AIRSPACE TRANSFORMATION:

CHALLENGES AND OPPORTUNITIES FOR AIR NAVIGATION SERVICE PROVIDERS

ALG

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Aviation, as we know it in all areas and modalities, is undergoing an epochal transformation. The new paradigm affects not only the conventional airspace but the entire sky, from very low level airspace up to the higher airspace, that were historically uncontrolled as not used by the traditional aircraft. This evolution requires air navigation service providers (ANSPs) to adapt quickly and effectively, addressing the need for modernization, the improvement of the quality of the rendered services, the increase in the volume and nature of airspace under control and the consequent operational and new cyber risks.

There is a need to evolve the operating and financial models, making corporatization a necessity to embroider this increasingly complex and demanding environment. As we explore these challenges and opportunities, it becomes clear that the future of airspace will not only depend on technology, but also on collaboration and innovation in financing, regulation, and day-to-day operational management.

As we navigate this pivotal moment in aviation history, it is essential to recognize the multifaceted challenges and opportunities that lie ahead. The convergence of traditional air traffic with new entrants, such as UAS and higher airspace users, combined with the need to decarbonise aviation by 2050 and to guarantee resilience to the increasing (cyber)security threats, demands for a comprehensive re-evaluation of our airspace and air traffic management strategies. This paper delves into the implications of these changes, highlighting the need for innovative regulatory frameworks and the integration of advanced technologies like artificial intelligence and hyperconnected control systems.

We will also discuss the critical role that ANSPs play in this transformation, emphasizing the importance of their modernization and corporatization to ensure a safe, efficient, and sustainable future for the aviation industry. Through this exploration, we aim to provide actionable insights for stakeholders looking to adapt to this evolving landscape.

THE NEW COMPLEXITY OF GLOBAL AIRSPACE:
DENSIFICATION, ADVANCED AIR MOBILITY, AND EMERGING TECHNOLOGIES

The majority of the most developed and developing countries is going to experience a sophistication of their airspace never seen before. This is derived from the simultaneous concurrence of several factors: the growth of traditional aviation, the launch of massive drone operations for a variety of air mobility applications, the massive transfer of payloads to outer space, the increase of frequency of supersonic flights and stratospheric balloons.

There will be an increasing densification of traditional airspace, with a greater incidence at peak times and dates. Today, few airports in some regions are not considering the expansion of their passenger terminals or even their runway infrastructure.

Low-cost and local airlines have made strong inroads into the market, already representing a larger share than traditional airlines. New routes and new destinations ended up consolidating, in many cases, with the reconfiguration of tourist and business demands as a result of COVID-19. The frequencies on each route tend to increase, breaking up into more smaller aircraft.

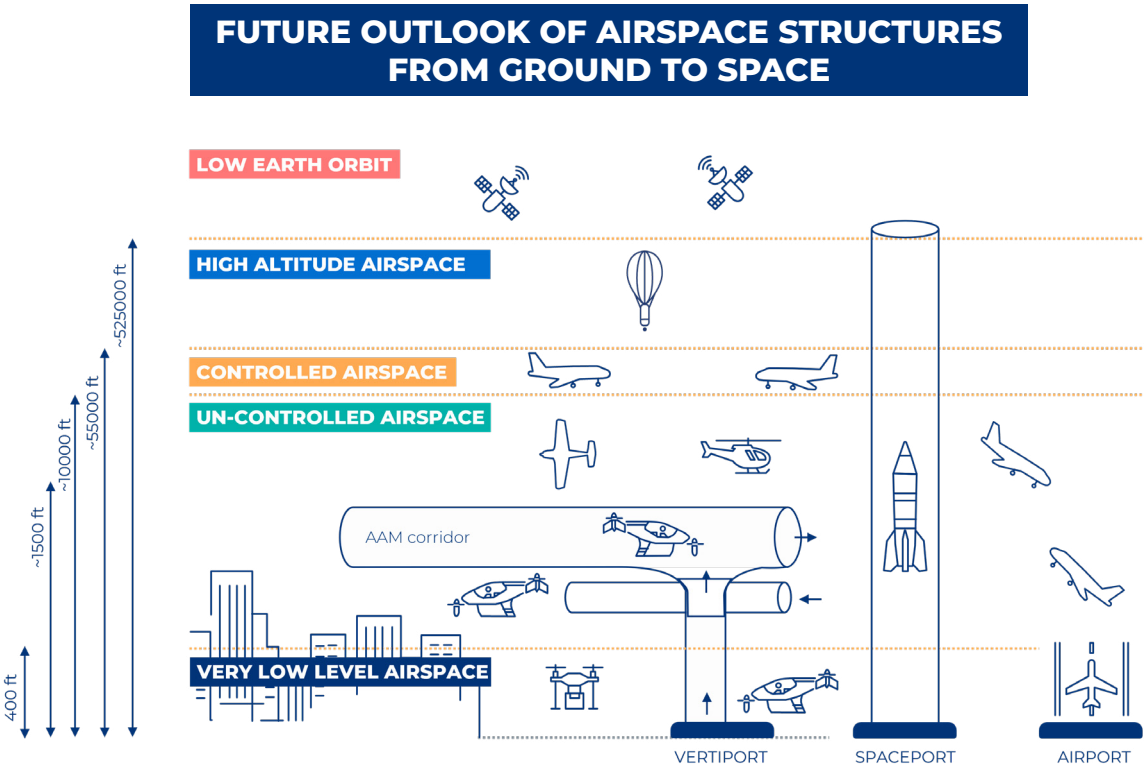
Overflights (flights that have origin and destination outside the country, but cross it during their route) will also tend to increase for the same reasons as domestic and international flights.

