the Network Manager can reduce the need for additional controllers, thereby lowering the overall cost of ATC services.
- **The costs generated by en-route delays:** (approximately €1.8 billion in 2019) When capacity is insufficient to handle traffic demand, delays become inevitable, leading to increased fuel consumption, emissions, and operational costs for airlines. The Network Manager should strive to minimize these delays through proactive traffic management strategies.
- **The additional costs of flight time, fuel, and the Emissions Trading Scheme (ETS)[5] related to sub-optimal trajectories:** (approximately €2 billion in 2019) By optimizing flight paths and avoiding congestion areas, the Network Manager can reduce flight times, fuel consumption, and the associated costs incurred by airlines. Additionally, the ETS internalization of environmental externalities should be considered to further incentivize sustainable practices.

By considering these factors and assigning appropriate weights to their respective impacts, the Network Manager can achieve a comprehensive optimization of the ATM network, encompassing environmental, operational, and economic considerations. This holistic approach will lead to a more efficient, sustainable, and user-friendly ATM system for Europe.

2.2 Streamlined and Modernized CNS Infrastructure:

To streamline and enhance the efficiency of the Communication, Navigation, and Surveillance (CNS) infrastructure, a novel approach is proposed: considering CNS infrastructure as a service procured from providers rather than as a function performed by ANSPs.

This paradigm shift aligns with the SES 1 legislative package, which categorized CNS services as subject to market forces. The FAA has embraced a similar model for Autonomous Dependent Surveillance (ADS-B), with companies like INMARSAT and AIREON offering CNS aeronautical services.

The European Satellite Service Provider (ESSP) has been selected to provide the European Geostationary Navigation Overlay Service (EGNOS) service in Europe and beyond.

[5] The ETS (Emissions Trading Scheme) internalizes an increasing part of the environmental impact of civil aviation in the costs borne by users.

The proposed approach of procuring CNS infrastructure as a service would yield several advantages:

- **Financial benefits:** economies of scale and synergies with other sectors (other modes of transport, telecommunications, etc.) could lead to substantial cost savings.
- **Accelerated technological evolution:** the procurement of CNS infrastructure from multiple providers would foster competition and innovation, accelerating the adoption of new technologies like VHF over ocean using satellite (currently being studied in the SJU project ECHOES) and next-generation Datalink.

Challenges associated with this approach include the potential for industrial monopolies that could stifle competition and hinder technological advancement. Additionally, concerns about loss of sovereignty must be addressed, especially considering the sensitive nature of ATC operations.

Another challenge lies in managing the transition from the current ANSP-centric model to a market-based approach. Existing technical services, currently responsible for maintaining CNS infrastructure, may resist change. This potential reluctance necessitates careful social management to ensure a smooth transition.

To maintain comprehensive control over the system, particularly in avoiding single points of failure, a new approach to security and certification will be necessary. This could involve establishing a central entity responsible for coordinating security standards and ensuring interoperability among different CNS providers.

In conclusion, procuring CNS infrastructure as a service holds the potential to enhance efficiency, accelerate technological innovation, and reduce costs. However, careful consideration must be given to potential challenges, such as the risk of monopolies, loss of sovereignty, and transition management. By addressing these challenges and implementing effective mitigation strategies, the European ATM system can benefit from this innovative approach to CNS infrastructure.

2.3 Reorganization of Air Navigation Services by establishing ATM data server service providers

The existence of high-speed networks connecting every single point in Europe, coupled with highly powerful servers capable of exchanging and processing vast amounts of data, has facilitated the emergence of a new digital industry. Cloud computing and client-server architecture have become the new norm, demonstrating their advantages in terms of performance, reliability, and security.

In line with the Wise Person Group recommendations, this technological landscape paves the way for the virtualization of ATM systems, revolutionizing their architecture.

Under the new model, ATC control centres will only retain controller working stations connected to centralized servers, embracing the proven principles of service-oriented architectures. This shift will transition from a fragmented architecture, consisting of numerous proprietary systems across ANSPs, to an open, modular, and unified structure.

