i4D and Space Communication

Looking for smarter skies in the near future

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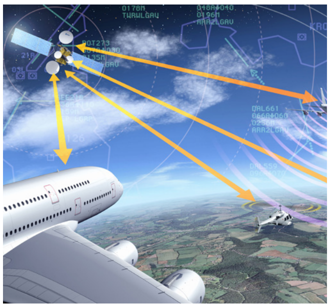

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At this frenetic time of pandemic situation and transport uncertainty, it is a perfect moment to pause a little bit, take a breath and analyse the evolution of the aviation sector in the current century. A key instrument of mobility, aviation continuously allows among others an accessible global movement and development, connecting parallel business development and tourism accessible to almost anyone

Similar to the Industrial Revolution, the ATM sector experienced a huge change of thought transformation in the late 90s. At that time, with the aviation growing at a fast pace, issues previously hidden and additional capacity needs started to become a global concern. Thus it was necessary to define future strategies that should cope with these necessities, giving raise to the introduction of the CNS concept, changing from a former technology approach to a completely new focus, based specifically on performance.

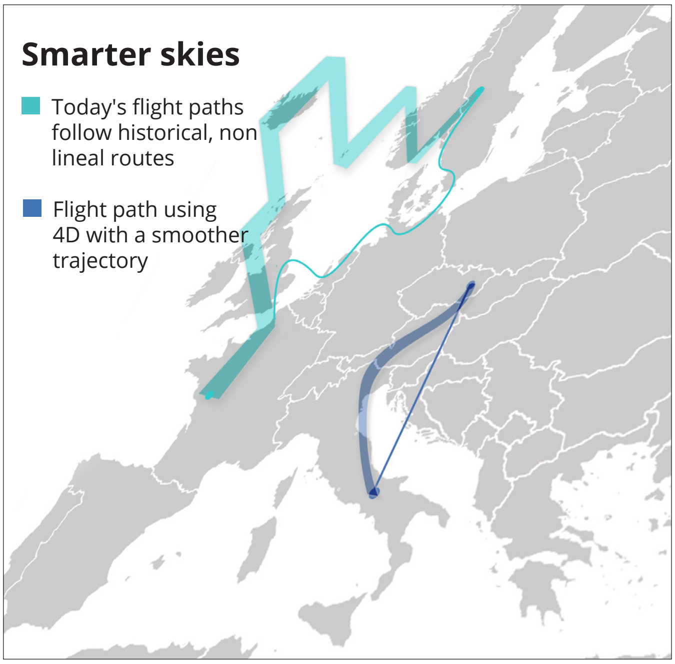
This "new" concept, which segmented the aviation context into 3 major frameworks (Communication, Navigation and Surveillance), allowed to establish specific evolutions, new enablers and tackle the needs expected for the future. That is not implying that the technologies were new, but rather they were looked under a new point of view. With the tremendous advantages that could be offered in terms of coverage, cost and capabilities, it was only time that the sector turned to space.

Given the importance of Europe in the global aviation market, it was pivotal the establishment of the Single European Sky (SES) framework, setting the fundamental keystones for the future growth of aviation and paving the way to European R&D together with coordinated deployment activities. This framework, including the establishment of the SESAR Joint Undertaking (SJU) and more recently the SESAR Deployment Manager (SDM), was complemented with a strong dedicated regulation along the way. Europe's full commitment to aviation development can be seen through several CNS-dedicated Implementing Rules (IR) such us the Data Link Services IR (EC 29/2009 and its corresponding amendments), the PBN IR (EU 2018/1048) or the most recent Common Project 1 (CP1) (IR (EU) 2021/116), amending Commission Implementing Regulation (EU 409/2013) and repealing the former Commission Implementing Regulation (EU 716/2014) known as the Pilot Common Project (PCP).

In this context, and long before the COVID pandemic and after the recovery will be achieved, the space-based technologies are playing a huge role supporting the European development of CNS and its main goals, including environmental preoccupations. The use of GNSS and EGNOS in Navigation, ADS technology in Surveillance, or Datalink systems such as IRIS SATCOM in Communications, are clear examples of current and future modernisation.

In fact, moving to Performance Based operations made possible to develop enhanced services that would provide more capacity and route optimization, key elements in the improvement of ATM. As a clear example, in order to cope with ever escalating growth in air traffic and environmental constraints, trajectory management (4DTRAD) was identified as one of the key pillars of the modernization of Europe's ATM system under the SESAR program. With the 4D concept, aircraft will be able to automatically adapt their speed and trajectory in-flight to arrive at a given point in space at a time pre-agreed with the ATC. This means that its management has huge potential to create more efficient aircraft operations and arrival sequences, while reducing fuel burn and aviation's environmental footprint, while also further enhancing safety.

