# Iris Capacity Assessment Report

## Executive Summary

Satellite Communications for Air Traffic Management (Iris) is a programme of the European Space Agency (ESA) and Inmarsat that has developed a satellite-based air–ground communication system for Air Traffic Management (ATM) as a complement to existing terrestrial based datalink services.

The Iris Programme is supporting SESAR to develop the next generation of digital communications by using satellites, complementing the portfolio of available technologies for a reliable, fast, and efficient Air/Ground communication infrastructure. Iris services will be operational by 2022, gradually helping to implement a more resilient and efficient European data digital transformation of Air Traffic Management, that, in turn, will allow increased automation, fuel saving, and CO2 emissions reduction.

At this stage of the project, it is important to demonstrate that the Iris infrastructure is capable of supporting the traffic demand required to alleviate VDL-m2. This is particularly relevant in a context of high risks of reaching a congested VDL2 network in the mid-term, and at the same time of growing needs for digital exchanges to support improved Air Traffic (ATS) and Airlines Operational Services (AOC).

With this aim, a study to assess the satellite capacity available for supporting Iris services complementary to VDLm2 has been carried out by the Iris consortium, based on an assessment conducted by various partners including TAS Italy and University of Salzburg. It confirms that Iris has the required capacity (with large margins) to support the increasing data volume expected to be offloaded from VDL2 in order to allow for the maximum extension of VDL2 lifetime. The study also highlights that the main challenge to achieve much needed VDL2 offload is having a regulatory framework in place that incentivizes airspace users and air navigation service providers (ANSPs) to start equipping and using SATCOM technology in a timely manner.

It should be noted that the study was performed based on assumptions considering the latest information available on avionics development and aircraft deliveries before taking into account COVID-19 impact. Nonetheless, even at a time when COVID-19 is strongly affecting the world economy, including the aviation sector with a severe passenger traffic reduction, an integration without hesitation of all suitable and available technologies into a DLS architecture is the right opportunity for Europe to achieve the digital transformation and green deal so much pursued by the European Commission (EC). This crisis might actually spark a digital

transformation for industry to immediately raise efficiency and cut costs, while at the same time prepare for the future when performance, safety and capacity requirements will become more stringent. In addition, the transformation would enable the timely provision of ATN services in line with the passenger traffic re-growing expectations

# Introduction

The Iris service will be operational by end of 2022. At this stage of the project, it is important to show that the existing Inmarsat satellite infrastructure (based on so called L-band I4 operational satellite constellation) is capable of supporting the traffic demand required to alleviate VDL-m2 until 2040 and beyond. This is particularly relevant in a context of high risks of a congested VDL2 network in the mid-term at the same time of growing needs for communications based applications in order to support improved Air Traffic (ATS) and Airlines Operational Services (AOC).

The study performed by the Iris consortium has demonstrated that Iris can deliver the required ATS performances with ample margins in terms of available spectrum to effectively complement VDL-m2 by off-loading traffic that otherwise would not be supported by existing VDL infrastructure.

The study was conducted as per the following objectives:

- Estimate Iris equipage rate coherently with the objective to successfully offload VDL2. This was achieved by calculating the percentage of off-load from VDL-m2 to satcom required to avoid the VDL2 breaking point (saturation of the network) and led to a theoretical number of required Iris equipped aircraft.

- Prove that the Iris system, based on the existing Inmarsat infrastructure, can cope with the expected capacity requirements (in Europe) in line with the identified off-load assumptions.

Simulation results have shown that the current BGAN system can support even the most optimistic (demanding) traffic growth assumptions up to 2040 with a spectrum margin of 100%.

The study also highlights that appropriate incentives from the EC may be required to fill the gap between actual Iris equipage rate as forecast based on pure commercial assumptions by aircraft manufactures and required equipage rate in order to substantially off-load VDL-m2 network. At the same time airlines would need to plan some retrofit of their fleet in addition to early introduction via the new aircraft deliveries, planned to start in 2023. Although the numbers calculated in the simulations are not exact figures, they give a fair order of magnitude for the ATM community to figure out the best plan for Iris deployment.

