The Satellite Communications System for Safe and Secure Air Traffic Management Data Links and Voice

1. Executive Summary

The satellite-based Iris system ready to be a key element in a successful European implementation of Data Link Services for Air Traffic Management and could underpin a global solution.

Iris is a Data Link Service (DLS) satellite system funded and promoted by the European Space Agency (ESA). Based on Inmarsat SwiftBroadband-Safety technology that is already certified for Air Traffic Service (ATS) oceanic use, it will be extended for use in continental airspace for the provision of Data Link ATS services (referred to as ATN B1 and ATS B2) and of Airline Operational Communications (AOC).

Developed for ESA by a world-class industrial consortium led by Inmarsat, Iris is already contributing to the European Commission's (EC) Aviation Strategy and worldwide aviation community; nonetheless additional steps are needed for the integration of Iris into the Air Traffic Management (ATM) communication network for supporting current and future Data Link Services in compliance with aviation standards.

The deployment of the terrestrial technology system known as VDL2, (which was mandated by the EC regulation 29/2009), is clearly showing difficulties in reaching the due DLS performances, thus affecting the effective operational use of the ATM network.

Europe already has one of the world's most congested airspaces and air traffic is expected to double by 2035. The DLS capability uncertainty risks thus to jeopardize the ambitious goals set by the EC through the European Aviation Strategy published in December 2005.

An integration of all suitable and available technologies into a DLS architecture will enable Europe to meet current and future performance, safety and capacity requirements that will become more stringent in line with increases in air traffic and data-hungry services.

Iris is a ready-technology that can immediately deliver the required ATS performances, in a complementary fashion through a full integration with terrestrial VDL Mode 2, as part of the overall ATS communication network. It can provide enough capacity for supporting the forecast medium-term data traffic increase in the busiest continental areas.

In agreement with SESAR Joint Undertaking (SJU), Iris was designed to comply not only with technical performance and requirements but also with the capability to support services for both air-ground ATS communications and AOC. It already provides enough capacity to support near-term, data-hungry AOC services, while guaranteeing the required quality of service for safety-of-life ATS services with scalability potential for future needs.

In summary: Iris is a readily available solution enabling EC's Aviation strategy. It is based on the following main pillars:

- Compliance with ATS safety and performance requirements for both short and medium term (ATN B1 and ATS B2 respectively);
- Immediate coverage of Europe and scalability to become a global worldwide component to support air-ground ATM communications;
- High capacity, guaranteeing the required performances for ATS safety services whilst also supporting the data-hungry AOC services needed for airlines operations;
- Resilience to malicious attacks, due to end-to-end secure and redundant mechanisms;
- Continuity, becoming a core part of the future air-ground communication infrastructure supporting future ATS needs;
- Scalability and cost viable solution using the multi missions[1] nature of satellite communications infrastructure, serving a large customer base that will constantly demand new, high-performance features;
- Future proofing, as upgrades to the existing system can be gradually implemented to fulfil future requirements for improved performance or compatibility with IPS-based technology.

The results achieved so far draw on the involvement of leading European institutional stakeholders (EC, SESAR Joint Undertaking, SESAR Deployment Manager, EASA and EUROCONTROL). ESA is committed to continue this cooperation with European institutions in support of the Single European Skies policy set by the EC. To this end, ESA has signed Memorandum of Cooperation with the SESAR Joint-Undertaking (SJU), the SESAR Deployment Manager (SDM) and EASA to guarantee the compliance of Iris to the required standards and legislations. Exchanges between the involved parties aim to provide full visibility on all Iris-related activities carried out or planned by ESA.

Iris technology is a reality based also on important milestone of technical validation already achieved within the SESAR1 programme, where Iris is solution #109 of the SESAR catalogue. Additional validation activities have been carried out in ESA's Iris Programme through several flight trial campaigns (the latest in July 2018), demonstrating that Iris meets target ATM performance requirements[2].

[1] Including non aviation missions

[2] RCP 130 RSP 160

Iris system is getting ready for the execution of a large-scale validation using certified avionics flying on revenue flights from at least two different airlines (the so-called "Iris Early-implementation" in 2020-21). The observed performances will be analysed with the support of pre-eminent ANSPs in cooperation with EUROCONTROL/Network Manager, while the airlines will exploit Iris commercial and operational benefits.

"Iris early implementation" will pave the way to the full implementation of the Iris system, which will rely on a common validation and deployment roadmap that ESA is defining with the SJU and SDM.

Major ATM stakeholders already recognise that satcom is one of the most mature solutions available today for complementing VDL2 in the short to medium term, while having strong potential for supporting global ATS air-ground communications in the long term.

Implementing this new ATS satellite-based communication component might require amendment of current DLS legislation by the EC. This should lead to a performance-based approach focusing on services and associated performances rather than on technology for DLS provision (further details of which are provided in this paper). Explicit recognition by EASA of the Iris technology as an acceptable means of compliance to such new legislation will be the key to unlocking funding for airlines and other stakeholders and thereby enabling a critical mass of aircraft to be equipped with Iris.