Business and general aviation also present aggressive growth trends, that contribute not only to offer increased connection to passengers, but also to densify airspace even more, and to increase demand for landing and take-off sites, vertiports, and ground recharging centers in the case of electric technology aircraft.

The use of the lower airspace, traditionally uncontrolled, will grow exponentially with the incursion of new entrants into lower airspace, particularly in terms of advanced air mobility (electric aircraft designed for the transfer of people and public security services including the police, ambulance, and firefighters) and swarms of drones for various logistic applications (delivery of medicines, search and rescue, oil rigs, and food logistics, documents or e-commerce) operating beyond the visual line of sight (BVLOS) from their remote (and in many cases automated) pilots.

Also, higher airspace will begin to be used more and more with the incursion of supersonic and hypersonic aircraft, stratospheric balloons, and the increased frequency of rocket launches, for the transportation of different payloads into space, especially in low earth orbit (LEO).

This whole case will be a reality in the coming years, since more than 200 cities, airports, or regions of the world, in at least 50 different countries, are already considering regulating all these flight operations.



Future outlook of airspace structures from ground to space. Source: ALG

ADAPTING TO A COMPLEX FUTURE: REGULATION, MODERNIZATION, AND THE CORPORATIZATION OF ANSPs

This new paradigm will require the agile development of regulations with greater scope and user types; modernization of ground-based infrastructure for the control, identification, navigation, tracking, and communication with all types of aircraft; operational and corporate reorganization of air navigation service providers (ANSPs); and the need to open to the market the industry of air traffic control, by introducing new schemes for the participation of private entities into the business, to foster higher volumes of operations, while keeping safety and security at the highest levels and minimum levels of obsolescence in an environment of competition based on continuous improvement.

This challenging panorama, which will increasingly impact both civil and military actors, will imply a significant pressure on the ANSPs by increasing the demand for work without detrimental impact to the safety of passengers, by potentially interfering with the privacy of citizens (particularly from drones flying over populations), while maximizing the operational efficiency (by reducing carbon footprint of flights with more direct routes and minimizing delays).

In the case of low-altitude airspace and drones, it will not be enough for the ANSPs to identify and track aircraft, but, in many areas, they will have to automate these tasks to allow simultaneous operations of hundreds of drones flying through the skies of a relatively small airspace, such as a city or a rural town. Given the great variability in nature, number, speed, and proximity it will be necessary that these swarms of drones can circulate in autonomous or semi-autonomous ways, managed by human only when specific circumstances demand for a control centre to take decisions.

Integrating artificial intelligence (AI) effectively into air navigation systems and ANSPs will transform airspace operation and management. Here are some key strategies:

PREDICTIVE ANALYTICS

- Route optimization, using AI algorithms to predict air traffic patterns, generating more direct routes and reducing wait times.
- Predictive maintenance, implementing AI to analyze aircraft data and predict failures or maintenance needs, which improves safety and operational efficiency.

CONTROL OF DRONES AND UNMANNED ATS

- Development of drone traffic management systems that use AI to monitor and coordinate the movement of multiple drones in dense airspaces.
- Real-time interaction, implementing AI systems that allow communication and coordination between drones and manned aircraft, guaranteeing safety.

