European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

FSR TRANSPORT
Florence School of Regulation

Issue 2020/18
April 2020

POLICY BRIEF

EUROPEAN TRANSPORT REGULATION OBSERVER

Enabling Air Traffic Management (ATM) Data Services

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Highlights

The Airspace Architecture Study (AAS), published in March 2019, set out a proposal for a future Single European Airspace System (SEAS) underpinned by optimised airspace organisation, progressively higher levels of automation and the establishment of common ATM data services, enabling seamless cross border air traffic service provision. The vision outlined in the AAS report requires operational, technological, organisational and regulatory changes to the existing SES architecture.

Whilst the AAS focused on the operational and technical dimensions of the proposed future ATM architecture, a number of questions remain open in terms of regulatory aspects and service delivery arrangements ('framework dimensions').

The framework dimension, including the regulatory framework and the service delivery models, constitute the enablers without which the proposed future vision cannot be realised. Hence, the Commission has taken further action to explore and address the related aspects critical for the future SEAS, by launching a study in October 2019 on the legal, economic and regulatory aspects of ATM data services provision and capacity on demand as part of the future European air space architecture. Subsequently, a major stakeholder engagement workshop was held in Brussels in November 2019, to inform all stakeholders about the scope and timing of the study, and to allow for key stakeholder groups to provide initial inputs to the study. In addition to this, a dedicated civil-military workshop was also organised by the European Defense Agency, to involve military and defense dimensions from early on.

With the study work now well underway, this workshop aimed at providing the experts from different stakeholder groups with an overview of the initial findings and results, as well as at generating valuable discussions regarding the most important aspects of ATM data services.

More specifically, the workshop sought to explore the following topics:

- Scoping and definitions of ATM data services;
- Costs and benefits associated with ATM data services;
- Future strategies of potential players of an ATM data services market;
- Economic regulation and other regulatory aspects.

Context and History of ATM Data Services

By Matthias Finger, Teodora Serafimova and Engin Zeki

Rather than commenting on the Online Workshop on enabling ATM Data Services, we thought it to be more fruitful to put our workshop into a historical perspective and to recall the broad context which has led us to the current debates, as illustrated in the summary of the workshop below.

How It All Started (1999 – 2012)

Conceived back in 1999, the Single European Sky (SES) initiative was the European Commission's response to reducing delays, increasing safety, mitigating the environmental impact and reducing costs related to service provision in the aviation sector. The SES sought to address these challenges by promoting the de-fragmentation of the European airspace and by creating a more efficient ATM system.

Historically, airspace structures and ATM infrastructures have been developed along isolated national blocks within the territorial and aerial borders of sovereign states. Because ATM operates national legacy systems with little interoperability and develops capacity in isolation from one country to another, internationally available airspace capacity is severely restricted and resilience/redundancy between the many ATM providers is almost inexistent. In 2013, the Commission estimated that the lack of standards and differences in procedures leads to roughly €5 billion in unnecessary costs each year, not to mention millions of tons in wasted jet fuel and excess CO_2 emissions due to inefficient routes. Seven years later, today, this figure has more than tripled to €17.4 billion per year due to the continued absence of a seamless airspace structure[1]. Most of these costs are being passed on to passengers in the form of higher ticket prices.

In 2004, the Commission set four high-level objectives, committing itself to tripling airspace capacity in order to reduce delays, both on the ground and in the air, halving the costs of ATM services, improving safety tenfold, and reducing by 10 percent the impact of aviation on the environment by 2035. To achieve these goals a framework of five pillars was established based on technology, safety, performance, airports and human factors.

From the very beginning, it was evident that technology would play a key role in this process, not only as an enabler of a more efficient ATM, but also as a way to facilitate the transition to a more logical organisation of the airspace without compromising the politically undesirable closure of control centers. In view of this, in 2007, the SESAR (Single European Sky ATM Research) Joint Undertaking, was set up to manage the technological and industrial dimensions of the SES. While SESAR has been largely successful and technology is no longer considered to be a barrier, progress on the political side has lagged behind[2]. We will discuss the specific barriers to the deployment of virtual centers in greater depth further down.

The second SES package of 2009 created a so-called "performance scheme", along with concrete indicators, as well as a refined Functional Airspace Blocks (FABs) concept. The FABs were set up so as to enhance the cooperation across national boundaries and to lower the costs of ANS. Nine FABs were created in total, each of which was to set up common operating procedures, technologies and fee structures. This was initially seen as an intermediate step towards a fully integrated Single European Sky. But the plan was met with resistance from national governments wary about sacrificing too much sovereignty over their airspace and giving up authority over their ANSPs. Also, and contrary to their initial intention, FABs have engendered an additional layer of bureaucracy, thus creating an additional obstacle to realising the SES.

As a result, people produced a series of novel ideas about how to centralise some of the services ANSPs are providing, all somewhat based on the assumption that the various activities of the ANSPs could be decoupled and that some of them could be centralised and tendered out to private services providers. In parallel, the emergence of digital platforms – e.g., Google, Facebook, Amazon – has created an intellectual climate, which led some people to ask whether the same evolution could not also happen or being actively promoted in ATM.

1. ICCSA-University of Bergamo for A4E, Cost of Non-Europe in Aviation (CONEA), February 2020

2. Finger, M., Bert, N., and Kupfer, D., (2014), Making effective use of technology in SESAR deployment, https://cadmus.eui.eu/bitstream/handle/1814/39128/ETR_Observer_2014_04.pdf?sequence=1&isAllowed=y

In 2012, during the SES Conference in Limassol, Cyprus, the then Transport Commissioner Siim Kallas expressed his frustration as to the slow, if not absent progress of the SES project, despite all the legislative, financial and institutional efforts to promote it (e.g., SESAR, performance scheme, FABs).