Keeping the leading position of Europe in this process in a united European front will give European industry a competitive advantage compared to other world players, whilst also contributing greatly to common global goals.

Benefits

The EC Implementing Regulation on Pilot Common Projects[3] supporting the implementation of the European ATM Master Plan will enable a large range of economical, safety and environmental benefits:

- Environment: reduced CO2 emissions
- High safety and security standards
- Air Navigation Service (ANS) productivity: reduced en-route and Terminal Maneuvering Area (TMA) costs per flight for airlines
- Operational efficiency for airspace users: reduced fuel burn and flight time
- Capacity: reduced delays, increased network throughput and increased throughput at congested airports

[3] https://ec.europa.eu/transport/modes/air/sesar/deployment_en

- Industrial leadership and innovation in ATM and aviation
- A more competitive European Union (EU) aviation industry globally
- Significant contribution to EU Gross Domestic Profit and job creation.

It is widely recognised that currently, without Satcom/Iris to complement VDL M2 data communications and to provide a sustainable solution for datalink services, these benefits will not materialise as expected.

Iris will enable airline operational and business improvements requiring robust communications infrastructure for services such as business critical Airline Operational Communications (AOC), a whole set of CNS services and new Electronic Flight Bag (EFB) applications. Furthermore, Iris will also adhere to current and future global standards based on future ATN/IPS that would allow airlines to have seamless Satcom-based ATM connectivity and service worldwide. Finally, Iris will enable new users to access the aeronautical communications infrastructure, in particular RPAS, General Aviation, military and helicopters.

A special objective is to contribute to reduction of CO2 emission, on which the airplanes are the major contributors, by optimizing routes and landing paths during flight. The ultimate fuel reduction that an aircraft can achieve is also impacted by congestion, which is managed by air traffic control outside of the airline's remit. Industry interviews and analysis of secondary data indicate that IP-based flight deck communications (e.g. Iris) could bring about a 2% reduction in current global fuel consumption, resulting in savings of 1.1 billion, Euro, 3.39 billion liters of fuel and 8.5 million tons of CO2 annually. Furthermore the capability to avoid turbulence areas through better real time info to the cockpit will also results in less CO2 emission because of less fuel consumption. Overall the availability of fully connected and controllable aircrafts will have a major impact in CO2 emission reduction in the aviation sector.

2. Air Traffic Management European and Global Context

In December 2015, the EC shaped a comprehensive European Aviation Strategy[4] for implementing a new Air Traffic Management administrative, operational and technical concept.

The expected benefits to Air-Traffic-Management (ATM) stakeholders are: to enable a three-fold increase in capacity, which will reduce both ground and air delays; improve safety by a factor of 10; enable a 10% reduction in the effects flights have on the environment; and provide ATM services to airspace users at a cost that is at least 50% lower.

To support such an ambitious goal, the Single European Sky ATM Research (SESAR) programme has issued the ATM Master Plan[5] outlining the essential operational and technological changes required to achieve improvements in terms of operational efficiency, capacity, safety and security.

SESAR has recognized the technological modernisation of the Air-Ground Air Traffic Service (ATS) Data link as a key enabler of a transformation towards Trajectory-Based Operations (TBO). Through TBO, flight trajectories will be continually updated during flight and shared among the relevant Air Traffic Service Units to maintain, by strategic actions, an optimal trajectory to destination, allowing air traffic control to offer better routings, sequence aircraft far in advance and maximise airport and airspace capacity. The combined effect of optimizing aircraft trajectories will be less fuel burn, reduced delays and lower emissions of carbon dioxide.

Furthermore, the continuous increase of traffic for both general aviation and new domains (e.g. UAVs) represents a major challenge for ATM systems, which are being required to handle a larger amount of data whilst also ensuring an improved level of safety[6] and security[7]. Aviation safety requires robustness and hence a solid

[4] Brussels, 7.12.2015 COM(2015) 598 final

[5] https://www.atmmasterplan.eu/

[6] Aviation safety means the state of an aviation system or organisation in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.

[7] Aviation security is the set of measures and resources implemented to prevent malicious acts (terrorism) targeting aircraft, their passengers and crew members. Whilst air transport is the safest means of transportation in the world, its security has always been at the heart of the aviation industry's concerns.

redundancy approach, while the integration of security in the end-to-end chain of the data link is already needed and will be vital for the ATM of the future.

Finally, the same novel technology will also be exploited from a more commercial perspective by AOC services[8]. These are capacity-hungry services and are in continuous evolution; they are also fundamental for airline operations.