These architectural principles have undergone extensive studies within the SESAR JU, demonstrating their feasibility and outlining the necessary steps to achieve a high Technical Readiness Level (TRL), with a particular focus on safety and cybersecurity issues.

As a result, a completely new economic model can be established by introducing ATM data server service providers. Some prominent examples include:

- **Surveillance service provision**, enabling the fusion of all surveillance data (Radars, Multi-lateration, ground-based, and satellite-based ADS-B) using the existing ARTAS system. This will provide a seamless air traffic picture for all of Europe.
- **Flight plan data service provision**, ensuring full consistency of flight plans at the European level, eliminating the existing problems of multiple flight plans for the same flights with inconsistencies leading to capacity restrictions and increased Air Traffic Controllers workload when transferring flights between ATC centres.
- **Aeronautical data service provision** based on the existing European Aeronautical Database (EAD), expanded to provide ATC systems with operational data fully consistent with Aeronautical Information Publication
- **Weather data service provision** to all aviation actors (ATC centres, airports, airlines).

The primary advantage of this approach is cost-effectiveness, achieved by streamlining infrastructure and reducing the need for duplicate systems, thereby optimizing overall investment, maintenance, and operational costs.

Additionally, numerous technical and operational benefits arise from this change:

On the technical side:

- **Scalability and flexibility**: Centralization allows the ATC system to adapt to changing demands and future technological advancements in a scalable and flexible manner.
- **Enhanced redundancy and resilience**: Critical size for systems enables the implementation of real contingency measures and backup systems, ensuring high availability and resilience.
- **Security considerations**: The security of a network of systems is only as strong as its weakest link, and thus defragmentation and centralization can help to improve the security of a network of systems. It also allows the consolidation of scarce resources, enhancing capabilities to manage cybersecurity effectively.

On the operational side, centralizing the ATM system server permits consolidating data from various sources, such as air traffic control centres, airports, airlines and even aircraft. By centralizing this data, it becomes easier to process, analyse, and share information in real-time across the entire ATM network. This ensures that everyone involved has access to the same up-to-date information, improving situational awareness and decision-making, thus entailing the following benefits:

- **Improved collaboration**: Centralizing data from various sources facilitates efficient collaboration between air traffic control centres, with consistent data sharing.
- **Operational flexibility**: Harmonization of operational concepts and procedures becomes more feasible, along with potential flexible allocation of sectors between adjacent centres, enabling dynamic resource allocation during busy periods or emergencies.
- **Air-Ground integration**: the current fragmentation hindered the development of a common strategy concerning integration between airborne and ground systems, the proposed centralised approach holds the promise of fostering a consensus on this integration. Beyond consensus on operational concept, with centralisation, we can streamline and synchronize the implementation within centralized servers, promoting seamless cooperation between aerial and terrestrial operations.

Centralizing data also opens opportunities to harness the potential of Artificial Intelligence (AI). Historical data covering the entire European airspace can empower AI algorithms to offer invaluable insights and benefits, such as:

- **Enhanced predictive analytics**: Better trajectory and workload prediction supports proactive route planning, airspace optimisation, and thus minimizing delays.
- **Automation of routine tasks**: AI can take over repetitive tasks, enabling air traffic controllers to focus on complex situations and strategic planning.

- **Automated decision support**: AI-powered systems can assist controllers in making critical decisions, recommending route adjustments, conflict resolutions, and aircraft sequencing optimization.
- **Autonomous operations**: In a longer term, AI and advanced automation may enable autonomous Air Traffic Control in specific areas and low traffic periods.
- **Improved safety analysis**: AI algorithms can detect anomalies in traffic patterns and Air Traffic controllers instructions, identifying potential safety issues.

In addition, by granting access to a wider system of companies and research centres outside ATM, the abundance of data may foster innovation in unforeseen areas.