To support 4DTRAD, the Initial 4D concept, also called i4D, has been developed by SESAR in EU and to be implemented as part of the CP1 regulation - ATM Functionality #6.Also analysed by NextGEN in the US, the main goal is to create more predictability and controllability about the position of the aircraft on a first phase before the full implementation of



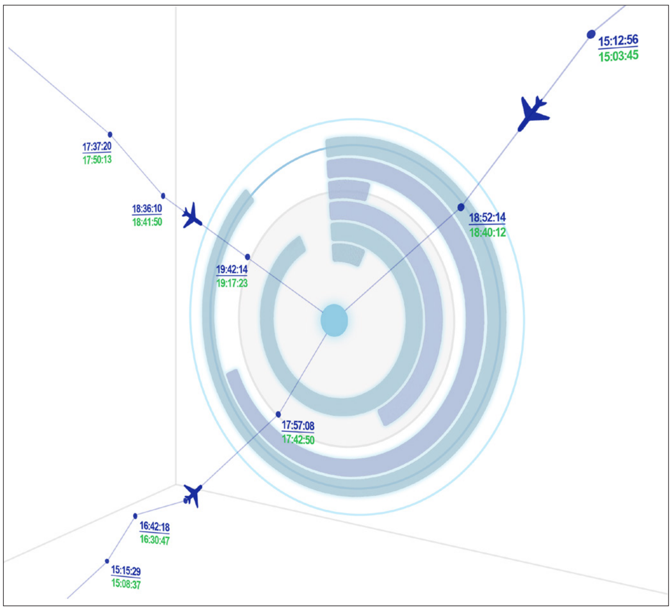


Figure 1- i4D Concept

the 4D concept. For this purpose, i4D consists of the 3-Dimensional point in space (latitude, longitude and altitude) plus adding the time as a 4-Dimension with real-time exchange of trajectory information between aircraft and ANSPs. This information sharing enables controllers to set a time slot in advance for aircraft to be at a specific Merging Point (MP), where multiple aircraft converge with the same destination, to sequence traffic for arrival. This means that any delay during the flight is in fact a deformation of the trajectory (e.g. level or horizontal).

The ultimate goal of the 4D trajectory aims at ensuring the flight on a practically unrestricted, optimum trajectory for as long as possible in exchange for the aircraft being obliged to meet very accurately an arrival time over a designated point.

I4D BENEFITS

A key enabler for ATM modernisation, 4D Trajectory management creates an environment where air and ground stakeholders share a common view of the aircraft's trajectory, including time, so that the flight can be managed as closely as possible to the airspace user's ideal profile, while optimising the flow of air traffic.

At an early planning stage of operations, the 4D trajectory is shared between airspace users, ANSPs and airport operators. It is then progressively refined, taking into account various constraints in airspace and airport capacity. Before the aircraft takes off, the 4D trajectory is agreed and becomes a reference that the airspace user agrees to fly and the ANSP agrees to facilitate. Throughout the flight, detailed information about the future projected-position of the aircraft is exchanged with all service providers on the route, and times are agreed with departure and arrival airports in advance.

Accurate 4D trajectories mean greater certainty about the projected position of aircraft in the sky and on the ground at any given moment, which represents benefits in terms of network predictability, safety and flight optimisation. In turn, resources can be effectively planned and use of airport and airspace capacity can be optimised. Better planning of flight trajectories also allows environmentally optimised flight profiles to be applied. Therefore, the use of 4D can be summarized in the following improvements:

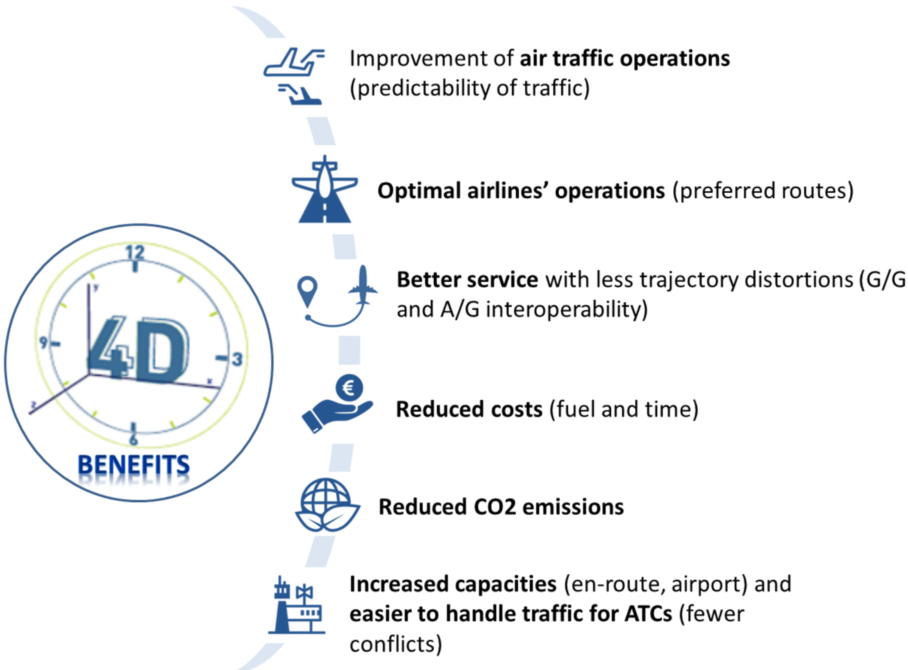


Figure 2- i4D Benefits

- Enhanced Air Traffic operations: moving towards trajectory-based operations makes the air traffic much more predictable, once the predictions computed by the aircraft's Flight Management System (FMS) are shared among all operational stakeholders on ground.

- Optimal Airlines' Operations: relaying on the provision of air navigation services in support of the airlines business needs, the airspace users can fly their preferred routes (e.g. performing continuous descent and climb actions) without being constrained by airspace configurations.

- Better service: thanks to the Ground/Ground and Air/Ground interoperability in i4D trajectories, it is possible to reduce the number of trajectory distortions (e.g. delays, level change, change of aircraft horizontal position), maximizing the quality of the provided service.

- Reduced costs: flying a preferred route have a direct impact in the duration of the flight, thus reducing the consumption of fuel, and providing additional flexibility to the airline fleet distribution.

- Reduced CO_2 emissions: not only because the flight distance is shortened and less fuel is burned, but also many flight characteristics can be optimised. The perfect examples are the possibility to adjust more efficiently the speed or flying at a more efficient altitude. Consequently, fewer emissions are emitted to the atmosphere, not to mention the benefits from the reduction in noise, pollution or over-flights the local communities.

- Increased capacities: with predictable trajectories the routes can be optimised to accommodate more traffic. In addition, the workload for pilots and air traffic controllers are decreased, potential conflicts can be anticipated and more time can be dedicated to monitor safety aspects. This will ease the ATCs work of handling traffic, allowing further level of automation support, the implementation of virtualisation technologies and the use of standardised and interoperable systems.

4D AND SPACE

As previously mentioned, since the 1990s the space-based systems have been enhancing ATM, especially within oceanic and remote areas of airspace. The current and expected integration of these services has allowed the thorough implementation of PBN across the globe, and a significant reduction in traffic separation standards, which have delivered clear and measurable benefits to all ATM stakeholders. As an example, some of the next set of ATM oriented space-based services that will be made possible thanks to Iris/SATCOM and ADS-B technologies, Galileo (Europe's global satellite navigation system), and the continuation of SBAS (new EGNOS updates).

For these new type of communications, the EC and SESAR are analysing new A/G complementary technologies to VDLm2 that can improve communications between pilots and air traffic controllers, decongesting the air traffic and used as an alternative datalink communication, since VDLm2 has shown difficulties in achieving the target DLS performances, limiting the operational use and adoption of the data link service.

The idea is that the currently congested spectrum does not become the limiting factor for the needed increase in aviation capacity, with Europe already one of the world's most congested airspaces and recent studies showing a capacity crunch expected in 2030-2035 (i.e. the Capacity Assessment Study performed by the University of Salzburg). More so with the expected growth once the COVID situation resolves and the traffic is back to normal levels. In this line, ESA, in agreement with SESAR and in partnership with Inmarsat, launched in 2008 the Iris Programme. with the intention to develop a full ATS data link services satellite delivery in order to support the EC SES' objectives, taking advantage of Inmarsat's SwiftBroadband–Safety.