3. Data Link Services

The availability of a reliable data communications system with adequate quality of service is a prerequisite to reach the objectives of the ATM Master plan. In particular, the core concept of Trajectory-Based Operations (TBO) entirely relies on an efficient means of exchanging data between the aircraft and the Air Traffic Control (ATC) system on the ground to maintain and share common and updated aircraft trajectories.
In the medium term, the target is to create a "converged[9]" data link system that will operate globally according to the current and next generation of data link services. Safety, performance and interoperability requirements are maturing and initial standards have now been published (ED-228 and ED-229). The second data link service package is ATS Baseline 2: it includes 4DTRAD service dealing with trajectory negotiation and exchanges, ADS-C EPP being a subset of it mandated by the PCP Regulation.

ICAO has endorsed it in the Global Air Navigation Plan (GANP). The strategy was developed in close co-ordination with the Federal Aviation Administration's NEXTGEN Programme[10]. Standards were developed jointly by EUROCAE and RTCA.

In the longer term (from 2040 on), after further R&D and taking the lessons learned from ATS B2 initial and partial implementation, another evolution step is expected when all aircraft will be fitted with these capabilities to reap the full benefits of TBO; this is the "Full 4D Business Trajectories". This new operational context will lead to the revision of the current ATS B2 requirements; this is not yet fully mature at this time, but under study in SESAR programme. In this perspective, the ongoing collaboration of ESA with SESAR JU is key, especially on the performance requirements evolutions (operational performance, safety and security) of the

[8] The AOC communications depend on the strategies defined by the airline companies for the operational procedures. Hence, messages are specific to the airline needs and can be different from one company to the other. Generally speaking, the AOC services are dedicated to flight plan management, air traffic operations and maintenance activities.
[9] Converged: capable of aggregating all ATM data links needs through a common solution supporting both Air Traffic Controller and Airline needs
[10] The Next Generation Air Transportation System, or NextGen, is the FAA-led modernisation of America's air transportation system to make flying even safer, more efficient and more predictable

future ATS communication infrastructure, in order to ensure that satcom is one of the core system in this future ATS infrastructure.

Furthermore, in addition to ATS data link services, data link system through appropriate design will be able to support the increased use of AOC by crews, dispatchers, crew schedulers and strategic planners, while maintaining required performances for ATS. Airline operations require services that offer the airlines great flexibility and control over their daily operations. AOC communications (although not critical compared to ATS) are of a strategic nature for flight operations and, as such, need to be included (securely) in the main data link service stream.

Data Link Services Evolution is summarised in Fig. 1 below.

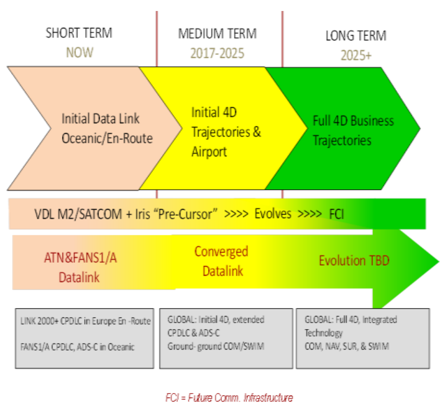

Figure 1: Data Link Service Evolution

4. Satellite Data Link Services in the context of SESAR

Satellite communications have an important role to play in the ATS communication infrastructure both in Europe and in the rest of the world, providing advantages in terms of global coverage [11], improved reliability and increased capacity.

Satellite systems are already used for oceanic and remote regions where they are the only available solution. A converged air-ground communication solution relying on both a terrestrial component and a satellite component will increase the robustness against breakdowns and the resilience to interruption of either of them, thus improving reliability. Lastly, a satellite component will provide additional bandwidth (and thus increased data link capacity) for European continental operations. This may be of significant value considering that data link capacity is much needed to boost the development of new applications and services.

Indeed, terrestrial VDL Mode 2 introduction has been impeded and delayed by its unexpected limitations, especially in terms of capacity. The original intention of the EC was to have the ATN B1 services operationally used across Europe above FL 285 by 2015. But due to VDL Mode 2 infrastructure performance issues, this deployment has now been delayed to 2020. This negatively affects the implementation of new ATM functionalities that rely on efficient and high-performance data links, delaying the benefits associated with such new capabilities. In this context the capability of satcom to provide performance compliant services in complement to the VDL Mode 2 (adding considerable capacity) represents a key asset for Europe in order to meet the ATM Master Plan objectives without further delays.

5. Iris: ESA's contribution to the ATS Data Link Services

In 2008, the European Space Agency kicked off the Iris programme as a contribution to the ATS data link services in order to contribute to the Single European Sky objectives set by the EC. Close working relations have been set up with the SESAR JU and now with the SESAR Deployment Manager to ensure coordination and consistency of all the European efforts in that domain.

After a four-year research phase involving major European space companies, in 2012 ESA started the development and validation/demonstration phase of a first-generation "precursor" based on the SwiftBroadband-Safety (SB-S) service of Inmarsat and relying on the L-band satellite infrastructure of this satellite operator.