IMPROVED SAFETY

- Anomaly detection, using AI to analyze real-time data and identify anomalous behavior in air traffic that could indicate safety issues.
- Pattern recognition, implementing recognition technologies to identify and classify different types of aircraft and drones.

PROCESS AUTOMATION

- Automatic traffic control, developing automated control systems that assist air traffic controllers, allowing them to manage traffic more efficiently.
- Resource management, using AI for optimal allocation of resources at airports, such as boarding gates and runways, based on traffic patterns.

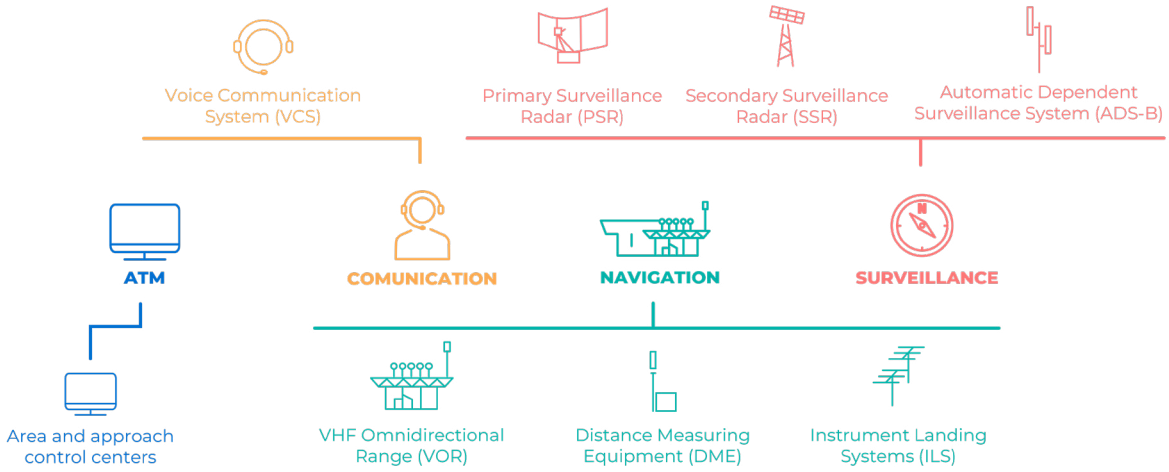
HYPERCONNECTIVITY AND BIG DATA

- Big data analysis, integrating AI into big data analysis platforms to process large volumes of information in real time, improving decision-making.
- Data visualization, developing visualization tools that use AI to represent complex data in a way that is understandable to operators.