## Scope of the Study

SESAR Deployment Manager (SDM) is coordinating the implementation of upgrades to Europe's air traffic management infrastructure. On the 27th of June 2014, the EC has adopted the implementing regulation N° 716/2014 known as the Pilot Common Project (PCP)[1]. This regulation is a European law that bounds the 28 Members States to implement 6 ATM Functionalities (AF), AF6 is Initial Trajectory Information Sharing, otherwise known as i4D. This regulation is supported by the SDM Deployment Programme[2] which gives an implementation date of 2025 for i4D[3].

An earlier regulation[4], the Datalink Services Implementing Rule (EC) No. 29/2009 gave dates for the implementation for Controller Pilot Data Link Communications (CPDLC). It stipulated the use of ATN/OSI and VDL2 whilst being open to new technologies, however, problems (see[5] the Data Link Services (DLS) Recovery Plan) with the VDL2 technology have resulted in delays.

The Recovery Plan is supported by several projects. In particular IP1 was aiming at designing the common ground-ground ATN network, in order to have a clear view on future European Target Solution, with its strengths and weaknesses, together with a well-defined assessment of performances of the current deployed infrastructures.

Based on assumptions drafted by IP1 on ATC & AOC volume growth and on possible offload of VDLM2 traffic to other technologies, a Capacity Assessment study carried out by SDM has addressed the capability of multi-frequency VDL2 to support Datalink services across a number of simulated scenarios. Specifically, the analysis has determined the capability (capacity and performance) of VDL2 to support the implementation of evolving datalink services within different increasing traffic cases and has shown its limitations in the long term. The Capacity Assessment Study contract has been won by USBG in August 2018, and this allowed for having common air traffic assumptions and datalink analysis between Iris and SDM.

The Iris Capacity study was conducted afterwards in order provide evidence that the forecasted traffic to be routed via satcom can be supported by the Iris network; this is an essential element for the decision makers to agree and plan Iris deployment as an efficient complement to VDL2 and as a primary datalink in the multilink system. The capacity simulation used the same traffic model as defined for VDL2 by USBG. Inmarsat and USBG developed scenarios to complement the IP1 work: for each year, the number of flights to be off-loaded to other technologies (in this instance Iris) to avoid VDL2 saturation was calculated.

Based on the forecast, Thales Alenia Space – Italy determined the required Inmarsat spectrum resources to be allocated to support the Iris Traffic.

More specifically, the Iris capacity assessment uses an event-driven traffic capacity tool developed by TAS-I, which has the USBG forecasted traffic as input and implements the BGAN air interface at packet level. Moreover, the tool takes into account the UT characteristics to evaluate the realistic link performances of each packet handled by the communication system.

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[1] EU No 716/2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan

[2] Deployment Programme Version 1 (DP v1) - FPA MOVE/E2/2014-717/SESAR FPA SGA MOVE/E2/2014-717/SI2-699519 – 30 June 2015

[3] The new version of the regulation (under review by the EC) pushes back i4D deployment to 2027.

[4] Datalink Services Implementing Rule (EC) No. 29/2009, as amended

[5] Data Link Services (DLS) Recovery Plan FPA MOVE/E2/2014-717/SESAR FPA SGA MOVE/E2/SUB/2015-467/SI2.724359 17-Oct-2016

The tool considers the Alphasat current beam coverage to assess the capacity demands per beam and for the overall system.

Inmarsat has then analysed the resulting capacity demand for Iris against the spare satellite resources of Alphasat in order to conclude on whether the current BGAN system (i.e. without any improvement or development) can support the Iris traffic forecast.

# Traffic Modelling and Assumptions

The IP1 project developed the detailed assumptions of the overall data traffic (ATS and ACARS AOC) that datalink services will have to manage in the short (2024) to long term perspective (2040) in the European region. Based on these assumptions, the VDLM2 Capacity Assessment, performed by USBG under SDM supervision, determined the "capacity breaking point" of the existing VDL2 technology so as to better understand when the complementary technologies would be needed.

Outside of these IP1 & CAS-VDL2 SDM projects, Inmarsat and USBG complemented the above by assessing what would be the ideal number of Iris equipped aircraft to provide the required relief to the VDL2 network to avoid such capacity breaking point possibly affecting the terrestrial network.