[11] An older data link system (FANS1/A) has been in operation in oceanic and remote areas for over 20 years, based on ACARS messaging. FANS1/A is installed on many long haul aircraft and is supported by the long-established Inmarsat Classic Aero Service. In the short term Iris would support existing ACARS operation through the enhancements already made to SwiftBroadband for oceanic safety services.

What is Iris?

Iris is a service running on the enhanced Inmarsat SwiftBroadband Safety (SB-S) infrastructure, for delivering operational DLS to airlines and Air Navigation Service Providers (ANSPs). Iris extends SB-S oceanic/remote service to busy continental areas, starting with Europe and scalable to global coverage. Iris supports safety services for the current and future Aeronautical Telecommunication Network (ATN-B1 and ATN-B2) and any other ATM applications requiring an efficient data link. This includes other data-hungry services in the AOC domain.

Iris key features include:

- Compatibility with safety requirements for ATS data link services (ED-120 for ATN B1, ED-228A for ATN B1 and ATS B2);
- ATN/OSI functionalities to be integrated within the existing ATS data link infrastructure;
- Security procedures for providing secured link connections between aircraft and ground network;
    - Delivering secure end-to-end (from cockpit to ground CSP/ANSPs interface) communication links for data path[12], thus greatly reducing existing common threats and risks;
    - Providing stronger controls for mutual authentication and data integrity that do not exist in today ATS communication links; and
- Plans for a pan-European Iris service provider certified by EASA

Iris Added Value to ATS Data Link Services

Iris is well positioned to work in a dual-link or multi-link configuration, together with the terrestrial-based VDL Mode 2 component, in order to provide far greater data link capacity. The resulting available bandwidth and throughput enable the growth of ATS data communications and offer a solution to demanding new AOC services. From the cost/benefit stand point, it should be underlined that Iris benefits from the existing SB-S infrastructure, which is shared with multiple mobile satcom users in other application fields (e.g. maritime and land mobile).

Immediate main benefits deriving from Iris adoption for Europe:

- Extend the lifetime of VDL Mode 2 and the data link infrastructure already deployed for CPDLC and accelerate the delivery of CPDLC benefits;

[12] Iris also provides similar secure services for voice communications (it is more relevant for oceanic areas)

- Support the continuous growth of AOC communications;
- Support the validation of ATS B2 services (i.e. 4DTRAD services) in partnership with SESAR, ANSPs and airlines; and
- Accelerate and enable operational deployment and usage of ADS-C EPP as a first step towards trajectory-based operations.

Initial assessment of Iris specific benefits identifies the following elements:

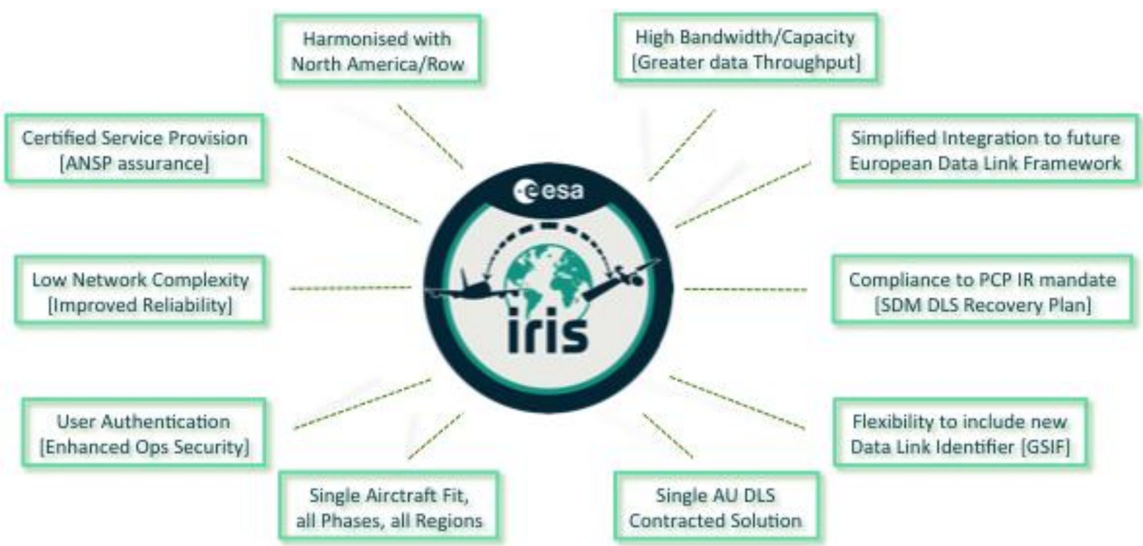

Figure 2: Iris Specific Benefits

Iris Services

Iris has been designed (in agreement between ESA and the SESAR Joint Undertaking) to support air-ground communications services for ATS and AOC. Major ATM stakeholders recognise that Iris is a candidate available for complementing VDL Mode 2 in the short to medium term, while having strong potential for supporting global ATS data communications in the long term (ICAO Global Air Navigation Plan).

