

Improving AIRBUS Flight Test Guidance with LEO Satellite Connectivity

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Abstract:

AIRBUS is operating a fleet of test aircraft dedicated to qualifications of incremental improvements of civil aircraft, as well as evaluation of innovative concepts. Some flight tests involve long range operations, as aircraft need to be exposed to severe conditions, such as icing, high altitude or strong side winds. To support such remote operations, AIRBUS has been using since 2014 the PLANET system developed by ATMOSPHERE. PLANET relies on satellite connectivity to support real-time exchanges between on-board flight test engineers and ground support teams. Through a web interface, PLANET provides a means to follow and guide aircraft operations anywhere. However, test aircraft are not always fitted with Satcom capability. Hence, AIRBUS and ATMOSPHERE worked together to develop a fully autonomous solution, in which PLANET software and Satcom connectivity are integrated in a single box. This new solution, based on Iridium Certus™ constellation, has been installed and tested in an A321neo aircraft in December 2025. Following positive return on experience, it is now planned to be deployed on other test aircraft.

The paper presents the new PLANET connectivity solution developed for AIRBUS Flight Test needs. It reviews the performance achieved during in-flight operations, provides return on experience, and discusses the potential exploitation of this reliable technology for future campaigns.

Key words: Flight Test Guidance, LEO satellites, Telemetry and Telecommand (TM/TC), e-Operations.

Introduction

AIRBUS is using line of sight (LOS) telemetry systems in support of flight testing activities, covering various needs: new aircraft development, maintenance and renovation activities and research programmes. However, if those systems cover most of AIRBUS flight test requirements, still some use cases cannot be supported due to range limitation or simplex operation. For this reason, AIRBUS has initiated a collaboration with ATMOSPHERE, an SME with expertise in satellite communication, to develop complementary means exploiting satellite connectivity potential. The first large scale experimentation was performed in 2015, in the frame of HAIC [7] research project, and was followed by multiple Natural Icing Campaigns. The collaboration enabled ATMOSPHERE to leverage its network-centric operations platform, called PLANET, to a high level of maturity, and to offer the solution to other aerospace actors, sharing similar needs. Building on this collaboration, a key constraint was identified: not all test aircraft are equipped with Satcom capability. To address this, AIRBUS and ATMOSPHERE jointly developed a fully

autonomous solution integrating PLANET software and satellite connectivity into a single unit. Leveraging the Iridium Certus™ LEO constellation, this new terminal was successfully installed and validated on an AIRBUS A321neo in December 2025, with plans to extend deployment across additional test aircraft.

With the objective to share this rich experience, the present paper is structured along four main sections: 1) review of AIRBUS flight test mission context and needs, 2) description of the new PLANET LEO solution, 3) return on experience, and 4) future perspectives.

1. AIRBUS Flight Test Mission Context

The most representative use case for PLANET in AIRBUS is natural icing campaigns, that require far remote operations. When flying in icing conditions, the wings, the engines and many systems of an aircraft may not perform in the usual way. The aerodynamics may be affected by a reduction of the lift coefficient, of the stall angle of attack, by a possible decrease of the horizontal stabilizer efficiency and an increase in drag. Flying in icing conditions may also have adverse consequences on engine

behavior. Certification rules specify cloud size and minimum droplets size. As all clouds have varying size of droplets, liquid water content and temperature, the regulations allow the tests to be performed with different values of these parameters according to a correction table.



Fig. 1: A321neo Test Aircraft

For natural icing tests, the main challenge is to find the proper flying area, since weather forecasts do not give sufficiently accurate liquid water content values and droplet sizes to choose suitable test areas.

In Europe, AIRBUS performs most of the tests in vertically developed clouds (tower cumulus or cumulonimbus). Some tests are also performed in horizontally stratiform clouds in North America, above the Great Lakes or over Alaska.

For icing tests, a specific instrumentation is installed on the aircraft. The liquid water content and the size of the droplets are measured with appropriate tools.



Fig. 2: Icing Campaign Probes

Cameras are installed at various places. A small rod, visible from the captain's seat, allows the crew to monitor the ice accumulation in real time.

