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Reinventing European air traffic control based on the covid-19 pandemic experience

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ABSTRACT

This article/paper proposes to take advantage of the crisis resulting from COVID-19 and its impact on Air Traffic Control (ATC) in Europe to reinvent it. The article explains its evolution, in particular, 20 years of Single European Sky reform process not having overcome the gridlock. The impact of the COVID-19 on aviation in general and specifically on ATC is described. It focuses on the avenues to overcome fragmentation and competing interests of the various stakeholders by reinventing EUROCONTROL Organisation as the agent to recover from the economic crisis.

1. Introduction

While Air Traffic Control (ATC) in Europe fulfils its role overall from a safety standpoint, it is suffering structural inefficiencies. Using the current crisis as a unique opportunity, one could significantly improve it—both in operational and financial terms, in the interest of the airspace users and passengers. Users would support such an effort.

Air traffic is unlikely to recover in the coming months, and the Air Navigation Services Providers (ANSPs) providing air navigation services in Europe are facing a “financing wall”. With fixed costs and less traffic, either the European states subsidise the ANSPs or the user charges per flight will increase significantly and impact airlines already severely hit by the crisis.

In this paper, we will first describe the primary weakness being the fragmentation of European ATC, which for more than 50 years has been recognised as such and led to the creation of EUROCONTROL and the initiatives of the European Commission (EC). However, previous initiatives have not succeeded because the International Civil Aviation Organisation (ICAO) law recognizes that every European state retains its sovereignty over the airspace above its territory (Baumgartner, 2007).

The history of EUROCONTROL is an example of the ups and downs of European integration.

Before describing the possible way out, we will focus on the successive packages of the Single European Sky (SES). The European Court of Auditors recently underlined, they have resulted in incremental improvements of the European ATC. It has not reduced its fragmentation, which is detrimental to European air transport.

Whilst recognising the value of the recent EC legislative proposal, the authors of this article will propose in section three a more ambitious approach. This is based on the Wise Persons Group Report: a transition towards a pan-European ATC, including reinventing EUROCONTROL from the operational and technical standpoints.

Whilst striving for the best solution, in the meantime, Europe could choose joint procurement with preferred, “standardised” technology for Communication, Navigation and Surveillance (CNS) infrastructure and joint development/procurement of ATC systems.

A more ambitious option would be to consider CNS infrastructure as a service and no longer as an investment. This approach would allow the

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total virtualisation of ATC systems. With an “infrastructure manager” using modest EU funds, this could be the second European-wide infrastructure after the Galileo Project. Centrally funded, it would remove significant financial risk from the operational units, unbundling operational and financial systems.

As far as airspace management is concerned, Europe could implement a top-down design to group Air traffic Control Centres (ACC), independent from national borders (which was the initial objective of the Functional Airspace Blocks FAB). This approach could foster the harmonisation and the modernisation of operational procedures, which are all out of date. One could even consider a single service provider for Europe, e.g. reinventing the founders’ vision of EUROCONTROL.

It should also be noted that considering the existing delegation of control in Maastricht, Zurich, and Geneva as examples, it could be argued that this does not jeopardize the states’ sovereignty or air defences.

With both options, a stronger political decision-maker is needed, the European Union Aviation Safety Agency (EASA) retains its role as a safety manager, but a more powerful network manager is needed. A single service provider for Europe, paid by European funds, would provide for robust financing and relieve the European states from subsidising their ANSPs. Also, user charges would no longer need to pay the costs for these services. Nevertheless, they could continue to be collected by EUROCONTROL’s Central Route Charges Office (CRCO).

2. History and context

2.1. Since the Chicago Convention, air traffic control has been a public service enabling the “freedoms of the air.”

In November 1944, the “Chicago Convention” set the foundations of air navigation rules and established the International Civil Aviation Organisation (ICAO). Today ICAO requires its 191 member states to provide air navigation facilities over their territory in compliance with its standards. However, the obligations for states under Article 28 are neither strictly nor narrowly defined. The States remain sovereign and retain considerable discretion and individual appreciation regarding how they intend to fulfil their obligations. While ICAO standards are global, multiple technologies used by ATC have been developed by industry due to some historical and local requirements, therefore creating a piecemeal of systems.

2.2. EUROCONTROL history reflects the ups and downs of the European Union

Based on the ICAO principles, all states fulfilled their duties by providing the corresponding services as part of their governmental administration. However, in 1958, the Director of the French Air Navigation Directorate, René Bulin, had the “vision” that civil jet aircraft would have to share the “upper airspace” which so far was only used by military aircraft and that its management would be more efficient at a European level. He convinced the United Kingdom, the Federal Republic of Germany, Belgium, the Netherlands and Luxembourg, the six member States founders, to sign the EUROCONTROL Convention in December 1960.