Virtual Centers: a Swiss Solution to a "European" Problem

Enter the virtual center model which had originated from Skyguide's local need to consolidate its two Air Traffic Control Centers (ACCs: Zurich and Geneva) into a single virtualised center in 2012. Previously, cloud-based services and service-oriented architectures, the founding technologies of virtual centers, had already been extensively used to increase cost-efficiencies and performance in other IT and network industries. Even though the virtual center model is not revolutionary from a technical point of view, it is nevertheless ground-breaking for the ATM sector. This is due to fact that it implies a paradigm shift from legacy and geographically-based ATM systems to service-oriented and virtual, i.e. location-independent architectures. As Skyguide's systems were at the end of their life cycle, the question arose whether the company should invest in existing (outdated) technologies or take the riskier path of the pioneer. The internal strategy discussions lasted over two years. In the end, the decision was clearly in favor of the virtual center.

The key elements of such a virtual center include a service-oriented architecture (SOA) for data services, a wide area network (WAN), and a harmonised controller working position (CWP), operating on the basis of open standard interfaces. In addition, a virtual center implies (what was previously called) an ANS Data Service Provider, which provides positioning, planning, and environment data services (to a virtual center). In order to set up its virtual center for Switzerland ("One Sky by One System"), Skyguide identified the following three phases: during the initial phase lasting between 2014 and 2016 Skyguide designed and planned the various components for the required changes, namely common flight plans and harmonised ACCs (Zurich and Geneva), Phase 2, which continues through 2020, standardises the data between the two ACCs based on a full-fledged service oriented architecture ("one system") and defines location-independent ATC and ATM services ("one airspace"). Phase 3, which will last until 2024, will lead to a full-fledged location-independent concept of operation for the upper airspace in Switzerland. This can then be further enhanced by the inclusion of external services, such as flight trajectories, flight data management, and route extraction.

Elevating the Idea to EU Levels

During the same period, but often at less advanced stages of development than the virtual center, a series of other disruptive ATM operational concepts also started to be discussed in EU circles, and even to be developed by some of the established ATM players, such as "remote towers", "sector-less ATM" and "flight-centric operations" as well as new upcoming "drone technologies". While some of these technologies and operational concepts have the potential to disrupt operations, others may lead to the disruption of the entire aviation industry. But among all these new technologies, the virtual center clearly offered the most immediate and most obvious solution to Europe's fragmented airspace, something that became rapidly obvious to many of the actors involved in European ATM. Consequently, both in parallel and in collaboration with Skyguide, other ANSPs also started to explore its virtues. SESAR, furthermore, was investigating where use cases could be explored. Many of the stakeholders, including major European ANSPs such as ENAV, NATS, DFS, ENAIRE, DSNA and COOPANS (a group of ANSPs), started projects to rationalise their infrastructure or to modify their flight data planning systems (FPDS) so as to adapt to cloud server functionality and to offer FDP services. Within the SESAR framework, the idea of a virtual center was and continues to be explored by way of three distinct types of use cases, specifically adapted to the operational and business needs of each ANSP. These are the rationalisation of the infrastructure, the delegation of airspace, and contingency. Additionally, these use cases all rely on the definition of an ADSP, providing data and services to multiple ATSUs (Air Traffic Service Units), thus enabling cross-border operations. In addition, Eurocontrol and the A6 Alliance of ANSPs joined the effort by working on a "digital Backbone", a shared data exchange infrastructure for the European ATM. This, among others, and together with SESAR helped and continues to push stakeholders to move towards

virtualisation. It goes without saying that the levels for both safety and (cyber) security have to be kept at least.

The importance of transitioning towards virtualisation and towards progressively increased levels of automation in ATM made its way into the Commission's 2015 Master Plan. Subsequently, in 2017, a joint European industry declaration stressed the need for a digital transformation of aviation. Virtual centers were particularly mentioned as a tool to enable the progressive decoupling of ATM service provision from the physical infrastructure. This, it was argued, could create both enormous efficiency and resilience gains, since data and infrastructure can be shared between different centers, thereby enabling better use of existing resources and reducing investment costs. As a matter of fact, Skyguide's virtual center had already demonstrated important cost-saving potentials thanks to the elimination of systems' and data centers' duplication. However, efficiency gains for a single ANSP are limited. As we learnt during the virtual workshop, these benefits would grow exponentially on a European scale. They can generate significant 'system-wide' efficiency gains in ADS provision, boosting, in addition, the system's resilience.

However, many of these new technologies are not compatible with the current fragmented and nation-based institutional system of actors. For example, flight-centric operations, despite being at a mature stage of development today, are only efficient in larger airspaces, thus calling for a cross-border approach. In short, and even though the virtual center and other technological ATM innovations, can lead to significant gains, notably in terms of efficiency, safety and resilience, they have direct and immediate economic, political, social, and legal implications. On the social side, the resistance might come from Air Traffic Controllers (ATCOs) and operational staff due to their fear of losing jobs, change in work practices and salaries. Also, the virtual center implies significant long-term investment, which typically only makes sense at the end of a legacy technology's life-cycle. Additionally, at a political level, location-independent ATC could be perceived by Member States as a threat to national sovereignty over their airspace. Finally, the legal framework of European ATM must be modified in order to allow for data sharing and service provision among ANSPs. No doubt, ATM is a conservative sector in which technological modernisation can be implemented, at best, in an evolutionary manner. And such evolution, if it ever is to take place, must thus be accompanied and facilitated by a corresponding evolution in EU regulations.