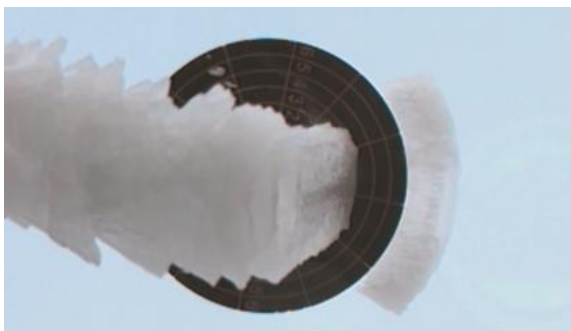


Fig. 3: Ice Accretion Visualisation

The area where the flight test campaign is carried out is determined several months before the departure and the choice is driven by the hypothesis to meet the required weather conditions.

When the tests are planned in North America (Great Lakes or Alaska), the development aircraft equipped with its FTI is flying with Test pilots, Flight Test Engineers and support teams.

A weather forecaster is determining before the flight the areas where the aircraft will meet the expected conditions and, with the help of PLANET, could give more information during the flight.

To perform Icing Campaigns the following items are required (at a minimum):

Nephelometer:

If the campaign is in Toulouse area, only one nephelometer can be accepted

If the campaign is remote, 2 nephelometers are requested (LHS & RHS)

ICD probe is requested

If 1 nephelometer: ICD on LHS and nephelometer on RHS

If 2 nephelometers: ICD probe on LHS behind the nephelometer

CEV probe is requested. It must be easily visible from cockpit (Pilot or video camera)

Video Cameras:

2 cameras in cockpit to visualize the CEV probe

1 camera to look at a leading edge of wing (wing with slat painting – see below). This camera must be adjustable (direction and zoom) from FTES (Periscope is a good option).

At minimum, a camera to visualize an inlet. If there is a tested engine, a 2nd one will be requested to see it.

1 camera to see the leading edge of PHR (priority 1) and VTP (priority 2)

If icing flights need to have a high lift configuration, additional cameras will be requested to visualize the back of the slats, the flap leading edge, to survey the head of new nephelometer and to survey the ICD probe de-icing

PLANET server or an equivalent is required with 4 parameters to send from FTI data server (CUB) to PLANET server; Zp & SAT from ADR1 + MVD & LWC from nephelometer

2. New PLANET LEO Solution

Conceptually, PLANET can be defined as a collaborative mission management solution. It provides means to exchange information in real-time among geographically distributed users. Link with the aircraft is ensured anywhere in the world thanks to satellite communication. The service is directly available on end user's devices through a web interface. Strategic mission information is readily accessible. Mission participants can interact live. Instrument data can be acquired, transmitted, displayed and shared.

From an architectural viewpoint, PLANET is structured as a star network, with one central ground server, connected to multiple on-board mobile servers. The ground server is a common infrastructure shared by several PLANET user entities. It supports the interfaces with satellite networks, weather and aeronautical data providers, and the web application server for ground users. The on-board server acquires data from the aircraft and the instruments, interfaces with aircraft satellite system (antenna or modem), and hosts the web application server for airborne users.

PLANET architecture is modular and can be easily deployed above or alongside legacy infrastructures. At high level, it can be sliced in three layers: the physical layer, the middleware layer, and the web service layer. The physical layer includes radio-communication devices (satellite modem, cellular modem), sensor modules (GNSS receiver, ADS-B receiver), low level acquisition or local communication interfaces (ARINC, Serial, USB, Ethernet, Wifi), and computer processing capability.

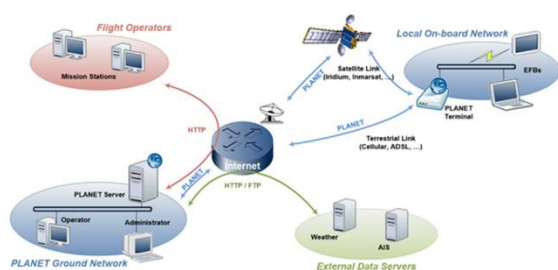


Fig. 4: PLANET System

PLANET middleware allows to abstract from physical layer characteristics, which can be very different from aircraft to aircraft, and provide real-time acquisition and application networking capabilities to higher level services. PLANET middleware is taking care of radio resources management. To optimize satellite capacity usage, networking software implements Quality of Service management with several levels of

priorities, and on-line compression algorithms, some of them domain-specific (e.g. for weather data). To facilitate information sharing and application integration, publish-subscribe mechanisms, based on MQTT protocol, are provided by PLANET middleware. Data types that transit in real-time amongst PLANET entities can thus be used by several concurrent applications.

As test aircraft are not always fitted with Satcom capability, AIRBUS and ATMOSPHERE worked together to develop a fully autonomous solution, in which PLANET software and Satcom connectivity are integrated in a single box. This new solution is based on Iridium Certus™ LEO constellation, which provides 40 times more throughput than first generation with native support of IP. The unit includes an Iridium modem 9770 which delivers 88kbps MT and 22kbps MO.