2.2.1. The year 1960 marked the beginning of the EUROCONTROL organisation and agency

According to the official history of EUROCONTROL (McInally 2010) reflects the European construction. Initial Convention said: “The Contracting Parties shall entrust to the Agency the air traffic services” in the [upper] airspace. However, soon after signature, France, and the United Kingdom, with the issue of national military airspace control, refused to hand over the Upper Airspace, while the other four Member States agreed in 1964 to set up an international ATC centre to manage their upper airspace in Maastricht.

At the same time, the six states agreed to establish the EUROCONTROL Experimental Centre and later the institute in Luxembourg in 1970, therefore turning a part of the Agency into an ANSP, with headquarters, an ACC centre, a research centre and an academy. Two other EUROCONTROL upper-level control centres were built at Karlruhe (Germany) and Shannon (Ireland). However, the German and Irish governments later re-nationalised them. The EUROCONTROL Central Route Charges Office (CRCO) was set up in the same period.

2.2.2. The member states eventually embarked on redefining the Organisation’s mandate

The Article 14 to “entrust to the Agency the air traffic services in the [upper] airspace not being implemented, an amended Convention, was signed in 1976 limiting EUROCONTROL to a “coordination role”. At the same time, the world economy was emerging from a decade of recession and together with the effects of the deregulation of air transport in Europe, the ATM system was unable to cope with the growth.

Delays were such that the European Civil Aviation Conference (ECAC) Ministers of Transport decided that the EUROCONTROL agency should be entrusted with new functions: development of the Central Flow Management Unit (thus giving this agency a vital operational role), management of the European ATC Harmonisation and Integration Programme (EATCHIP) and APATSI (Airport/Air Traffic System Interface development of ATM 2000 Strategy. They also agreed to revise the institutional arrangements with the signature of the revised Convention in June 1997.

2.2.3. Today

Twenty-four years later, the revised Convention is not yet in force, awaiting ratification by the last state (Turkey). Moreover, the number of EUROCONTROL members increased to 41. In 1992, the EU Maastricht Treaty implemented the co-decision of the Parliament and the Council introducing the R&D framework programme with a budget for ATC. Therefore, ATC R & D was no longer only paid by user charges but also by the European taxpayer budget.

The European Commission became a member of EUROCONTROL on October 8, 2002.

2.3. In Europe, the cost of ATC is fully recovered by user charges

Until the end of the 1960s, the “en-route” ATC public service was funded by the states and therefore free for “users”. In 1967, an ICAO conference agreed that the ATC costs could be recovered from Airlines through charges.

In 1971, the Central Route Charge Office (CRCO) began operations. Full cost recovery was gradual: the recovery rate for EUROCONTROL route charges started at 15% from November 1971, then 30% in November 1973, 60% in November 1975 and finally 100% in October 1981. The principles for establishing the route charge base and the principles for calculating unit rates are detailed in the EUROCONTROL document “Principles for establishing the cost-base for en-route charges and the calculation of the unit rates”:

For each flight, formula for the route charge is as follows:

\[ \text{Charge}_{(en-route)} = SU * \text{Unit rate} \]

The Service Unit (SU) is calculated as a function of the maximum take-off weight (MTOW) and the distance (D) flown:

\[ SU = \sqrt{\frac{MTOW \times D}{50 \times 100}} \]

\[ \text{MTOW} \]

\[ \text{D} \]
It is worth explaining that not all traffic pays route charges and that there is a certain level of cross-subsidy from airlines towards General Aviation and military flights.

The Service Provider then forecasts its yearly traffic and cost, deducing its annual Unit Rate before submitting it to a CRCO committee for approval. The CRCO then collects these charges on behalf of the contracting State, the amount is then reviewed the following year and based on ‘actual’ traffic and cost it is readjusted.

The Single European Sky (see below) legislation introduced a novel approach to cost efficiency target setting mechanism, and a new risk-sharing mechanism was introduced, aiming to incentivise ANSPs economic performance (ACE report 2017). The costs planned for the reference period (RP) are frozen for the length of the RP. If actual costs are relatively lower, the State/ANSP can keep the difference. On the contrary, if actual costs are relatively higher, the State/ANSP must bear a loss.

2.4. The Single European Sky was a legislative programme of the European Commission to reform ATC in Europe

All intergovernmental initiatives in Europe to modernize ATM were triggered by major crises affecting the travelling public. The Balkan War in 1999 was a significant crisis for European aviation, with delays 30 percent higher than in normal times.

2.4.1. The European Commission concluded that there was a need to act to manage the airspace, regardless of the countries’ borders (EC COM 614/1999, “the creation of a Single European Sky” SES)

It was implemented in three steps: SES I (2004), SES II (2009) and an unsuccessful attempt to go further in 2013 with the SES II + package.