Lessons from the Florence Forums

And this is where the different Florence Forums came and come into the picture, the recent workshop on ATM data service provision being just the latest example. Indeed, introducing new technologies is always challenging, but even more so in the case of a complex and fragmented network industry such as ATM. It was during the 4th European Air Transport Regulation Forum, held in Spring 2013, that "Virtual Centers" were put forward on the agenda of a broader European audience for the first time. We remember well that the concept of sharing services had not convinced everyone. While important advances have been achieved in recent years, with ANSPs and the suppliers' industry today collaborating in the context of developing virtual centers, just seven years back ANSPs and the major players of the manufacturing industry argued against it. However, the topic was set and from there on it appeared from different angles in every Florence Air Transport Forum. In its 8th Florence Air Forum, back in 2016, we finally were mature enough to professionally discuss the potential of these new technologies for European ATM with all the important stakeholders. The virtual center, as proposed by Skyguide, emerged during the discussions as having the biggest potential for improving European ATM, but also for creating disruption at the institutional level. And the previous Florence Forums on ATM had indeed already alerted us to the numerous sources of resistance vis-à-vis the Commission's project of a Single European Sky, namely financial disincentives, the industry's current structure, and the so-called "social question".

Firstly, all ANSPs in the EU are still state owned entities. With governments as their owners, ANSPs and their owners, at present, lack the financial incentives to push for reforms which in turn could decrease their revenue stream. Moreover, for the full benefits of the new technologies to be reaped, deployment has to be system-wide, as opposed to piecemeal. In the world of ATM it is difficult to imagine the entire system closing down, therefore a transitional period is to be expected, marked by overlaps and duplications of systems, translating into a sub-optimal use of both during this period. This, in other words, means that the introduction of new technologies

in ATM will likely entail high transition costs both to network providers and to users. On the other hand, it was argued already during the 8th Florence Forum in October 2016, that the introduction of cross-border competition in the field of data provision could help overcome this obstacle, namely by enabling ANSPs to reduce their own infrastructure costs. Indeed, the storage and collection of data by every individual center separately creates costs that can easily be avoided.

Secondly, the very structure of the industry makes it inherently inhibitive to technological change. It is no secret that ATM is a highly protected sector, whereby collusion between providers and suppliers of ATM equipment is observed at least to some extent. ANSPs, manufacturers and regulators form a microcosm that is hardly ever confronted with the entry of new market players. The technology used has to undergo several years of testing and certification before it can be deployed. Regulation is very detailed and leaves little room for entrepreneurial initiative. The combination of these factors has contributed to making ATM a highly conservative technology sector. Moreover, whereas disruptive changes in other network industries were largely the result of customers' demand, the focus on customers has been traditionally missing in ATM. As monopoly businesses, ANSPs have not had to depend on "customer satisfaction" to stay in business. On the other hand, it was argued that data and data services had the potential to ore actively involve the airspace users, notably the airlines, and to perhaps create new partnership between airlines and ANSPs as a possible driver of change.

Thirdly, the "social question" remains a central consideration in the development of any new ATM technology. Unlike in other industries, the level of automation in ATM is still relatively low. Increasing automation naturally raises concerns regarding the creation of redundancies. Impact assessments conducted by SESAR JU, have reassured that automation would change the nature of the work and the training of ATCOs, though it would not create redundancies and layoffs could be prevented by long term planning. On the other hand, looking at the history of technological progress, it seems unlikely that innovation in ATM would not eventually lead to reducing the number of work places in this sector. The involvement of ATCOs in all stages of the process, it was argued, would thus be key to ensuring that the solutions are socially acceptable, practicable and lead to an overall improvement of working conditions.

Clearly, ANSPs and their management are in a central position to drive technological change. Yet getting these actors to proactively embrace new approaches will be pre-conditioned on having the right incentives in place. Currently ANSPs are faced with costs and risks that are not sufficiently outweighed by the corresponding ensuing benefits. This can be overcome by putting in place a conducive EU regulatory framework and corresponding incentives schemes. But, in parallel, the potential of rapidly evolving technological developments should be explored and discussed.

And this is what we did during the 10th Florence Air Forum, held in Budapest in October 2018. As a result, the Forum emphasised the need for a new model for ATM services, with location-independent data services at its core. The mechanism to create momentum, it was argued, would be by creating incentives for the early adopters of ADS, where service providers would work in a virtualised environment and could provide specialised and standardised services, independently of their location.

Digital Platforms and the Prospect of 'Platformisation' in Aviation

Despite the initially lukewarm reception, the idea of virtual centers and of digitalising ATM more generally started gaining traction during the past few years, aided as it was by the emergence of parallel debates on digital platforms and the prospect of a 'platformisation' of everything, including aviation[3]. Indeed, digitalisation is transforming all industries, including the network industries, and it will not stop at ATM. As such, digitalisation is creating a new model of industrial organisation, whereby platforms are becoming the new intermediaries between the infrastructure services providers and the customers, thus exploiting the network effects of multi-sided markets. Such digital platforms benefit consumers by fulfilling unmet needs, often more flexibly, more efficiently and at a lower cost. They do this mainly by exploiting the inefficiencies of the underlying existing network infrastructures.