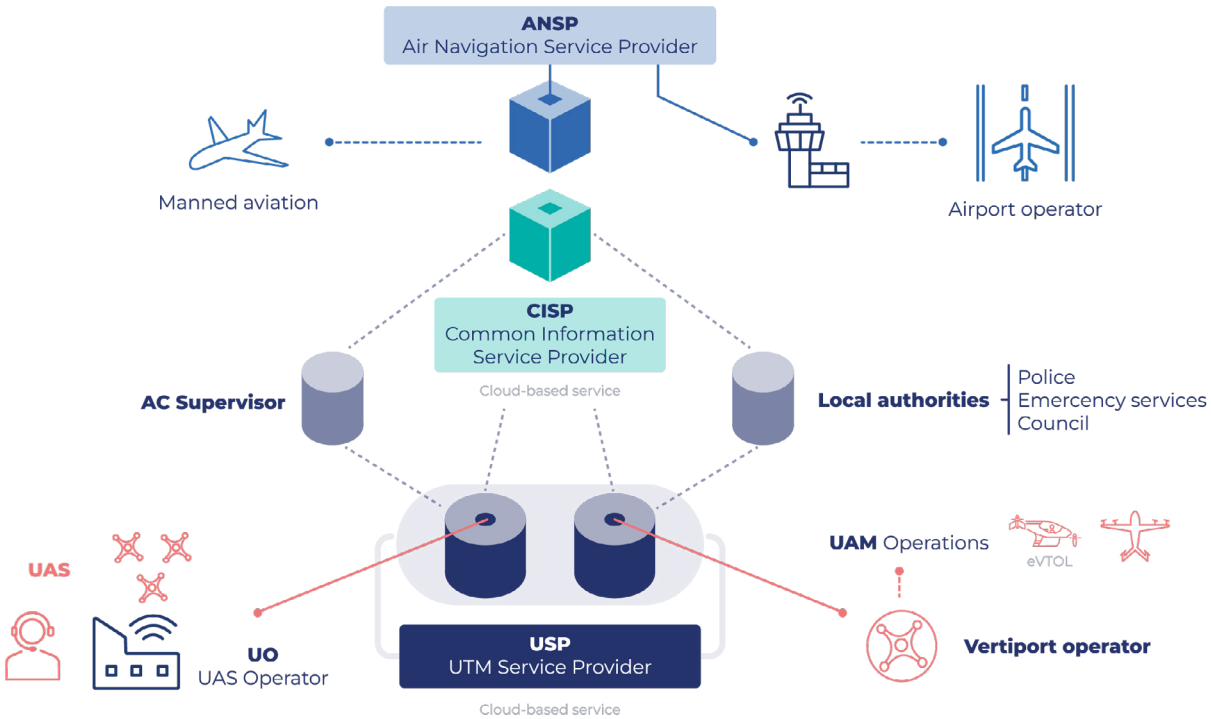
TRAINING AND SIMULATION

- AI simulators to train air traffic controllers in complex scenarios, improving their ability to respond to unexpected situations.
- Personalized training, implementing AI systems that adapt training according to the needs and performance of everyone.

The ANSPs will thus enter the world of hyperconnectivity, fostering an enormous processing of data in real time and leveraging on artificial intelligence, introducing technological applications that are completely new to the sector. This evolution will be accompanied by considerable investments in digital technologies substituting legacy systems with their new digital versions providing improved performance while at the same time introducing new technology to deliver new capabilities.



ATM/CNS conventional infrastructure components. Source: ALG



New infrastructure components for UTM and AAM. Source ALG

This technological advancement will require disbursement of relevant amounts of funds that will not only have to be allocated to the acquisition of new equipment (CAPEX) over the next few years, but also to the increased needs for hiring and training specialized personnel for operation and maintenance of this infrastructure (OPEX), composed by a mix of legacy and new systems with new requirements to minimize cyber-security threats in a safety-central domain.

In Europe and the U.S.A the investment is estimated to be around €50billion until 2040, while at least other €10billion will be needed in the Asia Pacific region where traffic is growing faster than anywhere else. If we add-up Africa, Latin America, and Middle East this figure can easily overcome the €100billion value.

ICAO[1] and international best practices recommend that this modernisation effort is funded by the users of the air traffic management system, in a financially sustainable manner through the ANSPs' own revenues, which are mainly composed by fees they charge for the use of airspace. The processing and collection of these fees is another area that must be addressed with the infrastructure of high data processing and hyperconnectivity referred to in previous lines.

Increased technology will enable more efficient and safer flights, resulting in savings on travel time (and energy) that will directly benefit users. Part of these savings can be transferred to the increase in the prices of the related service charges, which in turn will allow investment in even more technology, thus generating a virtuous circle.

This means that the ANSPs have greater financial and corporate autonomy with which they will also be able to react more quickly and with higher levels of efficiency (in terms of technology and human resources) to the increasingly demanding needs for new investments and scalable operations.

The critical path for ANSPs therefore presents two types of challenges: corporatization and modernization. The two are, for many reasons, strongly interrelated.

[1] ICAO defines in its manuals 9161 and 9082 the principles of the financial management of the ANSPs: fund the cost of the service through the recovery of payments from its users.

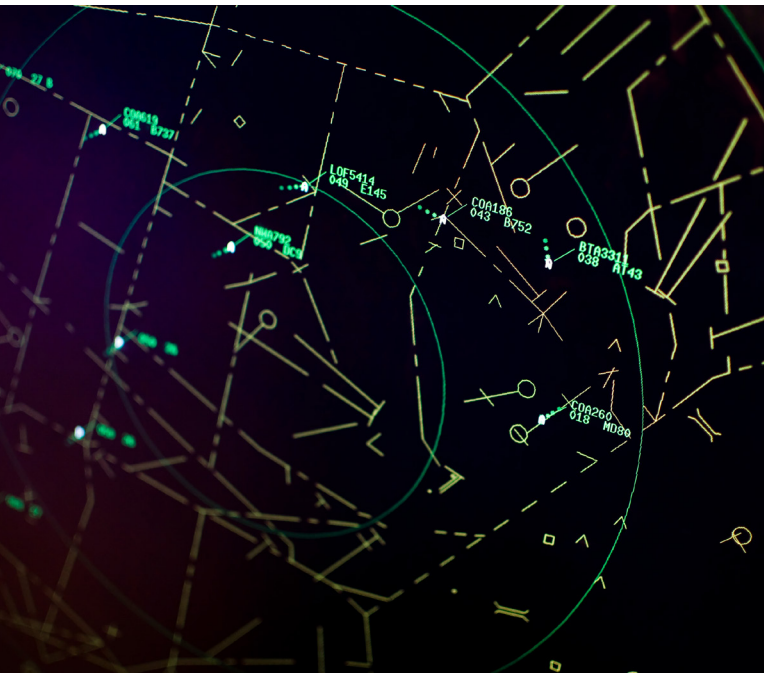
THE BENEFITS OF AUTONOMY:
ENHANCING ANSP EFFICIENCY THROUGH FINANCIAL AND OPERATIONAL INDEPENDENCE