2.4.2. Single European Sky I (2004)

This package contained of four regulations, namely:

(a) 549/2004, the framework for the creation of the SES
(b) 550/2004, the provision of air navigation services (ANSs)
(c) 551/2004, the organization and use of airspace in the SES, including the creation of Functional Airspace Blocks (FABs)
(d) 552/2004, the interoperability of the European network.

A Single European Sky ATM Research Body was established (SESAR) whereas, for safety, the European Aviation Safety Agency (EASA) was founded.

In spite of Mrs Loyola de Palacio (Vice-President of the EC in charge of Transport) considered the opportunities provided by Common Foreign and Security Policy (CFSP) to organise civil/military involvement in EU Policy, the member States were reluctant to cooperate. They felt it pre-mature to link military operations to civilian (Fartek and Rivet, 2011).

The EC requested the newly created Performance Review Commission (PRC) to assist in evaluating the SES. The December 2006 report recommended acceleration of the FABs and the technology development (SESAR) and empowering the EUROCONTROL Agency in its pan-European functions like the ATM network design.

As a result, the Commission proposed, in 2009, a SES II package.

2.4.3. Single European Sky II (2009)

This package identified fragmentation as the primary bottleneck. Under the overarching objective of performance, the SES II was structured into five pillars:

(a) a technology pillar, with SESAR as its key element,
(b) a legislative pillar, with a target date for the implementation of the FABs and the role of the network manager attributed to EUROCONTROL Agency,
(c) a safety pillar for ATM and Communication Navigation Surveillance (CNS) attributed to EASA,
(d) the airport pillar,
(e) a human factor pillar.

Performance expectations were already mentioned in the “Performance Report” dated2006. Increased performance expectations were formulated through EC Regulation 1070/2009. Later on, Implementing Rule (EU) 691/2010 established a performance scheme for ANSs under the responsibility of the Performance Review Body (PRB).

2.4.4. Towards SES II+ (2013)

The plan for SES II plus was stated by Commissioner Siim Kallas in his Limassol speech in October 2012, entitled “10 years and still not delivering”:

The agreed European Union-wide performance targets, especially in matters of costs and delays, have not been reached and five billion euros are wasted annually due to inefficiency.

On 11 June 2013 the EC published COM 408/2013, "Accelerating the implementation Single European Sky", or SES II+. The proposed regulation (EC COM, 2013/410 e COD 213/186) aimed to remove the fragmentation of the European ATM system by enabling industrial partnerships in FABs and reinforcing the role of the network manager.

The European Parliament did not pursue this proposal.

3. The current situation

3.1. SES did not achieve its initial objectives, as acknowledged by several official reports

In 2015 the EU institutions decided to evaluate the SES implementation:

- The SES unit issued a report to the parliament (December 16, 2015 highlighting that the FAB operational objectives have not been achieved, generating extra costs of close to €5 billion a year. Infringement proceedings were thus initiated against 23 Member States.

Regarding the environment, horizontal en-route flight efficiency (shorter routes) improved slightly in 2013 (5.11%) but did not meet the target (4.92%). In 2014, flight efficiency stood at 4.9%, falling short of the target of 4.67% for the first reference period.

With respect to capacity, good progress has been made in reducing capacity delays. In 2012 and 2013, the EU-wide target was met. In 2013, en-route air traffic flow management (AFTM) delays decreased by 15% compared with 2012, as traffic volumes fell by 1.3%. By contrast, the ATM sector failed to achieve the network target of reducing delays to 0.5 min per flight in 2014, owing partly to weather conditions but also social unrest and poor contingency planning to manage the knock-on effects. En-route AFTM delays occurred mainly in Cyprus, France, Germany, Poland and Spain. As regards cost-efficiency, during R1, air navigation service providers (ANSPs) reduced their cost bases because of lower-than-planned traffic volumes. Actual costs were between −3.4% and −5.9% lower each year than planned costs (or determined costs). As a result of lower air traffic levels, the actual en-route unit costs were 0.4% higher than the EU-wide target for 2014.

The European ATM sector remains fragmented, and the costs of its services are comparatively high. The unit cost of air navigation services is particularly high, with users paying about EUR 10.5 billion annually (in user charges, delay costs and flight inefficiencies). These high costs result mainly from the fragmented service provision and infrastructure, antiquated technology and low productivity in this labour-intensive
industry (labour amounts to 63% of costs).

At the technical level, the comparison between the European ATM system and the systems in other geographical areas shows that at equivalent operational complexity, the non-ATCos costs are 30% higher in Europe compared to the US FAA and NavCanada.

- The European Court of Auditors (ECA) issued the 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” highlighting that:

  The SES has contributed to incremental improvements but has not generated the expected change of performance and has not sufficiently reduced fragmentation of the European ATM system.

  In short, while the EC had been quite successful at liberalizing air transport and somewhat successful at regulating access to airports, it is currently in gridlock with the Single European Sky, a centrepiece in overall air transport performance.