The same data modelling, traffic assumptions, and growth expectations were used.

## 1.1 Data Application Assumptions and Modelling for Iris simulation

The same set of ATS (FANS 1/A, ATN B1 & ATS B2) and AOC applications as for the VDL2 CAS was considered for the Iris simulations as depicted in the figure below:

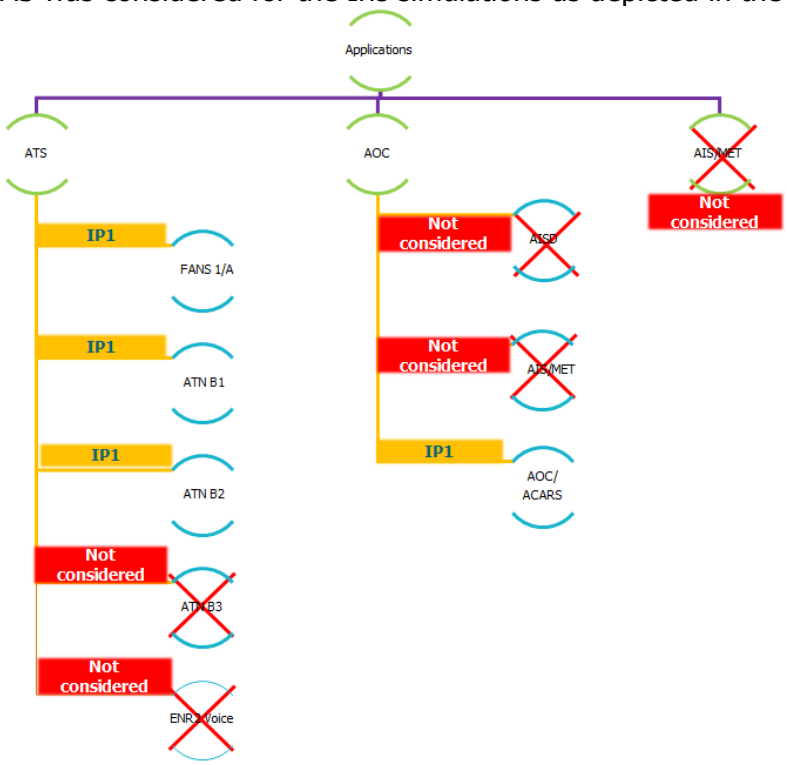


**Figure 0-1 Safety applications type**

## 1.2 Equipage Rate Forecast

To estimate the equipage rates, the following realistic industrial scenarios of Iris avionics availability per aircraft family were made based on discussions with OEMs and aircraft manufacturers.

- Planned on A320/A330 by 2021 (AOC over SATCOM available mid 2020)

- Expected on A350/A380 by 2023-2024
- Considered on Boeing models ATS B2 capable around 2026
- Possible  Regional Jets around 2026
- Not considered for the other families representing 18% of the flights (old mainliners, turboprop, helicopters, military and general aviation).

*NOTE: The usage is defined to be 100% - so if an aircraft is equipped with IRIS terminals it will use it to transmit all its ATS/AOC data instead of sending it via VDL2 link.*

Additional theoretical scenarios were defined in the Iris project to simulate off-loading options with the objective to identify the required number of satcom equipped aircraft to cover the off-loading demand and extend VDL2 life span beyond 2027 when its capacity crunch will appear. Different parametric studies scenarios have been defined mainly varying over number of frequency deployed for VDLm2, and level of traffic (realistic or more demanding.

As a first conclusion, there is a gap between the theoretical scenario and the realistic industrial scenario. Focusing on the scenario where VDLm2 will work on 6-frequency (considered as likely to materialise), it is however to be noted that the gap between the theoretical and realistic scenarios could be compensated by incentives to reach a critical mass of Iris aircraft. This would in particular support the objective of the digital transformation, pillar of the ATM Master plan, building a real airborne capability to further support smart AOC applications and TBO concepts deployment.