Iris communications service will deliver the following:

ATN/OSI Data Safety Services supporting the following applications:

- **ATN Baseline 1** - the current set of ATS data link services, a CPDLC subset of which is mandated through the DLS Implementing Rule; and
- **ATS Baseline 2** - The proposed future set of ATS Data link services envisaged for the introduction of trajectory-based operation, with only a small subset covered by the PCP Implementing Rule (i.e. ADS-C EPP service);

ACARS Data Safety Services - Existing FANS1/A data link communications for remote and oceanic regions, as implemented for the current SBB Oceanic Safety;

Cockpit Voice Service for oceanic airspace - Prioritised circuit-switched (CS) and packet-switched (PS) channels will be provided for cockpit voice communications, again using the extensions provided under the SwiftBroadband Oceanic Safety;

AIS/AOC Data Service: Airline information and operational control services.

The delivered ATS data link services fulfil the set of operational safety, performance and interoperability requirements applicable, as shown below:

	Remote / Oceanic (current)	Converged (future)	Domestic / EnRoute (current)
Operational Safety & Performance (SPR)	ICAO GOLD	ED228 / DO350	ED120 / DO290
Interoperability (INTEROP)	ICAO GOLD	ED229 / DO351	ED110 / DO280
Current Implementations	FANS 1/A deployed in many remote/ocean areas including via SATCOM	-	Subset of ATN Baseline 1 being deployed in Europe (DLS IR)
Iris Precursor	**Support ACARS service via SBB**	**Support ATN Baseline 2 via SBB**	**Support ATN Baseline 1 via SBB**

Iris Architecture

Iris System Architecture

A high level architecture of the Iris concept for ATN and ACARS, omitting redundancy, is shown in Figure 3.

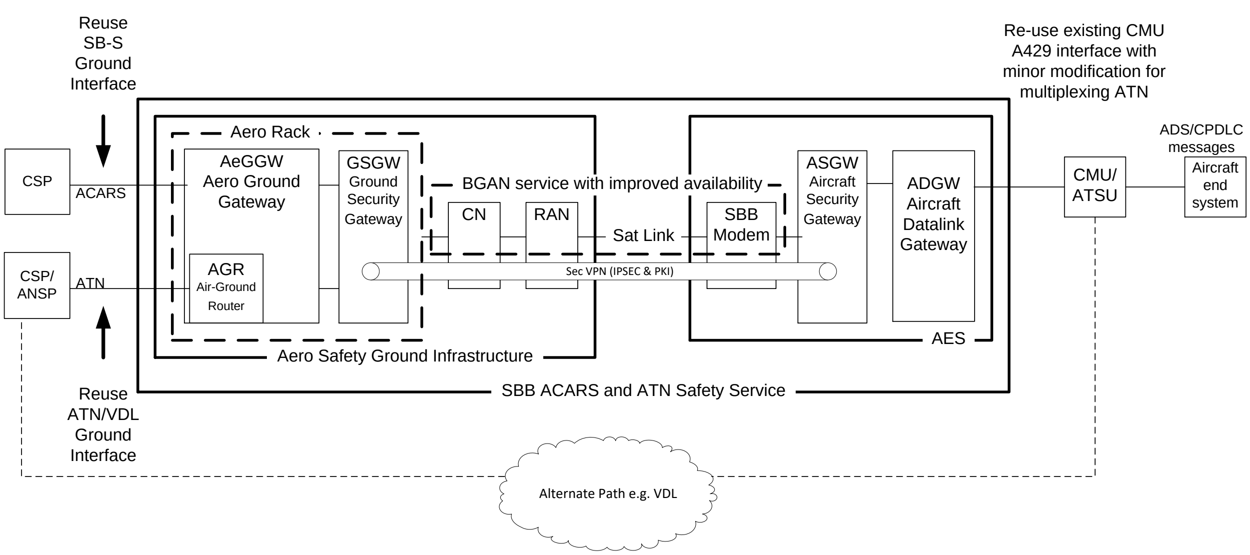

Figure 3: Iris High Level Architecture

The high level Iris architecture consists of three main component: Ground Segment, Space Segment (Satellite) and Aero Segment (Aircraft).

The main **Iris ground segment components** are integrated in the Aero Rack, which includes the following elements.

AeGGW Aero Ground Gateway – a new component for this system. The AeGGW is the physical entity handling ATN/ACARS traffic to/from an AES. It contains the GDGW and the Air-Ground Router (AGR). The AGR is an ATN/OSI router software function within the AeGGW that peers with the ATSU/CMU on the aircraft. The AeGGW routes/receives ATN/OSI packets on the terrestrial interface through the AGR and delivers these over the satellite link through the GDGW.

GSGW Ground Security Gateway is the peer of the ASGW and terminates the IPSec secure VPN tunnel established by the AES.

GDGW Ground Datalink Gateway supports combined delivery of ATN and ACARS traffic over the satellite link, expanding on similar functions developed and operational for the SB Oceanic Safety ACARS service. Its peer is the ADGW on the aircraft.