3.2. The reasons for this gridlock

At the Budapest Air Forum: Single European Sky, the way forward (9 November 2018) reasons for the gridlock were presented (Baumgartner, 2018 “The Single European Sky – why is its implementation late?”) (Baumgartner and Finger, 2014).

In considering why Single European Sky was delayed, there are a number of key issues to consider:

3.2.1. Lack of political strength to face diverging interests of the actors involved

There are too many actors with diverging interests among which two issues in particular jeopardize the SES:

a) Some states see the SES initiative as a challenge of their sovereignty and a also causing concerns for their legal liability. This resulted in very lukewarm response to delegate more decisionary power to the European Commission and Community Agencies (e.g., EASA).

b) ANSPs are either fully or partly owned by states, which benefit from the ANSPs’ revenues.

As a result, one concludes that airlines and the European Commission are the only actors interested in the SES.

3.2.2. The EC has become a micro-and technical regulator instead of a policymaker

Technical and operational issues have been addressed by legislation at the political level instead of being developed in a harmonized way at the technical and operational level. The most significant example is the Controller Pilot Datalink (CPDLC) mandate based on a technology that became obsolete when the mandate was approved, thus forcing airlines to invest inappropriately in this technology instead of moving to a new digital era.

3.2.3. Unproductive use of EU funds cemented fragmentation and perpetuation of old technologies

When the SESAR Joint Undertaking was created to pool the research, EU Funds were made available, and a roadmap was developed to deploy results. A SESAR deployment manager was created to distribute the research funds. Instead of coordinated projects, the funds were used to upgrade national systems with old technology (see TRAN committee report on SESAR). This situation has led to increased fragmentation of system service provision with high barriers to interoperability.

3.2.4. An inefficient technological infrastructure

Technological infrastructure covers Communication Navigation Surveillance (CNS) and ATM systems.

Communication, Navigation and Surveillance is the technical infrastructure to provide air traffic control and includes means to communicate between all actors, to navigate and survey the planes under the control of the ATM system.

ATM systems cover the systems necessary for the work of Air Traffic Controllers. Historically, they were limited to the systems in the control centres. Many interconnected systems now contribute to air traffic control, such as centralized systems at the European level (Network Manager systems), airport management systems, and ATM systems supporting operations in Airline Operation Centres.

The consequences of the current fragmentation are far from negligible:

- **Higher costs**: the costs of this technological infrastructure are 30% higher in Europe compared to other geographical areas at equivalent complexity but not fragmented, such as NavCanada or the US FAA.

  Another aspect is the waste of spectrum.

- **Waste of frequencies spectrum**: For Safety reasons, the aviation sector is blocking a spectrum of frequencies valued commercially and financially at amounts exceeding the financial resources of aviation.\(^5\)

  We can anticipate an increasing pressure to release frequencies or to make aviation pay, at market price, the cost of using these frequencies.

- **Obsolescence of systems**: the proliferation of equipment, and their heterogeneity, make the possibilities for pan-European evolution more complex. This situation prevents the systems from being adapted at an affordable cost to the necessary changes. This sub-optimal deployment was also strongly underlined by the “European Court of Auditors” (ECA) in its 2019 report on the deployment of SESAR.

- **Weaknesses in systems interoperability**: data exchange is based on technologies and protocols dating from the 1980s.

3.2.5. A toothless network manager

The primary mission of the Network Manager (NM) is the optimal balance between the capacity of the system and the demand coming from the Airspace Users. Another mission related to this Demand Capacity Balancing (DCB) management is crisis management (e.g., the Eyjafjallajökull volcano crisis). This search for the optimum is carried out continuously at three timescales: Strategic (from three years to six months before the actual flight), Pre-tactical (from 6 months to the morning of operations), Tactical (just before - a few hours - and during the flight).

This function is based on a technical infrastructure made up of a set of powerful modelling, simulation, and optimization tools, as well as a very significant data warehouse enabling the most accurate demand forecast. The analysis is then reflected in the Network Operation Plan (NOP) and the NOP Gateway, the reference tool to support collaboration in all three phases. At each of these timescales, NM estimates when and where there is a risk of imbalances between demand and capacity and takes measures to reduce these imbalances, or if this is not possible to minimize operational impacts.

All these measures are fundamentally based on Collaborative Decision Making requiring a global win-win spirit. Unfortunately, Air Transport is highly competitive at the level of airlines, and to a lesser, but non-negligible extent, at the ANSP level. This situation triggers non-cooperative behaviours, and since the Network Manager does not have the legal power to impose solutions, there are situations where no compromise is found, leading to sub-optimal situations for the European Network. Problems also exist at a data level, where some actors are

\(^5\) Aviation is underutilising the spectrum that it keeps for its own use, compared to other industries like telecommunications. If aviation had to pay this spectrum at the same price the other industries do, the cost would be unbearable.
member states have, de facto, accepted the main governance of the planned legislative revision of SES.