The former PCP (IR (EU) Nº 716/2014), now repealed in favour of the CP1 (IR (EU) 2021/116), as part of the current CNS regulation in Europe, set the implementation of 6 ATM Functionalities (AF), in which AF6 is Initial Trajectory Information Sharing (i4D). To support this future functionality of the European Framework, the implementation of the Extended Projected Profile (EPP) group is needed among others. This optional group, consisting of up to 128 waypoints in four dimensions, will be encased within the ADS-C messages sent by the aircraft making use of the data link services. This group and its use are defined in the ATS-B2 standard (ED-228), and provide valuable data to the controllers about the aircraft's intent. That is why a more robust, resilient and larger communications are needed in support of the current infrastructure deployed in Europe. Here comes into play the Iris Programme: already designed to meet ATS-B2 performances (and of course the currently mandated ATN-B1), ATN/OSI infrastructure compatibility with safety requirements for ATS data link services, and including security procedures to provide secured link connections between aircraft and ground network. Summarizing, IRIS is a satellite end-to-end data link between the airline and the ATSP eliminating known issues and risks with stronger capabilities in support of the European ATM framework, more so with the already planned certification from EASA as a pan-European service.

Consequently, Iris contributes to the main goals of the aviation sector increasing safety in aviation, being greener and environmental friendly, together with higher resiliency plus efficiency in the form of a new continental satellite-based A/G communication system for ATM in Europe. Iris solution relieves the pressure on ground-based radio frequencies by using mobile satellite communications.