The main **Iris Aero Segment components** that constitute the peer entities of the ground segment are implemented within the Satellite Data Unit (SDU) on the Aircraft Earth Station (AES) satcom terminal and include the following elements.

ASGW Aircraft Security Gateway, responsible for establishing the Secure VPN tunnel between the aircraft and its peer GSGW, for the provision of an IPSec VPN for secure air-ground datalink communication.

ADGW Aircraft Datalink Gateway, expands on similar functions developed and operational for the SBB Oceanic Safety ACARS service. It is a functional block within the AES that is responsible for encapsulating ATN/ACARS messages in an IP wrapper to allow them to be sent to the ground via SBB; and to de-encapsulate received ATN/ACARS IP messages for transmission to the aircraft CMU.

Also on the aircraft is the CMU (Communication Management Unit). The CMU manages aircraft communication across multiple sub-networks such as Terrestrial HF, VHF radio and satellite-based communications, selecting which subnetwork to use based on availability and local routing policy.

The main **satcom-related components** for delivering Iris Swift Broadband (SBB) based services include the following key components.

CN Core Network provides the services, switching and routing of traffic to and from the AES, via the RAN towards external terrestrial networks. The CN consists of a suite of UMTS network nodes having separate Packet and Circuit Switched domains.

RAN Radio Access Network is responsible for all radio-related aspects of the Inmarsat BGAN ground system. It controls AES communications over the satellite to the ground network. Each Inmarsat satellite is served by at least one RAN.

INMARSAT **I4 satellite fleet** is deployed worldwide and covers around 98% of the Earth's surface (with the exclusion of some polar regions above 70-80 degrees).

Iris Redundancy Architecture

The Iris system needs to meet stringent targets in terms of network availability and service outages. In order to meet these demanding operational requirements, a comprehensive redundant system solution has been conceived, with no single points of failure and the ability to detect and switch over quickly to standby equipment in the event of failures.

Figure 4 below shows the Iris approach for redundancy implementation:

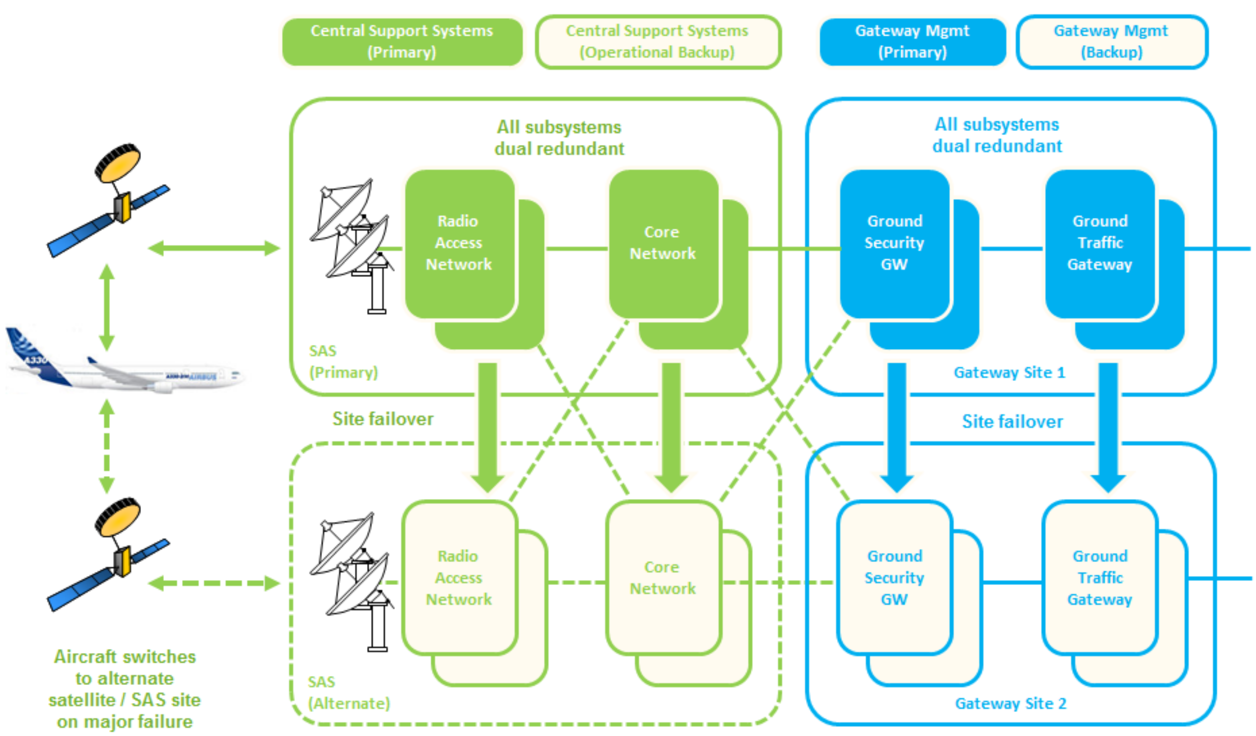

Fig. 4: Iris Redundancy Architecture

Iris Security Architecture

The Iris solution also includes security mechanisms to ensure the end-to-end authenticity and integrity of ATS data link exchange. This approach aims at establishing secure domains for Iris services in the ground and air segments for delivery of ATS data link traffic; it also foresees the implementation of the necessary controls to ensure that the equipment within these domains is managed securely.