Fig. 5: New PLANET LEO FTI Equipment

In addition to its enhanced communication performance, one of the key features of the solution is that it still requires a small passive omnidirectional antenna to operate. Coming with a standard 3.5-inch footprint, the antenna is very easy to install, and it does not create additional drag. The unit also contains a GNSS receiver for autonomous time and position acquisition.

The operation of the connectivity on a passive omnidirectional antenna also means there is no satellite pointing system required, which greatly simplifies the design and does not introduce any coupling with other aircraft systems such as inertial reference system. The 1.2kg indoor unit can be powered directly on Aircraft 28VDC supply and has modest power requirement (10W). With the transceiver and server functions being integrated within a single sugar box size, the complete solution is very easy to integrate in AIRBUS test aircraft cabin. See all specifications in [1]. On the user side, Ethernet, Serial and WiFi connectivity options are available. Flight test engineers usually connect directly their tablets to the WiFi access point to benefit from PLANET services. One Ethernet port is dedicated to the

interface with AIRBUS FTI acquisition and distribution system (CUB).

AIRBUS and ATMOSPHERE had a first opportunity to install and test PLANET LEO FTI solution, on AIRBUS A321neo for an operational icing campaign. The installation started in September 2025 for an actual campaign in December 2025.



Fig. 6: PLANET 9770 FTI Equipment in A321neo

The mission objective was to validate a new APU on natural icing conditions. The certification is achieved by flying under severe icing conditions. To this aim, AIRBUS is relying on PLANET system for optimal flight guidance. An external icing expert was providing flight guidance in real time to maximize encounter of icing conditions. He guided the aircraft from the ground using PLANET functionality: chat, geomarkers, icing probes telemetry and weather layers.



Fig. 7: PLANET User Display

The PLANET 9770 FTI unit is installed inside the cabin space, close to the Iridium rooftop antenna. The antenna is connected with a low loss ASNE0406 cable of approximately 2m (0,36dB loss/m). It provides services on FTE Tablet using WiFi. It was verified during commissioning that WiFi was also received from the cockpit. PLANET 9770 FTI receives and decodes a selected set of instrumentation data through Ethernet (CDP_DVM, ICD_LWC, ZP1, SAT1 and Navigation Data). This set of data is defined by the Client PC connected to the main AIRBUS instrumentation data concentrator (CUB). The TAP box creates a copy of the data that circulates on the Ethernet and prevents any intrusion from PLANET 9770 FTI on the instrumentation LAN. In principle, position data is received from the CUB. However, in addition, a GNSS antenna is affixed to a window to get

autonomous time and position acquisition. It is possible on PLANET interface to select the source of data used for positioning.

The end users of PLANET application are connected via local WiFi. In addition to collaboration features (track/chat/geomarkers), local weather conditions (radar, satellite imagery as well as lightning data) were distributed by PLANET service.

The A321neo operational campaign included 5 on-site flights, and 2 ferry flights (Europe to/from Canada) which enabled to collect and analyze communication performance data based on operational traffic.

Signal reception has been logged in-flight during return Ferry Flight. The signal has been monitored for approximately 10h.

The results are displayed in the following graphs. During the monitored time, the constellation was always visible and very few occurrences of total signal outages (4) were recorded. The average signal bars over the complete session is 4.95/5, which is very good. From this, it can be inferred that the RF installation of the terminal is good.

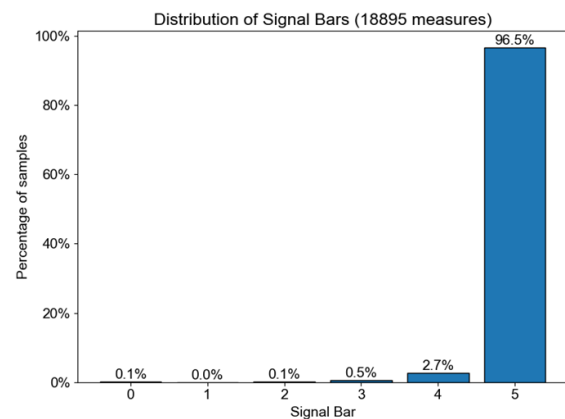


Fig. 8: Distribution of Signal Bars

The transmission delay has been analyzed using the regular position reports (about 60 Bytes reports, transmitted every 10s). The complete mission dataset has been used for transmission delay analysis.