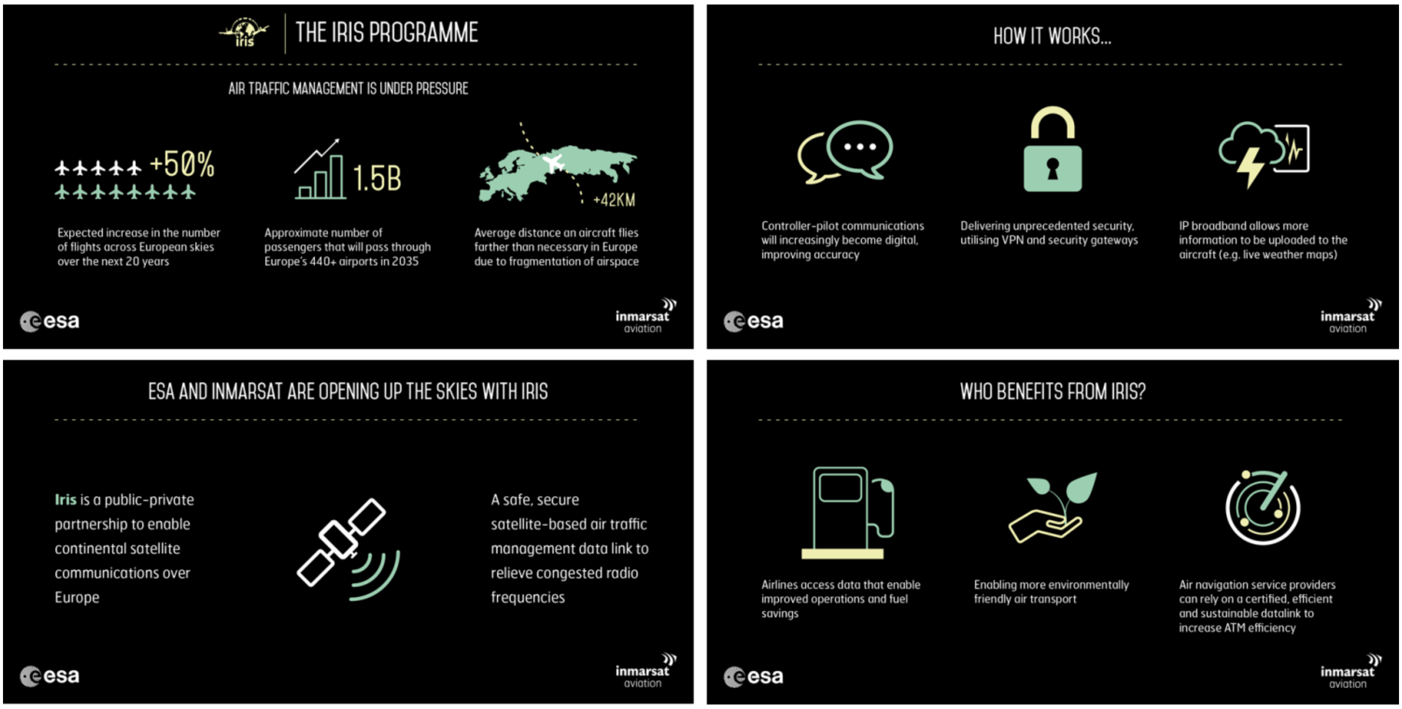


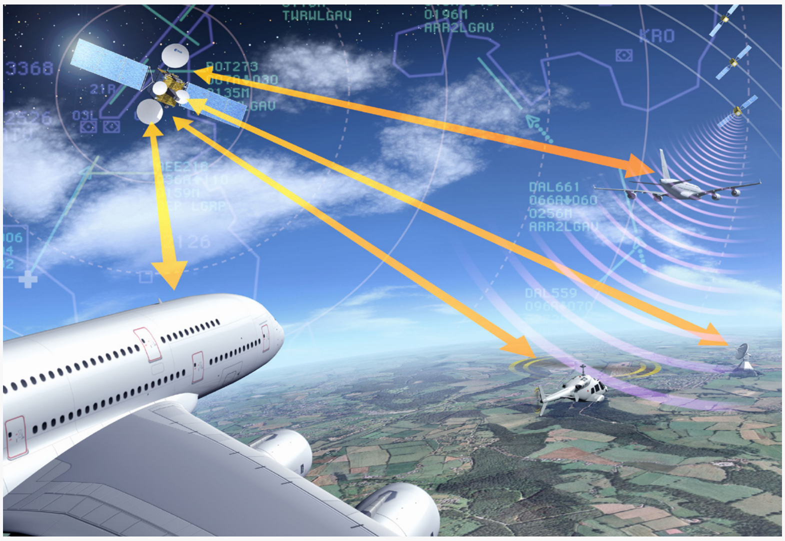
Figure 3 - Satellite Communication for Air Traffic Management (Iris) Overview / Credits: INMARSAT and ESA

The integration of space-based services in the ATM framework has the advantages of enabling seamless coverage for CNS services within the ECAC, and harmonisation of on-board equipment for those using the European airspace.

That means added powerful benefits from Iris to all the aviation industry, from airlines to ANSPs across Europe, specifically enabling high bandwidth (increasing the bandwidth available for this essential data transfer), complementing the existing provisions for ATN datalink delivery in continental Europe (SATCOM as complementary technology of VDLm2), increasing the resilience and availability of continental CPDLC data exchange and cost-effective satellite-based datalink communications. This allows aircraft to be pinpointed in the 4D SESAR concept operations including latitude, longitude, altitude and time. Iris and the resulting services will mean improved A/G data exchange as well as increased flight predictability.

In the mid-term, it is also expected to contribute to enabling full 4D trajectory management over airspaces across the globe by 2028 and consolidating data link as the primary means of communications between controllers and cockpit crews.

IN A NUTSHELL



The use of GNSS (e.g. EGNOS) in Navigation, ADS technology in Surveillance, or Datalink systems such as IRIS SATCOM in Communications, are clear examples of current and future modernisation supported by Space-based systems.

The need to implement i4D is an essential enabler for the growth of aviation. In Europe is fully supported by the PCP/CP1 regulation and helped in the ATS-B2 standard, detailing EPP information within the ADS-C messages. The benefits that this functionality will bring to the sector will be huge, not only to airline operations but also to the ATS providers and for local communities, having a better service and reducing cost and CO2 emissions. Hence, we will be achieving a top priority of the SES goals, since moving towards a greener mobility.

Nowadays, IRIS is the only mature complementary technology being readied for its entry into service, sponsored by ESA, and with many stakeholders involved in the project: industry, manufacturers, ANSPs and airlines. Being prepared to provide ATS-B2 services, with a high quality of Service and fully covering Europe, IRIS will fully contribute to the 4D SESAR concept and the enhancement of operations, supporting airspace users and ATS Service Providers. This new technology brings a top advantage using satellites for real-time data exchange between the pilot and the controllers, with more precise flight tracking and efficient operations, reducing delays and saving fuel. Moreover, a cooperation agreement between Inmarsat and ESSP has been recently signed to consolidate the development of Iris IOC Phase 3 service related activities, promoting the use of SATCOM and paving the way for the future Iris service declaration.

In summary, Iris promotes the modernisation and automation of ATM operations in Europe. Hence, it can be said without question that i4D and IRIS are paving the way towards the future.

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ACRONYMS

Acronym	Definition
4D	4-Dimensional
ADS-B	Automatic Dependent Surveillance–Broadcast
A/G	Air/Ground
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
CNS	Communications, Navigation and Surveillance
CP1	Common Project 1
CPDLC	Controller–Pilot Data Link Communications
EC	European Commission
ECAC	European Civil Aviation Conference

Acronym	Definition
EPP	Extended Projected Profile
ESA	European Space Agency
EU	Europe
GNSS	Global Navigation Satellite System
MP	Merging Point
OSI	Open Systems
PBN	Performance-Based Navigation
PCP	Pilot Common Project
SBAS	Satellite-Based Augmentation System
SESAR	Single European Sky ATM Research
US	United States
VDLm2	VHF Data Link - Mode 2

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