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# RESULTS

The Iris capacity simulations take input traffic (under the same assumption of the exercise carried out by SDM pre-COVID), including both ATS and AOC, and estimate the number of SATCOM carriers required to carry such traffic, by accurately modelling the Iris system, respecting the delay requirements of each application.

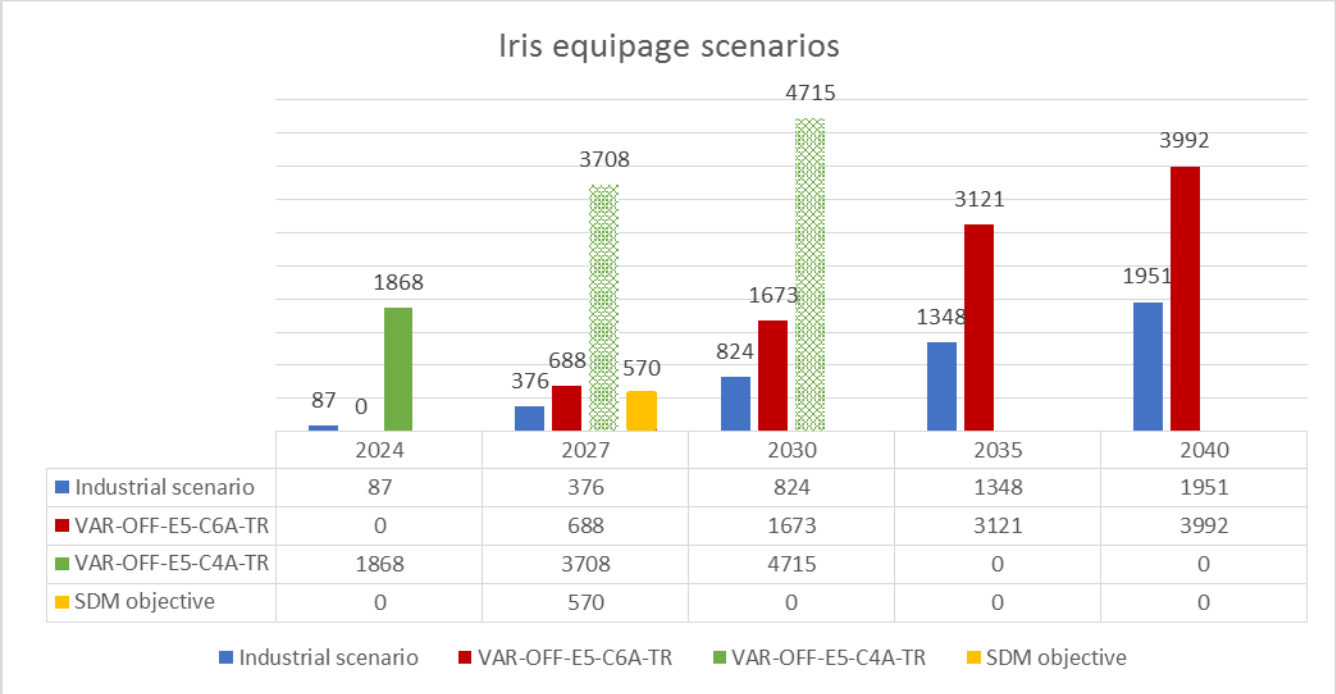
The results show that the underlying SATCOM infrastructure can carry the traffic required to off-load VDL2, both when four or six frequencies are considered for the terrestrial system. In particular, the most bandwidth consuming scenario corresponds to the year 2040, assuming a high traffic growth profile, where a maximum of three 200 KHz Iris carriers are needed in the most loaded SATCOM beam for the return link. At Iris system level around 50 carriers are needed across the entire coverage area; the current Inmarsat system can handle this capacity demand, which is well below the overall system capabilities boundary.

The study has also identified the required the number of Iris equipped aircraft to be deployed in order to timely enable effective offload VDL2 network from the traffic in excess (i.e. to avoid saturation), yet to be updated taking into consideration the impact of COVID-19.

The following figure presents a comparison between the current Iris equipage rate forecast, also called industrial scenario, and the theoretically required number of Iris equipped aircraft considered in the Iris capacity study.