3. Montero J. J., and Finger M. (2018), 'Platformed! Network industries and the new digital paradigm', *Competition and Regulation in Network Industries*: https://journals.sagepub.com/doi/full/10.1177/1783591718782310

As such, digitalisation also holds great potential for the aviation industry, and it is therefore not astonishing that the idea of a centralised data layer across and above the fragmented ANSPs has been gaining attention. Also, and in parallel, ANSPs have noticed the pressure from players outside the traditional ATM community, such as for instance, the emerging Unmanned Aerial Vehicle (UAV) industry which is actively developing new ways to provide air navigation services[4].

Airspace Architecture Study

Enters the Airspace Architecture Study (AAS) in March 2019. Developed by SESAR-JU, it aims at reaching a Single European Airspace System thanks to digitalisation and virtualisation of ATM, along the lines initially proposed by Skyguide's virtual center. In order to implement such a Single European Airspace System, the current airspace architecture is to be modified, more precisely duplicated by the addition of data and application services layer in between the ground infrastructure and air traffic services. Ultimately, decoupling the provision of raw data and air traffic services, it is argued in the study, will improve airspace organisation, notably thanks to higher levels of automation and the active use of common ATM data services. This new model for ATM data service provision would be supported by the creation of dedicated ATM data services providers (ADSPs), who would provide flight data, Aeronautical Information Services (AIS), Meteorology (MET) and Communication, Navigation and Surveillance (CNS) services to Air Traffic Service Units (ATSUs) regardless of flight information regions (FIR) boundaries.

The AAS considers virtual centers as one, if not the key technology in order to enable a Single European Airspace System. Specifically, virtual centers, it is argued, make a geographical decoupling between ADSPs and ATSUs possible. This, in turn, allows for location-independent ATC service provision: in its virtualised configuration, a single ATSU might use ATM data services from multiple ADSPs, and, inversely, one ADSP might be able to serve multiple ATSUs. Such flexibility is expected to increase competition for the provision of services, hence increasing cost-efficiency and scalability. The AAS anticipates that the implementation of virtualised services could be implemented by 2030.

Wise Persons Group: Elevating ADS to the EU's Policy Agenda

2018 saw the creation of the Commission's "Wise Persons Group" on the future of the SES. Motivated by the persistence of airspace inefficiencies and their negative impacts on the travelling public and the airspace users, the group was charged with producing recommendations as to the direction that European ATM should take. In April 2019, the group published its Report, issuing a set of ten recommendations.

The report reinforces messages of the AAS, among which, the need to optimise airspace by embracing new technologies and automation. Building on the AAS, the Report calls for transforming its recommendations into an actionable roadmap to be reflected in the ATM Master Plan, thus lifting the concept of ADS on to the EU policy agenda. The Report underlines the need to ensure that the right governance be put into place to drive this transformation, which in turn is to be overseen by the European Commission.

Of particular interest here is recommendation number four on the creation of a new market for ADS providers, as already recommended by the AAS. The Report reinforces the need to transition towards common ADS provision in support of several ATS providers simultaneously. While the Report notes that the existing regulatory framework does not prevent the creation of ATM Data Service Providers (ADSPs), it draws attention to a number of issues that would require particular attention, such as the organisational and certification requirements that would be required for ADSPs, taking due account of safety and security issues, as well as the possible need for clarification or regulation on the issue of access to, and ownership of, data. Given the transnational dimension of their potential market, ADSPs, it is stated in the report, will need to be certified by EASA, in compliance with the SES regulatory framework. In order to address "social aspect"-related barriers to the uptake of ATM data services and the virtual centers, the Report calls for the establishment of a "human dimension roadmap" as part of the evolution towards the Digital European Sky.

4. Finger, M., Bert, N., and Kupfer, D., (2014), Making effective use of technology in SESAR deployment, https://cadmus.eui.eu/bitstream/handle/1814/39128/ETR_Observer_2014_04.pdf?sequence=1&isAllowed=y

… and now in the hands of the Commission

The European aviation sector needs a high-performing European ATM system to cope with traffic fluctuations and ever-increasing global competition, while facilitating cost-efficiency and environmental benefits. Clearly, important momentum has built up over the past years, notably through the AAS, and the subsequent Wise Persons Group Report, on the need to overhaul European ATM with a key role attributed to digitalisation. Not least, in its European Green Deal, the von der Leyen Commission pledges to progress work on its proposal towards a truly Single European Sky in order to help achieve significant reductions in aviation emissions. After having developed a clear vision, however, the Commission now needs to steer the different technological actors into the right direction.

Enormous technological progress has been achieved to date, as made clear during our Virtual Workshop on Enabling ATM Data Services. However, technology alone will not suffice in getting us to this efficient European ATM system. Rules and institutions will have to evolve to accommodate or simply to allow these technologies to be deployed. Indeed, the pursuit of the SES has been a big European laboratory which has given rise to all kind of technological innovations, but if the rules of the game do not change now and do not allow at least some of these technologies to be rolled out, this will hamper the development of many innovative European firms and ultimately the European air transport industry altogether[5].

ANSPs, in particular, will be decisive in driving the technological change, yet the barriers and risks they currently face will have to be addressed. While it is becoming increasingly clear that public funds will not be used for incentivisation purposes, early adopters will have to be rewarded by means of direct financial support or via links to the performance and charging regimes. Conversely, disincentives for late movers will also have to be envisaged. A future performance scheme should only allow cost levels that are equal to or below that of the corresponding data services in Europe. ANSPs whose systems are at the end of the life cycle should be motivated to switch to service based technology. This could be encouraged by supporting the purchase of services (OPEX) more than the investments in own systems (investments). The European Commission will have an important role to play in overseeing progress and in ensuring interoperability. In this respect, the performance and charging schemes along with the role of the Network Manager will have to revisited, with a view to facilitating new capacity for on-demand services and improving the system's efficiency and resilience. Lastly, but very importantly, ACTO recruitment and training would have to be examined to ensure these are future-proof and consistent with an increasingly digital ATM environment.