In July 2010, Eurocontrol was designated by the EU as the PRB that will assist the EC in establishing and managing the performance scheme for ANSs. SES II puts the entire SES endeavour under the banner of “performance,” though this aspect was already prominently mentioned in the so-called “Performance Report” dated 2006 (Performance Review Commission, 2006), which clearly stated that an SES could only be achieved if a performance scheme was introduced. By doing so, the Commission would acquire a significant amount of power vis-à-vis member states.

Indeed, by agreeing that the EC has the competence to set targets, the member states have, de facto, accepted the main governance of the political agenda, as well as its timing.

Counter-productivity was especially apparent in how the objectives on costs were handled with harmful effects blocking the required increase in staff recruitment, which was nevertheless necessary to cope with the resumption of traffic in 2017. The COVID crisis highlighted the weaknesses and fragility of the current performance scheme setup.

In addition (Montyka et al., 2020), Button (2019), as cited in Finger et al. (2018), pointed out at the 10th Florence Air Forum that the problems with FABs are indicative of the lack of incentives. Moreover, he indicated that FABs had not been fully implemented because, in economic terms, there was no incentive to adopt them or penalty for not doing so. Penalising ANSPs for not delivering optimal capacity was a solution also proposed by IATA (2018) in response to a growth in summer delays of over 130 percent compared with 2017. Moreover, Finger et al. (2018) indicate that the financing and incentives (or conversely, penalties) must be performance- and objective-based, with a firm commitment from the Member States to make appropriate investments.

3.3. A Wise Person Group to shape the future

Following the European Court of Auditors report already mentioned, in 2019, the European Commission (DG MOVE) created a Wise Persons Group (Report of the Wise Persons Group on the future of the Single European Sky 2019) and tasked this group to reflect on the future of the Single European Sky (SES) to produce recommendations for the direction that European ATM should take.

These recommendations were:

- To adopt a network-centric approach and to strengthen EUROCONTROL Network Manager executive powers and fully integrate airports in the network,
- To implement a digital European sky as recommended by the Airspace Architecture Study; by using the performance and charging scheme to incentivise the digitalisation of air traffic services and use public EU funding only where necessary from a network perspective, and create a new market for ATM data service providers,
- To have the role of people delivering the ATM services evolve by reviewing current licensing and training requirements for ATCOs,
- To simplify and strengthen economic regulation and establishing an independent economic regulator at the European level, by establishing a Seamless European (Upper) Airspace System including a common route charge, while encouraging airports to procure tower services through competitive tender or contract.

3.4. The EC legislative proposal for implementation

Following the recommendations from the Wise Persons Group, the European Commission initiated in the second half of 2019 the process to develop a legislative package to amend SES accordingly. Unfortunately, the COVID-19 crisis happened, which delayed the development of the planned legislative revision of SES.

The European Commission took on board the impact of this crisis and the latest environmental priorities as expressed in the new European Green Deal and decided to progress in the process of amending SES regulations publishing on 22/09/2020 the amended proposal for a regulation on the implementation of the Single European Sky, and the proposal for EASA to act as Performance Review Body of the Single European Sky.

The main points of this proposal are:

1. To adopt a new approach to the performance scheme with an independent PRB agency (hosted by EASA) in charge to assess and approve the performance plans for en-route air navigation services.
2. Establish two national entities delineated and independent from the service provider: National Competent Authority in charge of safety oversight, National Supervisory Authorities in charge to issue economic certificates, to oversee the correct application of procurement requirements of CNS, AIS, ADS, MET and terminal ATS services, and to certify these services vis-à-vis performances regulation, and monitoring en-route services performances.
3. Strengthen the role of the Network manager.
4. Deregulate the Functional Airspace Blocks (FABs).
5. Unbundle infrastructures and MET and terminal ATS services, subject to market conditions.
6. Possibly introduce a common unit rate for en-route air traffic services across the Single European Sky airspace and focus on “clean technology” and modularity to foster investments. The unit rates should be set by the NSAs, rather than by the Member States, after verification and approval of the Agency acting as PRB. Possible modulation of charges to incentivise implementation of new technologies (decision at EU level)
7. Provide standard information services for crewless aircraft (i.e., drones)

This paper was written when the discussions between the council, the European Parliament and the Commission were ongoing. The co-legislators can now start negotiations since the TRAN committee position was announced and not contested during the Parliament’s July 2021 plenary session. Given that the positions of the Parliament and the Council are very different, it will probably not be easy to reach a compromise.