The industrial scenario is based on industrial and market plans developed with expert knowledge from aircraft manufacturer Airbus in particular, as Airbus family aircraft are likely to constitute a large share of the early Iris users. It does not take into account the possible incentives available to airlines when Iris is defined as an essential enabler to delivering the ATM Master plan.

Furthermore, the industrial scenario considers the latest information available on avionics development and best understanding today of the possible COVID-19 impact on aircraft deliveries, although still to be confirmed. However, it is to be noted that the COVID-19 impact on the traffic level and therefore on the required number of aircraft derived from the capacity study has not been taken into account: the traffic growth originally (pre-COVID-19) defined "realistic" is considered and both results for four and six frequencies options are shown.




| | 2024 | 2027 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|
| Industrial scenario | 87 | 376 | 824 | 1348 | 1951 |
| VAR-OFF-E5-C6A-TR | 0 | 688 | 1673 | 3121 | 3992 |
| VAR-OFF-E5-C4A-TR | 1868 | 3708 | 4715 | 0 | 0 |
| SDM objective | 0 | 570 | 0 | 0 | 0 |

**Figure 2: Comparison between forecast of Iris equipage rate (industrial scenario) and Iris capacity study findings for the 4 (VAR-OFF-E5-C4A-TR) and 6 (VAR-OFF-E5-C6A-TR) channels scenarios**

The above figure shows that:

- There is a significant gap between the industrial scenario and the needs (except in 2024 with six frequencies available for the VDL2);
- Even considering a working assumption of at least 5% of the flights equipped with complementary communications by 2027 is not sufficient in both options with four and six frequencies on VDL2. (The 5% target was set up in discussion with SDM )
- Depending on the ability to implement the VDL2 network transition from four channels to six channels, the situation may be critical in 2024 and before.

Even if the six channels scenario is implemented from 2024, the fleet equipage should start in 2022/2023 for reaching the 2027 objective with a realistic ramp-up.

This would require significant EC incentives for accelerating the Iris equipage of the ECAC fleet, boosting the Iris forward fitting rate and addressing partially also the retrofit. This would allow to fill the gap between current expected number of Iris equipped aircraft and the number of required Iris equipped aircraft.

We can therefore draw the following conclusions:

- Iris system has sufficient capacity to accommodate for the ATM traffic exceeding VDL2 until 2040;

- The off-load of VDL2 can be effectively implemented with the support of EU incentives in order to timely reach a critical mass of equipped aircraft.

# Conclusions

The objective of the study was to demonstrate that the Iris network can manage the ATC and AOC traffic that could be expected in various scenarios of VDL2 saturation.

**More than enough capacity**

The simulations have demonstrated that the BGAN system, baseline for Iris service, can support the Iris traffic for all considered scenarios with 100% spectrum margin. Also to be reminded that the system model and assumptions have been defined with a conservative approach. On the contrary, the traffic growth forecast assumptions are optimistic. This has led to simulating a worst-case scenarios from the requirement perspective up to 2040.

Prioritisation of the ATC traffic has not been simulated although this functionality exists today in the system - there was no need to simulate it given the capacity demand was lower than available resources. To be noted: Inmarsat, USBG and TAS-I run additional capacity simulations[6] specifically focusing on AOC services and anticipating a significant growth for AISD+ AIS/MET in Europe, confirming that the system do not need to be scaled up.

It can be concluded that Iris can be relied upon to complement the VDL2 network and create a datalink service infrastructure that matches the most likely evolution of datalink usage in Europe.

**Need for a regulatory and incentives framework**

The simulations were also useful to understand what Iris deployment scenario should be organised in the perspective of having a reliable datalink services infrastructure for the 2024-2040 timeline. Today's conservative Iris equipage scenario is mainly relying on equipping a share of the new deliveries to the European airlines, largely for the A320 family aircraft. The simulation demonstrates that to anticipate a VDL2 saturation in 2027-2030, a higher number of aircraft equipped with Iris would be needed. Incentives at European level would stimulate Iris equipage for a number of aircraft consistent with a robust European datalink service and real digital transformation of ATM.

[6] These simulations were done outside of the activity detailed in the present report