Figure 5 shows Iris Security Architecture approach:

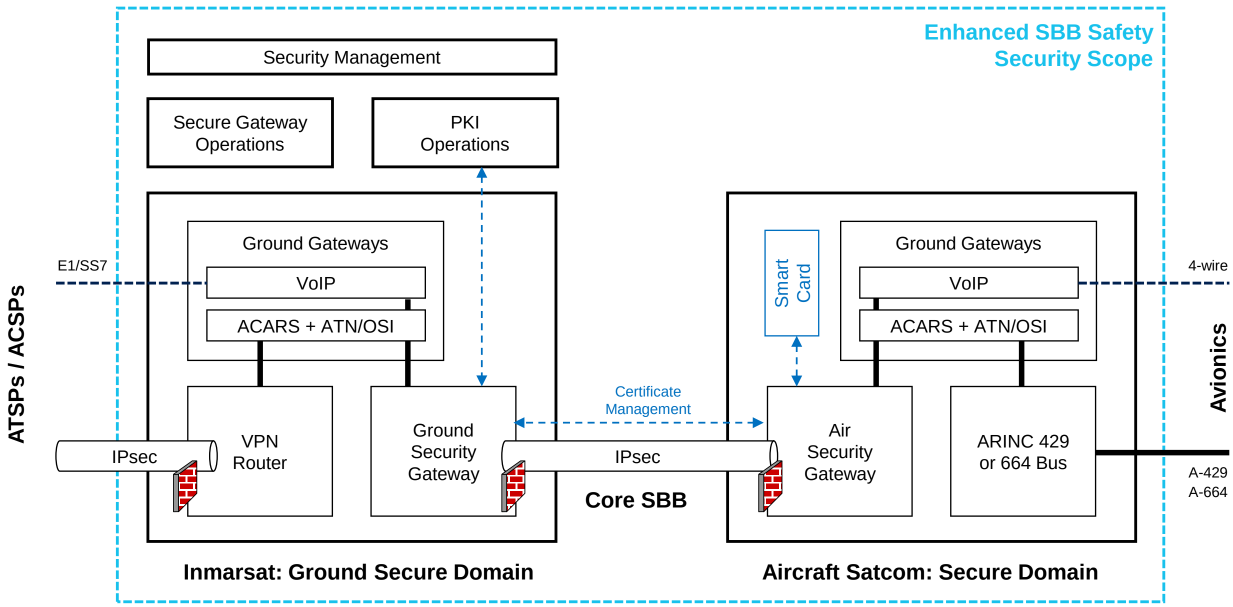

Fig. 5: Iris Security architecture

6. Iris Validation

The activities for the validation of Iris are performed in collaboration with SESAR-JU, through the SESAR1 and SESAR2020 Programmes. Thanks to the achieved results, Iris has been included as solution #109 of the SESAR catalogue (SESAR1).

Coordinated and complementary pre-operational validation activities have been carried out within ESA and SJU framework through several flight trial campaigns (the last one in July 2018), demonstrating that Iris meets the target performance requirements[13].

[13] **Short term:** ED-120, SPR Standard for Initial Air Traffic Data Link Services in Continental Airspace. Referred to as ATN baseline 1, in force through the DLS implementing rule EU 29/2009

The next phase of Iris is intended as a large-scale validation. The Initial Operational Capability (IOC) includes a key milestone in the implementation roadmap of the system, the so-called Iris "Early Implementation" or Iris Pilot. It will equip certified avionics flying on revenues flights (to be with selected airlines) for a 12-18 month period in 2020-2021. The achieved performances will be analysed with the support of (currently) five ANSPs[14], while involved airlines will analyse the benefits of Iris for AOC services. EASA will be given full visibility of this phase and will actively monitor Iris Early Implementation by providing feedback and advice. This phase should be complemented by Very Large Scale Demonstrations, to be executed under the SESAR2020 programme. These will include multi-link environment (to be planned) and i-4D interoperability in oceanic-continental airspace (known as EAGLE).

Upgrades to Iris for the longer term are under study to assess how future performance requirements will be met from 2030 onwards.

7. Iris Deployment

ESA and Inmarsat are implementing and co-funding all activities that will deliver the IOC from 2021. This requires close integration between the ground and the airborne elements. Iris works with two avionics suppliers to finalise Iris functional development and integration into the SB-S avionics (available by end 2019/2020). Avionics are planned to be certified between Q4 2019 and Q2 2020 and will be used for the Iris Early Implementation phase (also known as Iris Pilot).