Back in 2010, air travel across western and northern Europe was severely disrupted as a result of volcanic eruptions in Iceland. The absence of a coordinated European response to the crisis, leaving millions of air travelers stranded, was a clear illustration of the insufficient progress towards an efficient ATM system and a truly single European airspace. While the event built up momentum for an overhaul towards a unified ATM system, it was short-lived in nature. Ten years later, today, the COVID-19 crisis offers a second chance to redesign the system, by taking advantage of the low traffic period to invest in the necessary technological and infrastructural changes and, most importantly, to put into place a conducive regulatory framework.

5. Finger, M., Bert, N., and Kupfer, D., (2014), Making effective use of technology in SESAR deployment, https://cadmus.eui.eu/bitstream/handle/1814/39128/ETR_Observer_2014_04.pdf?sequence=1&isAllowed=y

Main Takeaways from the Discussion

By Teodora Serafimova

An Overview of the Study: Definitions, Boundaries, Scope

The workshop was kick-started with an overview of the initial findings and results of the European Commission's study on the "Legal, Economic and Regulatory aspects of Air Traffic Management (ATM) Data Services Provision and Capacity on Demand based on the Future European Air Space Architecture Study". With the study work now well underway, this workshop aimed at generating discussions and collecting feedback on the most important aspects of ATM data services. More specifically, the workshop explored the following topics: 1) Scoping and definitions of ATM data services; 2) Costs and benefits associated with ATM data services; 3) Future strategies of potential players of an ATM data services market; and 4) Economic regulation and other regulatory aspects.

While a formal definition of ATM Data Services (ADS) has already been developed by the study team, it was acknowledged that further fine-tuning may be needed, bearing in mind it would need to be inserted into the regulatory system. More specifically, ADS are defined as providing Air Navigation Service Providers (ANSPs), airspace users (AUs), and airports with information on the intended movement of each aircraft, and with real-time information on the actual progress of each aircraft, based on operational data received from Surveillance, Aeronautical Information Services (AIS), Meteorology (MET), network functions and any other relevant services which generate operational data.

ADS also provide decision advisory tools to air traffic service units (ATSUs) based on advanced data processing and transformation technologies (i.e. machine learning, AI, etc.). The proposed definition of ADS is not monolithic, in that it can be broken down into different modules or sub-services. An ATM data service provider may or may not focus on providing different subsets of the above defined services and information. As a consequence, a specialisation or differentiation of ATM data service providers may be foreseen.

The most important elements in the definition of ADS are the boundaries. The lower boundary between ADS and data production is initially defined at the point where operational data enters the "main ATM systems" (i.e. the radar tracker, the flight data processing system (FDPS), or other tools and applications attached to these). The upper boundary, on the other hand, namely the one between ADS and Air Traffic Services is initially defined at the point, where the data is displayed on the screens of the controller working positions. These defined boundaries, it was argued, allow for a clear distinction between services, fit well into the existing framework of legislation (to the extent possible) while allowing for maximum flexibility of business models.

In order to better substantiate the proposed ADS definition, a description of what is considered under the scope of ADS has also been developed, and includes the following sub-services:

1. flight plan and flight object data processing;
2. surveillance data processing (whilst surveillance *services*, however, form a separate set of services outside ADS); and
3. applications and services related to data transformation and processing.

Conversely, services that would fall outside of the scope of ADS were also mapped out, namely,

1. services which provide inputs, or receive outputs from ADS (e.g. surveillance services, meteorological services, AIS, network functions providing data for air traffic service providers (ATSPs) and other services, network services (including air traffic flow and capacity management (ATFCM), existing network functions and network crisis management);
2. communication services, which, it was noted, are essential to enabling ADS as well as extensive data exchange between actors, and, do not generate or process (ATM) data on their own; and
3. navigation services, which are services that provide aircraft directly with positioning information, however, do not provide inputs or receive outputs from ADS.

These services are mainly concerned with the maintenance of an infrastructure and with ensuring that positioning information can be delivered. In other words, regulation for ADS will not be valid for these above listed ATM data services, which are excluded from the scope.

What is more, the study distinguishes between two different sets of data categories, namely raw data and processed data. The Airspace Architecture Study (AAS) has previously introduced data processing, data integration and data production activities. Here, a definition of raw data is developed and refers to all data that is created, collected, validated, formatted, standardised and then transferred to ADS. In other words, raw data is the output of the data production layer: data which is exchanged between different actors in the data production and processing layers. It is understood, that raw data may, in fact, be processed to a certain extent already by the data producers, still, from the perspective of ADS it is considered raw data.

Processed data, on the other hand, refers to information, which is created by way of integration, transformation, visualisation or any other way of processing data provided by data producers. Processed data is the output of the data production and integration layer: data which is exchanged between actors in this layer or which is provided to actors from the ATS and network services layer. It is understood, that processing may happen on many different levels, consequently, many different levels of processed data may exist simultaneously. Processed data can thus be an input for ADS providers. Having presented an overview of the definitions, the study team underlined these are not yet cast stones, and that there is room for further fine-tuning.