4. The authors’ proposal for a transition towards a pan-European ATC with EUROCONTROL reinvented

As explained in previous chapters, the new initiative from the European Commission is a step forward, in line with the recommendations from the ECA report and the Wise Person Group conclusions. In terms of safety, the current position of EASA and the National Competent Authorities (NCA) has proven its efficiency and will be further strengthened with the new proposal requiring complete independence from providers and economic regulators.

The rest of this legislative proposal by the European Commission is a step forward, but the authors of this paper believe that it will not be sufficient to solve the latent issues that the COVID crisis has dramatically underlined.

This study proposes a step further in terms of defragmentation that would require significant organisational changes of the European ATM system, mainly along the six following axes:

6 European Commission, “The European Green Deal -COM (2019) 640 final,” 12 2019.
7 For a better understanding of the proposal two documents are worth mentioning: Questions & answers – Single European Sky: for an efficient and sustainable air traffic management
Commission staff working document ‘A fresh look at the Single European Sky’.
A stronger political decision-maker, with significantly increased transfer of competence to the EC in the ATM domain,

A Network Manager with stronger power in Airspace design and capacity management.

A defragmentation of Air Navigation Service provisions. Even though the Functional Airspace Blocks finally failed, the rationales behind their creation are still valid, and it is more the implementation (bottom-up approach) that should be revised.

An infrastructure manager in charge not only of the management of pan-European programmes but also responsible for standardisation (in cooperation with industry through standardisation bodies such as EUROCAE) and gradually taking over the overall procurement at the European level of the ATM/CNS infrastructure according to the market rules, including the deployment of new data services.

A strengthened R&D setup for Europe, more agile, less bureaucratic and facilitating innovations in a significantly more digital environment.

A true pan-European Performance Manager with expertise allowing for a holistic approach towards performance regulation.

4.1. A stronger political decision-maker

Policy decisions made in Europe should be based on a transfer of competence from the States to a stronger political decision-maker. Its role should not be limited to regulations development and co-funding of national projects but should cover the following roles:

- A focal point for ICAO with the support of the Network Manager and the infrastructure manager.
- A decision-maker for route charges (modulations, unique en-route route charges).
- An Owner of a binding master plan which is no longer the repository of all technical ideas coming from all actors but a tool to give clear direction on the targeted system.
- An Owner of the overall investment plan.
- A decision-maker in term of environmental performance objectives.

The issue of the geographical scope of the EU, especially in the context of Brexit, should be addressed. Possible solutions could be:

- Two-layered governance: intergovernmental (EUROCONTROL Council) at a pan-European level and an EC decision-maker for EU states,
- Aviation agreement with non-EU states to centralise at an EC level pan-European dimension.

4.2. A more powerful Network Manager with an enlarged role in environment

The recent regulation proposes to reinforce the role of the Network Manager mainly in two aspects which is already a good step forward:

- Making the Network Operation Plan binding for all service providers,
- Putting the Network Manager in a position to manage the capacity brokering process, including the possibility to facilitate delegation of Airspace.

To go further, the Network Manager should be empowered with four key pan-European roles:

- Airspace Manager: to allow a Top-down Airspace design to avoid current lose – lose fights at the well-known hot-spots,
- Capacity Manager based on pan-European Demand Capacity Balancing (DCB) analysis and decide on the best measures for a better balance, including mandatory delegation of airspace from congested ANSPs to less congested neighbouring ANSPs.

4.3. Defragmentation of air navigation service provisions

The failure of the Functional Airspace Blocks should not prevent any kind of optimization of the service provision organisation, considering that current fragmentation is sub-optimal (too many ANSPs below the critical size).

New models should be investigated:

- A single service provider for Europe, reinventing the vision of the founders of EUROCONTROL.
- A top-down design of bigger ACCs (operationally meaningful) with designated ANSPs and possible periodic competition.

4.4. A pan-European Performance Manager

The reform of the performance scheme proposed by the recent EC legislative package, with an equivalent position between a central, independent and powerful economic Performance Regulator Board (PRB) agency (hosted by EASA) and National Supervisory Authorities (NSA), seems theoretically achievable, provided that this PRB and NSA are entirely independent of any providers and from safety regulation.

However, it must pass a revision of the EASA’s basic regulation and will have to start from scratch as it does not have any data, nor has the staff to provide the needed expertise, and it will reduce to a limited geographical area scope. Instead of starting from scratch, it would make much more sense to build the future independent economic regulator (PRB) around the expertise of the Performance Review Unit (PRU) and the performance data warehouse of EUROCONTROL. A mixed committee for the governance of the independent regulator shall include EU and the non-EU EUROCONTROL Member States.

4.5. An infrastructure manager

The recent regulation foresees this role should be limited to the management of the pan-European implementation programme (such as Reduced Vertical Separation Management 20 years ago). This approach would solve the issue underlined by the ECA concerning the SESAR Deployment programme that did not permit the implementation of the solutions developed by SESAR Joint Undertaking. This regulation also foresees a separation between operational and technical services, considering that the latter should be subject to market competition, but only as an option and leaving the final decision at a national level.