The activities related to the implementation of Iris will be performed in cooperation with SESAR DM, with the final goal of creating a global ATN communication network where the implementation of the satcom component is the result of a combined ESA and industry effort.

In this context, Iris Early Implementation can be considered as the first milestone of a common validation/implementation process, where all the major institutional partners of ESA (SJU, SDM, EASA) will provide their expertise and contribution.

8. Iris Service Distribution

Inmarsat does not intend to be the Iris Service Provider (ISP) but positions itself through Inmarsat Operations as the operator of a satellite service based on Inmarsat satellite infrastructure and delivered to ISP. The latter will be responsible for the

Medium term: ED-228A, SPR standard for the proposed future set of ATS data link services in converged airspace but not yet subject of an EU implementing rule. This standard is referred to as ATS Baseline 2

[14] NATS, ENAIRE, MUAC, DFS, ENAV

delivery of the Iris services to the ANSPs, in compliance with regulatory and safety requirements.

ESSP, a company closely linked to major European ANSPs that already provides the pan-European EGNOS navigation service[15], is working closely with Inmarsat in order to prepare the instalment and the certification of the future Iris Service Provider.

The organisation of service distribution will be finalised by 2020 and will be compatible with the data link services re-organisation defined by the SESAR Deployment Manager under EC mandate.

The preparation of the certification of the Iris Service Provider set up has already started, with the aim to get the certificate in 2021. The verification and validation activities for the ground infrastructure will run in parallel to the certification activities.

9. Iris current implementation: Next steps

From the standpoint of a legal framework, the opportunity for Iris IOC to be introduced alongside VDL Mode 2 already exists [16]. Although ATN/VDL Mode 2 is currently the only deployed solution for supporting European ATS data link services, the 29/2009 Implementing Rule leaves the door open to air-ground communications technologies other than VDL Mode 2, provided that required safety and performance requirements are met and a service is available in the European airspace above FL 285.

The deployment of the SESAR solutions identified and mandated within the PCP Regulation is channelled through and organised within the SESAR Deployment Manager.

Even if Iris as such is not mentioned within the current PCP Regulation, it is critical that Iris activities are considered as part of the overall data link infrastructure for the ATS services.

10. Iris in the future

In line with the expectation of the aeronautical community, the EC is preparing for a full digital transformation in ATM, towards a higher level of automation and virtualisation. The goal is to meet the increasing level of performance and capacity

[15] ESSP is a Pan European certified navigation service provider overseen by EASA
[16] European Datalink Services Implementing Rule - No 29/2009 and No 310/2015

required by European aviation, which is moving from conventional aircraft to potentially hundreds of thousands of highly connected and automated air vehicles/devices offering advanced data-driven services.

In this context, Iris aims to become key enabler for the modernisation and rationalisation of ATM operations, as a primary component enabling the European Communication-Navigation-Surveillance (CNS) infrastructure to deliver improved services.

By consolidating and capitalizing upon the results of Iris with Initial Operational Capability (Iris IOC), the Iris Programme will support:

- **Iris Service Provider ground segment upgrades.** Iris will develop the satcom interface to the common European ATN backbone for an operational use of Iris in a multi-link environment. In close collaboration with SESAR Deployment Manager the Iris Service Provider will transition Iris towards operational deployment.

- **System and Technology Development for Iris global evolution**. Iris will explore the migration to internet protocols of the SESAR's Future Communication Infrastructure (FCI), in compliance to standards that will be adopted at a global level. Iris will also continue supporting the Hyper Connected ATM – i.e. future ATS and AOC (Airline Operation Communication) services - that will demand higher capacity and higher performance. All the segments will be addressed.

- **Enhancement of Iris to become a primary component of the European Communication-Navigation-Surveillance (CNS) infrastructure**. Technology development will be performed to integrate communications with navigation and surveillance services, in a rationalised CNS infrastructure for optimised air traffic management. The evolution of satellite constellations will support current and future ATM operations for all phases of flight.

11. Conclusions

ESA's satellite-based Iris system, developed by a world-class industrial consortium led by Inmarsat, is significantly contributing to the EC's Aviation Strategy and the aeronautical community.

Yet additional steps are needed for the adoption of satellite into the ATS communication network and the provision of current and future DLS with the required performance.

The results achieved so far draw on the involvement of leading European institutional stakeholders (EC, SESAR JU and SESAR DM, EASA and EUROCONTROL). ESA is committed to further this cooperation with European bodies in order to help fulfil the Single European Skies policy set by the EC. In this respect, joint bilateral MoCs are in place between ESA and EASA, SESAR JU and SESAR DM, and exchanges between the involved parties aim to provide full visibility on all Iris-related activities carried out or planned by ESA.

A further step towards integrated and coordinated action with all the above institutions is now required to develop a shared implementation plan of the Iris system.