Reactions to the Study

Some concerns were expressed with regards to the rationale and determining factors behind the proposed separation of the ADS concept in the study from the point of view of the end user. The proposed separation into ADS and non-ADS data was seen as problematic, given the fact that an overall picture is put to use operationally (i.e. when we look at the controller working position, namely the screen, we see an integrated data picture). Concerns regarding the exclusion of surveillance services from the definition of ADS, in particular, were shared by a number of participants.

To address these concerns, the study team clarified that the processing of surveillance *data* is in fact regarded as being under the scope of ADS, i.e. the transformation of data plots into trajectories and the situational picture, which can then be used by the controllers after fusing it with the flight plan data to control the aircraft. Having said that, surveillance *services* (as defined today) are, indeed, regarded as a separate set of services and thus excluded from the scope of ADS. Surveillance services are about providing the necessary sensors, maintaining them and ensuring they receive the signals from the aircraft, so that they can provide the surveillance data plots into ADS. In sum, while surveillance services are indeed outside of the scope of ADS, they do feed surveillance data into ADS. It is by no means an intention of the study to exclude surveillance *data* from ADS. Moreover, the study team reassured stakeholders that an integrated picture is the targeted end product of ADS, while clarifying that a specific ADS for human machine interface (HMI) is not foreseen. For more advanced applications, on the other hand, operational data from airlines may be needed, which will subsequently be shared with operational stakeholders under certain conditions.

In reaction to the proposed formal definition of ADS as "providing Air Navigation Service Providers (ANSPs), airspace users (AUs), and airports with information on the intended movement of each aircraft..." elaborated above, some participants noted that, keeping in mind the EU regulatory framework, this would imply that ADS providers are not included in the context of the ANSPs. It was subsequently clarified by the study team, that ANSPs could at the same time provide ADS, though, the wording of the proposed definitions did not imply this, as the intention was to not exclude any other possible (new) ANSPs as a provider and/or recipient of ADS. In developing new definitions, stakeholders stressed the importance of keeping in mind the existing and ongoing work of the International Civil Aviation Organisation (ICAO), which is defining many of the boundaries at the international level, and with which any newly developed EU norms and definitions need to be aligned.

Other participants questioned the value added by ADS providers, given that, where possible, standardised raw data is already being exchanged between ANSPs

in Europe today, with the concrete example of French-Belgian exchange of radar data. The study proposes the introduction of "intermediary ADS providers" (ADSP), which, some argued, could imply further fragmentation and thus undermine the objective of de-fragmenting the European ATM system. While the study team acknowledged existing best practices in exchanging of surveillance data between ANSPs, they underlined that, in order to achieve the objective at hand, i.e., to enable capacity on-demand and to foster a dynamic cooperation, as foreseen in the AAS, a more conducive EU framework for the exchange and processing of data would need to be created. Reducing transaction costs and overhead of data sharing, while at the same time, creating a flexible, resilient and reliable airspace architecture that can support capacity on-demand is precisely what the ADS concept would seek to enable.

Demand-side Perspectives

An illustrative example of the demand-side perspective has been the Swiss experience of implementing a virtual centre in order to overcome both airspace and technical fragmentation. Within Switzerland there was the same challenge as we know throughout Europe – one might call it also the "European problem". The country had two area control centres, one in Zurich and one in Geneva, both relying on different systems, resulting in a fragmented Swiss airspace. The creation of a virtual centre was started in 2015 as a means to overcome this problem of fragmentation. The virtual centre "virtualises" the service provision, while rendering it location-independent. Five years on, today, Switzerland has one system and one data centre in place. While two physical area control centres continue to exist, these logically operate as one under the same system. The Swiss experience has shown that the virtual centre can enable the provision of services in a location-independent manner. To achieve this, a shift away from the vertically integrated system has been needed, towards a service-oriented, horizontal-layered architecture marked by a modern IT system.

This problem is of course very familiar to the rest of Europe, where currently 68 area control centres and 37 different systems co-exist. A majority of these are vertically integrated, from the radar signal up to the controller's working position. Until recently, a defining characteristic of an ANSP has been its ownership and operation of local assets and equipment (e.g., radio and radar), and so the operating model, too, has been local in nature. This is now being changed by digitalisation, as we see the emergence of non-local services and as sensor data is being connected over a network, enabling access to surveillance data which no longer is local. This, in turn, also changes the definition of an ANSP. An ANSP is no longer defined by the local or national environment, but by how we manage airspace and how we communicate with an aircraft. This shift in the operating model is the driving factor behind the splitting up of data – which actually leads to less fragmentation, not more, thanks to a different architecture. The sourcing of services needed for an ANSP to manage an airspace, can be done completely location-independently by different service providers, which stops the fragmentation at the local level.

The availability of a cost-benefit analysis (CBA) supporting the implementation of the virtual centre concept was among the questions raised in the ensuing debate. The Swiss virtual centre project, which has indeed been preceded by a sound CBA, is already enabling important cost reductions, in particular through the elimination of systems and data centres' duplication. Besides the clear cost saving benefits, the deployment of a virtual centre has rendered the system more flexible and resilient. The current European airspace management setup is highly inflexible (and the COVID-19 pandemic makes these weaknesses very apparent). Currently, in order to meet growing demand, substantial amounts of funding must be invested into bringing capacity up and bringing controllers into area control centres. In the current set up there is no possibility of sharing capacity and providing redundancy among the centres. Virtualisation or location-independent operation stands to improve resilience of airspace management, while avoiding wastage of financial resources.