We consider that this would be insufficient to solve the current inefficiencies identified above due to fragmentation. They recommend that all the CNS/ATM infrastructure should be managed at the pan-European level with two options:

- The first one would be to move from a model of purchasing specific solutions by each ANSP to joint procurement of standardised commercial products. The advantages would be a reduction in costs by promoting reuse and allowing manufacturers to invest in innovation, which would help export European industrial products.
- The second one would be a more ambitious option would be to see the CNS infrastructure as a service and no longer as an investment.

Until now, standardisation and interoperability have been considered the solution for ATM systems. On paper, the current relationship between ICAO defining high-level orientations and RTCA/EUROCAE
working together to refine the standards before ICAO endorses them is appropriate. However, it does not work as it is a purely bottom-up approach with ANSPs using the EUROCAE tool to prevent any attempts to defragment the system.

Therefore, we suggest three possibilities:

- The first would be the delegation of management of technical systems, which technically no longer need to be collocated with control positions. This arrangement already exists in the Maastricht ATC centre, which manages the technical systems of the military air traffic services of the Netherlands and Belgium, while the control positions are still located in the respective national military centres. Feasibility has also been proven even further with Slovenia ACC.

- The second would be to rely on joint development/procurement of ATM systems. This arrangement already exists, at least partially, with examples such as ARTAS (advanced Radar processing system procured by EUROCONTROL on behalf of many ANSPs), or as COOPANS, which is a “purchasing group” of several ANSPs which together specify and jointly purchase the evolutions of their systems. These examples have demonstrated the feasibility of joint procurement as well as the benefits in terms of economics and the standardization of human-machine interfaces.

- The last option and certainly the most ambitious, identified in the Wise Person Group recommendations, consists of the systems’ total virtualisation. This virtualisation consists in moving from a very monolithic systems architecture to an open and modular architecture, then thoroughly reviewing the overall architecture of the ATM system in Europe and its economic model by setting up ATM data server service providers (e.g., radar data, flight plan data, weather data, and aeronautical data). The various experiments carried out so far have demonstrated the technical feasibility of such an approach. Beyond apparent economies of scale, advantages will be in scalability and simplification of functional improvements.

All these options would require a strong infrastructure manager to take the lead. The authors consider that the unique solution would be to designate EUROCONTROL Agency in that role as it is the only organisation that can provide the required expertise and overview needed for such an undertaking.

4.6. An agile and efficient setup for R&D

SJU has been a useful tool to pool European funds; however, as R&D is co-funded by its members, it has shown its limitations:

- Priorities were always a compromise between national interests driven by their individual strategies linked to an uncoordinated investment plan (despite the attempt of the Master Plan to steer R&D along a shared vision).

- High administrative burden and bureaucratic procedure drastically impeded the required agility of R&D. In some cases, three years were spent from the agreement on a new idea to the initiation of the research project.

- No possibility to stimulate innovation exists outside the signed partnership and, in order to embark on this partnership, new actors must be recognised for their benefit.

The authors of this paper propose that a new technological pillar be set up by EUROCONTROL and the European Commission, merging the SESAR JU and the EUROCONTROL R&D into a Joint Research Centre such as the ones that already exist in other domains. A Joint Research Centre would have the advantage to:

- Increase flexibility and agility of R&D, to allow quick re-orientation to answer urgencies such as the capacity issues in 2018 and 2019 and, more recently, the pandemic crisis.

- Animate an ATM European innovation hub. It would be close to the needs and to the network of R&D centres of excellence in our domain and, above all, to other domains which will necessarily come to ATM to bring the state-of-the-art expertise lacking in the standard ATM R&D network (such as digital industry, machine learning/artificial intelligence, cybersecurity, and drones).

4.7. A new financing scheme

The COVID 19 crisis has had a catastrophic impact on the air transport sector. Despite a recent increase in traffic in the European region, which is currently levelling out at about 50-60% of the 2019 traffic, forecasts indicate that this reduction in traffic will continue for some time.

The multilateral agreement of the CRCO is based on traffic volume. The current crisis has thus left ANSPs cash-strapped. To help ensure a flexible and efficient ATM system resilient to such crises, we propose a review of the current route charging arrangements in the CRCO area. This analysis should also consider the different route charging mechanisms used by other States or regions.

We propose that part or all of the activities involved in the provision of ANS are funded independently of the current “airspace users pay all” principle. The possibility of creating an infrastructure fund at a multi-national level to finance ANS provision should be considered. Such an approach would prevent a situation where states have to step in to financially support ANSPs, which run out of funds when traffic significantly decreases. This new type of financing would be easier to implement in the context of the options described above, which will take significant elements of the ATM infrastructure as common European assets or services. The ultimate step is a single ATM provider with a single ATM/CNS infrastructure managed as a European infrastructure.