Global experience indicates that when (airports and) air navigation services are operated by autonomous entities (public or not), their overall financial situation and management efficiency improve .

In fact, making ANSPs independent does not mean privatizing them. ANSPs are strategic entities for most countries, which is why they are always intended to be under the control of governments. Even in the most extreme cases such as the United Kingdom and Italy where they are fully or partially privatised, they are governed by the possibility of veto by their respective governments.

But there are many more references to ANSPs that, being public, are fully independent from the national regulator and have financial autonomy. Such is the case of Spain, Germany, Argentina, Brazil, and Central America, among many others, each of them with its own modalities and particularities.

[2] ICAO Policies on Airport Charges and Air Navigation Services (Doc. 9082) - 2012.



The advantages over the traditional 20th century prevailing operating model (i.e. a single organization that combines regulation and service delivery) are very clear and exceed the possibility to increase financial autonomy and economic efficiency. It goes through the operational efficiency brought by the commercial acumen of business entities, so desired and necessary for an increasingly densified and sophisticated airspace. It will also exempt the State from the responsibility of financing and developing infrastructure, as well as maintaining such infrastructure at optimal technological levels.

In Europe, there are already signs that efficiency is gained through the autonomy of the public sector and the participation of the private sector.

Partially privatizing is not the only way. The main references have successfully implemented different financing models:

In the case of **NATS** in the United Kingdom, it operates under a corporate model that combines income from user fees and service contracts. Privatization has allowed it to improve operational efficiency and investment in technology. It presents a clear reduction in costs and an improvement in punctuality in air traffic management.

DFS Deutsche Flugsicherung in Germany is a public entity that operates autonomously and finances its operations mainly through airspace use fees. The implementation of a cost-based fee system has optimized transparency and fairness. DFS has managed to maintain high standards of safety and efficiency, while adapting to the changing needs of air traffic.

NAV Brasil has been implementing a charging system that includes incentives for the efficient use of different air navigation services, encouraging the modernization of systems. This has allowed for greater transparency in financing and facilitated investments in new technologies.

Nav Canada is a not-for-profit organization that funds its operations through user fees, allowing it to reinvest in technology and services without relying on government funding. This structure has allowed Nav Canada to implement technological innovations and improve the user experience while maintaining a high level of safety.

Spain has opted for a model in which ENAIRE (the national public ANSP) holds the 51% of **Aena** (the national airport operator), thus providing for dividends that constitute a significant revenues stream in addition to the air navigation services fees. This approach has allowed to improve the overall financial efficiency of aviation sector in Spain, while reinvesting in a coordinated manned in the modernization of its airports and air navigation systems.

NAVIGATING THE FUTURE: PROACTIVE MODERNIZATION AND COLLABORATION FOR EFFICIENT AIRSPACE MANAGEMENT

The future of airspace presents significant and complex challenges, driven by the increasing volume and variety of air traffic at all levels, the entry of new actors and vehicles and the adoption of new technologies. This new paradigm requires air navigation service providers (ANSPs) to take a proactive approach to modernization and corporatization, as a leverage to enhance operational efficiency and introduce the capability to easily scale operations to handle variable demand in time and space. The integration of advanced automation based on digital technologies and artificial intelligence, will be critical to efficiently serve all users in an increasingly congested environment, while always maximising safety.

In addition, the need for an agile and collaborative regulatory framework that allows the participation of the private sector is clear, to ensure an effective and smooth transition to digital operations. International experience suggests that the financial and operational autonomy of ANSPs can result in more efficient and effective management, benefiting both industry and end-users. In this context, it is crucial that States around the world not only recognise these challenges, but also act to implement innovative solutions that allow them to adapt to facilitate the evolution of the aviation sector in the coming decades.

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