Stakeholders inquired about the type of ATM system elements and functionalities that should be considered essential for virtual centres, arguing that, in the end all, of these systems should form part of the scope of the ADSP definition. What is more, stakeholders stressed that the integration of the services obtained from a virtual centre need to be based on a common standard and on clearly defined interfaces.

Supply-side Perspectives

To illustrate the supply side perspective, the example of the Coflight Cloud Services programme was presented, which too dates back to 2015, and is also based on the idea of a virtual centre. Cofligth Cloud Service (CCS) enables the remote (location-independent) delivery of data services to ANSPs, regardless of their size, as opposed to relying on a physical system. It offers interoperability, costs reductions and a lower environmental footprint.

A set of five business services offered by the CCS programme were outlined as solutions for ANSPs, namely: 1) technical integration services; 2) validation services; 3) training services, i.e. support provided to customers in training ATCOs before going into operation; 4) contingency services, providing back-up modes in alternate countries for ANSP, e.g., Paris and Rome as back-up; as well as 5) operational services to allow customers to go into real time operation. A roadmap has been elaborated for the provision of these services and the development of respective activities. This roadmap is fully aligned with the ADS provision concept as proposed in the AAS and seeks to go into the direction proposed in the transition plan. The elaboration of formal definition of ADS in the Commission's study was therefore welcomed as helping to reinforce the development of the CCS programme going forward.

In the context of contingency services, stakeholders inquired about the consequences in case of major failure of the primary system, and more specifically, whether and how the provision of services in relation to local ANSPs is envisioned. In response to this concern, it was clarified that reliance on virtualised service provision would minimise the risk of failure, which is precisely the reason why the internet was introduced in the defence industry 40 years ago. What is more, in the case of the CCS programme a major failure of the primary system, would result in a contingency service through the platform located in the alternate country that will re-establish the service according to the defined KPI so as to ensure a safe operation.

To sum up, stakeholders welcomed the above projects as helpful in demonstrating the practical benefits of the virtual centre concept. However, some stressed that each project should define from the start precisely 'how' it will enhance performance, be it financially, environmentally or in another way. These objectives should serve as guiding principles throughout all stages of project implementation. What is more, regarding the question of a supporting CBA, it was underlined that one should keep in mind the existence of two kinds of CBAs. The first one, evidently applying to the single ANSP, and whose positive effect has already been shown by the above projects. These benefits, however, appear to be limited at least when compared to the much bigger 'system-wide' effects of ATM data service provision (which is the second kind of CBA). This is because ADS provision (ADSP) enhances service interchangeability, allowing seamless switching onto the system of another provider. This is currently not the case in the ATM world. In order to support and push the implementation of efficient system-wide ATM data services both SESAR and the PRB would have an important role.

System Perspectives

Presentations of the system perspectives echoed the above messages relating to the important benefits linked to the ADS concept, coming in the form of enhanced capacity to share investments, enabled access to data and systems-as-a-service, as well as enhanced resilience for airspace users. From the point of view of systems' suppliers, ADS schemes facilitate the aggregation of demand and reduce deployment costs through the creation of economies of scale thanks to digital platforms and more standardised products. Having said that, stakeholders also noted that the study focuses on centres' automation, whereas the rest of the ATM system, including data provision, appears to be left out, and thus called for the need to adopt a broader definition of the scope of ADS.

Today, ATM manufacturers deliver ATM systems to service providers which produce and use their own ATM data. Tomorrow, however, many stakeholders, including ATM manufacturers themselves, could be in a position to become ADS providers, which ought to be examined closely, both in terms of risks and opportunities.

ADS can enable service providers to focus on their core services. For ATM manufacturers several possibilities exist, including being a systems-supplier or the provider of an ATM system as a service. There is also the opportunity for manufacturers to actually be an ADSP for surveillance, trajectories, or any other new service that will be required in future. That could be implemented for one single ANSP or multiple ANSPs, or for other

stakeholders (e.g., airspace users, airports, network managers) either through alliances or partnerships for instance. Here, stakeholders underlined the importance of system integration for the implementation of ADS.

From the systems perspective, the technologies needed for the implementation of ADS already exist today, but what remains to be put into place is the right regulatory framework. Incentives, in particular for the early movers, will be key for fostering technological uptake. And this incentivisation should not only be limited to CAPEX, but should also cover OPEX, given that service providers need to be encouraged to rely on the use of data provided by ADSPs.

The suppliers' perspectives clearly demonstrated that important advances had been made over the past five years and that strong commitment exists from manufacturers towards implementing ADS in line with AAS objectives. With this in mind, stakeholders called for an open ATM platform, while avoiding an overly prescriptive regulatory framework given the constant evolution of the market and the emergence of new market players, with completely different financing instruments compared to those of traditional market players. Another point of discussion was the regulatory interference to be expected between existing regulatory frameworks and upcoming regulatory frameworks (i.e., relating to the implementation of ADS provision). Providing such legal clarity on the expected interactions will be key for all relevant stakeholders.

Having said that, multiple challenges remain to be addressed. Firstly, new technologies, reliant on high degrees of automation, entail serious challenges for safety and cyber security, which in turn need to be addressed for ADS to be successfully implemented. Here, aspects related to the certification of ADS schemes was raised as a key element to be taken into account by the study team. In terms of the certification and classification of ADSP, the study team clarified that they foresee as working hypothesis the ADSPs becoming ANSPs under the current regulation, which in turn will have to be overseen and certified by an entrusted entity. While the exact nature of this certification is currently being analysed and is yet to be determined, two possible options could be envisaged for the moment, namely EASA (as a European entity) or, alternatively, national supervisory authorities.