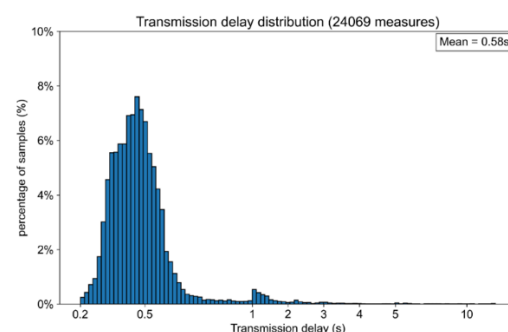


Fig. 9: Transmission Delay Distribution

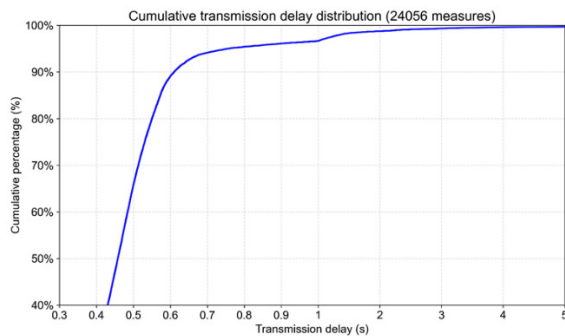


Fig. 10: Cumulative Distribution of Transmission delay

During this campaign, the transmission delay of position reports was on average 0.6s. Moreover, we can notice that 95% of transmission delays were below 1 second, and 99% below 5s.

In some occurrences, the transmission took more time, but all position reports were properly received during the complete campaign.

3. Return On Experience

PLANET LEO FTI system worked perfectly during the complete A321neo campaign (around 80 hours of operation).

During the campaign, the communication performance was very good, with very few signal outages and no loss of data during the whole campaign. The transmission delay, below 1s in average, and below 5s for 99% of the samples, answers most flight test use cases.

From a user experience, operation of PLANET system over LEO vs. traditional GEO systems used in the past brought no noticeable difference.

Overall, the new PLANET LEO solution proved to be robust and dependable which are key added values for flight test operations.

Based on those successful achievements, AIRBUS Flight Test Department is now preparing follow-on operations. This includes further operations on A321neo, but also deployment of the PLANET LEO solution on other test aircraft, including A350, A380 flying test bed, and possibly other platforms.

4. Perspectives

In recent years, multiple new offers in terms of aeronautical satellite connectivity have been brought to the market, providing higher capacity and cheaper service. Hence, beyond PLANET LEO solution, AIRBUS is currently studying how to exploit new satellite communication options in the context of flight tests. With high throughput, low latency satellite services, it would be possible to switch legacy telemetry stream from LOS to LEO Satellite with minimal impact.

On its side, based on A321neo mission success, ATMOSPHERE is successfully promoting the solution to legacy and new users in the flight test and flight science domains, including high altitude operations for HAPS command and control and Fairings recovery missions.

In addition, ATMOSPHERE is continuously improving PLANET product portfolio to maximize user experience and benefits. For test and telemetry users, a more capacitive solution has been recently introduced that delivers 88kbps MO, still with an omnidirectional passive antenna. Complete specifications are available in [2].

Lastly, PLANET LEO solutions can now provide Iridium PNT service, as an alternative and independent location and timing means for GNSS-denied areas.

Conclusion

Satellite-enabled test and telemetry tools have been successfully introduced in AIRBUS flight tests operations in recent years. AIRBUS and other aerospace users experience shows that these tools bring high added value for conducting various types of flight experiments, and they should be considered as complementary means to traditional line of sight telemetry systems. Advances in satellite technology, with cheaper and better solutions, will enable us to extend the range of the supported use cases in the future.

Acknowledgement

The authors acknowledge the contribution of AIRBUS flight test engineers and other PLANET users that kindly provided feedback on their experience on the equipment and service.

References and links

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Glossary

DLR:	Deutsches Zentrum für Luft- und Raumfahrt
FTI:	Flight Test Instrumentation
GEO:	Geostationary Earth Orbit
ICD:	Ice Crystal Detector
LEA:	Leading Edge Atmospheric, LLC
LEO:	Low Earth Orbit
LOS:	Line of Sight
LWC:	Liquid Water Content
HAIC:	High Altitude Icing Crystals
HAPS:	High Altitude Platform Station
MO:	Mobile Originated
MT:	Mobile Terminated
NAT:	Network Address Translation
PNT:	Positioning, Navigation, Timing
SME:	Small and Medium Enterprise