4.8. The human factors

If recognised, the human factors challenge could be overcome.

Some 17 799 staff (31%) were ATCOs working on operational duty, split between ACGs (55%) and APP/TWR facilities (45%). On average, 2.2 additional staff were required for every ATCO in OPS in Europe. In 2018 (ACE Benchmarking report 2018), 56 718 staff were employed by ANSPs. An additional 2000 staff work in the various European institutions such as EUROCONTROL, EASA and EUROCAE in the matters which will be affected by our proposal. It is therefore urgent that a roadmap for change is created to assist the system’s evolution.

4.9. Summary of proposed options

The recommendations made above can be summarized as follows:

4.9.1. At the operational level

- A stronger Network Manager, identical to US Air Traffic Control System Command Centre (ATCSCC), with authority:
- ✓ In the optimal design of European airspace to eliminate artificial congestion points, at the borders between ANSPs,
- ✓ In capacity management,
- ✓ In arbitrage in the dynamic balancing of demand and capacity
- ✓ Overall optimization of the operational, environmental, and economic efficiency of the network
- ✓ And in the central management of weather forecasts
- A reorganization of the provision of air navigation services at the European level:
4.9.2. At the technical level

- A rationalized and modernized CNS infrastructure:
  - Option 1: Common purchases of equipment based on standardized specifications.
  - Option 2: "CNS-as-a-service"
- ATM systems
  - Option 1: Common development and acquisition of ATM systems.
  - Option 2: Delegation of the management of ATM technical systems between ANSPs
  - Option 3: "ATM systems-as-a-service"

All these options can be seen as steps towards a truly integrated European ATM system capable of meeting current and future challenges. It will altogether allow better cost control, the pooling at the European level of financial risks such as those encountered in the crisis we are suffering, better operational and environmental efficiency, and greater mobility possibilities for staff through operational harmonisation. This approach will also make it easier to modernize the system and finally bring it into the technologies of the 21st century, 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.

No progress has been recorded on the Environmental Efficiency Indicator (KAE/KEP) defined for the 2nd reference period of SES 2 (RP2; 2015–2019) and the performance target has not been met.

If we implement the above recommendations, we can expect significant improvements coming from ATM, in particular:

- By giving the Network Manager a real authority on Airspace design, on capacity and demand management, it will be able with its already available tool and data, to minimize environmental impact of flights.
- Rationalized CNS infrastructure: even if significantly less important, we cannot neglect the direct impact of CNS/ATM infrastructure with an estimated annual average consumption of 1,140 GWh equivalent to 311K tonnes CO2, which, if it can be fully decarbonised, would represent a sizeable achievement. Even if this full decarbonisation is not easily reachable, it seems obvious that rationalising CNS infrastructure will allow significant savings in terms of CO2 emissions (for example rationalising Surveillance infrastructure has the potential of decommissioning several Radars with an estimated consumption of 0.3Gwh/year per Radar),

The difficulties and risks are multiple but manageable:

- At the social level: The scale of such a change can only arouse resistance from staff who could legitimately fear for their jobs. The duration of the implementation of such a reform should make it possible to establish the social dialogue required for the definition and implementation of the necessary support measures and even transform this ambitious project into a mobilizer of all staff, who will have to be actors of this change.
- At the level of the ANSPs: we can expect the fiercest resistance from the ANSPs, which are the first beneficiaries of the current fragmentation. In the last decades, this resistance has been demonstrated against any attempt to rationalise the European ATM system. We cannot expect anything other than continued resistance, especially from the management level of these ANSPs, which may fear jobs reduction in case of rationalisation. A strong political position will have to be shown at the European level, and at the same time, initiate negotiations to accompany such a change.
- At the state level: we can expect strong resistance from the states pushed by their ANSPs. The sovereignty argument is already being put forward, especially at the military level. The example of the Maastricht Centre shows that this problem can easily be solved for the benefit of all stakeholders. On the other hand, the COVID crisis has put the ATM system in such a dramatic financial situation that the states might consider as necessary a significant change in the organisation of the European ATM infrastructure to cope with which such a situation.
- At the level of the Airlines: These companies, through their various associations, have always been strong supporters of rationalisation and defragmentation of the European ATM system, seen as the only way for a real performance improvement and cost reduction. The current crisis and the perspective of a high increase in route charges can only make them even more inclined to call for a rapid and courageous reorganization of the European ATM system. However, companies that have recently received heavy subsidies from their states will perhaps be less vocal in their criticism against these states that have contributed to their survival.

Credit author statement

Pierre Andribet: Writing – original draft, Writing – review & editing.
Marc Baumgartner: Writing – original draft, Writing – review & editing.
Jean-Marc Garot: Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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