Another challenge relates to the 'quality' in terms of service and network stability, which are vital technical pre-conditions to be met. Lastly, but also very importantly, the successful implementation of ADS will depend upon the readiness of ANSPs. From the point of view of market- and business development, it was argued that a collaborative approach around ADS schemes would be more effective for airports, ANSPs and the NM, as compared to using mandatory measures via regulation. Lastly, it was underlined that the development of ADS should take into account the brownfield lifecycle of European infrastructures and systems (i.e. the years of developments vs. implementation) in order to avoid slowing down current investment programmes and incentivise deploying SESAR solutions.

Market Entrant Perspectives

Similarly, while market entrants perceived data services as a clear business driver in ATM, they were in favour of a more holistic definition of ADS than is proposed by the study team. This in turn calls for further work so as to build a common understanding of 'service' and 'service provision', as well as to better understand the operational use cases for ADS.

On the technology side, there is a need to differentiate between service granularity (i.e., which services can be provided), and technical modularity (interoperability between all the services modules). Here, once again, the critical importance of addressing issues of safety and cyber security was highlighted, given their particular relevance in today's increasingly digital world, where different services are provided by different service providers. When it comes to technical modularity, the importance of differentiating between ATM data service provision and aeronautical data service provision was underlined, whereby for the latter a holistic view would be essential. There is a need for more clarity and firm commitment for EU data service policy for all aeronautical data.

On the framework side, the questions of 'who owns the data' used in an operational environment, when we see different data service providers converging at the ANSP as well as who is to be granted access (with or without a fee) and to what type of data are yet to be answered. On the support side, the technological rules and procedures will need to be agreed on and set by means of regulation. There is also a need for broad buy-in from States. Last

but not least, the implementation of the ADS should be in line with and support the achievement of objectives set out in the European Green Deal.

Human Factors and the Staff Perspectives

From the staff's perspective, ensuring safety and resilience of the system was highlighted as crucial, which in turn depends upon communication, navigation and surveillance (CNS), system monitoring and control, cybersecurity as well as data processing integration of ATM in ADSPs. Taking into account the criticality of safety aspects, stakeholders agreed that this topic requires thorough examination (including in the study), if we are to secure buy-in from States and political stakeholders. While software, AI, and networks are all addressed within the existing regulatory system, however, it was pointed out that within Regulation 182 safety assurance is not regarded mandatory anymore. The need to take into account technical failure conditions and incidents reproduction for controllers was highlighted in developing the new architecture.

One of the biggest challenges, from the staff's perspective, would be to find a 'fair cost model' which takes into account the fact that existing airspace users would be paying for the creation of data which new airspace users of tomorrow will also use.

Conclusion

While the definitions and scoping of ADS are still 'work in progress', the virtual workshop was helpful in revealing that stakeholders' views about the way forward are largely converging. Existing European technical and business examples are already proving feasibility as well as the merit of the ADS concept in line with the AAS study. The ADS stands to improve efficiency, resilience and flexibility: all of which are urgently needed in today's European aviation system. The ADS concept is crucial in enabling us to effectively deal with spikes in demand, by securing extra capacity, and conversely, to address situations of surplus capacity.

One key takeaway from the discussions was that 'technology' is not the main challenge, but rather the regulation and commercial incentives that are to be put into place so as to enable and motivate ADS provision. A key objective is to ensure that the ADS concept is enshrined in the basic rules of the Single European Sky (SES) because of the potential it holds for efficient, scalable capacity and redundancy thanks to digital services. The optimal market design would be flexible, thus avoiding a situation where a 'one-solution-fits-all' approach is being prescribed to all stakeholders (as was done back in 2013, where vertical unbundling was mandated). By contrast, the Commission's present intention is to leave it up to each Member State to decide whether to remain vertically integrated or alternatively to shift into a service-oriented model. Where a decision is taken to remain vertically integrated, it is the expectation of the Commission that the service provision should be as efficient and redundant as that of a pan-European service-oriented provider who can unlock network efficiencies. It goes without saying that both safety and security have to be ensured and that the human factors and staff perspectives have to be included. Many fundamental decisions and regulatory changes are yet to be made before the ADS concept can take off. This is not expected before 2025, which is the start of next reference period of the SES.

When it comes to regulatory aspects, stakeholders underlined the need to distinguish between data, data services and the underlying system's architecture, given that these elements need to be looked at separately. In particular, rules will have to be established to determine how raw data (including data coming from airlines) is to be accessed in the future by potential ADSPs, and subsequently, how this raw data is to be shared in an operational environment. Here, it is important to build on the principles of the Digital Single Market. The processing of raw data for the purpose of data services, raises important questions relating to safety and ADPs' certification. In order to avoid issues linked to mutual recognition of national certifications, it was acknowledged that an EU entity, such as EASA, would be in a good position to oversee and certify ADSPs. With a heavily strained EU budget, it was underlined that tax payers' money would likely not be used to incentivise new technologies. Instead, these incentives will have to come from regulation. The importance of approaching CBAs from a systems perspective was highlighted (and already has been foreseen in the study). It would then be left up to each individual market actor to make their own business decision as to whether to become a data supplier, or for ANSPs to decide whether to source data from an external supplier.

QM-AX-20-018-EN-N

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With the support of the Erasmus+ Programme of the European Union

doi:10.2870/234900
ISSN:2467-4540
ISBN:978-92-9084-831-8