

New LEO Satellite Connectivity Test and Qualification for future Stratospheric Flights

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Abstract:

CNES Balloon Division has been developing and operating a wide range of stratospheric balloons for more than 60 years. This unique activity answers the needs of a broad user community including science institutions, governmental agencies, and aerospace industry. In the context of increased interest in stratospheric flight capability, CNES Balloon division is currently preparing a new generation of infrastructure to offer more flexible and safer flight options to end users. To this aim, CNES is evaluating and qualifying new technologies, including satellite communication, as offered by ATMOSPHERE. Amongst several options, CNES assessed the capability and benefit of new ATMOSPHERE's PLANET Satcom product line, based on Iridium Certus™ LEO satellite constellation. The activity, which covered vacuum chamber tests and functional performance tests, culminated with actual stratospheric flights performed from Timmins, Canada, in August 2025. The paper presents the achievements of the development and qualification programme of new satellite connectivity solution for future CNES Balloons infrastructure. It presents the performance achieved during on-ground and in-flight qualification tests, and discusses the potential exploitation of this reliable technology for future missions.

Key words: LEO satellites, Telemetry and Telecommand (TM/TC), High Altitude Operations, Balloons

Introduction

CNES Balloon division is currently preparing a new generation of infrastructure to offer more flexible and safer flight options to their end users. To this aim, CNES is evaluating and qualifying new technologies, including satellite communication, as offered by ATMOSPHERE. Amongst several options, CNES assessed the capability and benefit of new ATMOSPHERE's PLANET LEO Satcom product line, based on Iridium Certus™ satellite constellation.

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

1. CNES Mission Context

For more than 60 years, CNES has developed and operated a wide range of stratospheric balloons supporting scientific research, atmospheric monitoring and aerospace technology demonstrations. These platforms serve a broad user community including research institutions, governmental agencies and the aerospace industry.

Stratospheric balloon missions require continuous monitoring and command capability to ensure safe operations. Large balloons (BSO) carrying payloads of up to 1,000 kg must remain connected with ground operators throughout the flight to support real-time monitoring telemetry, command and control (C2) of the platform, and Flight termination capability (FTS) if required.

Telemetry typically includes position data (latitude, longitude, altitude and speed) along with system health information such as battery voltage, temperature and subsystem status. Telemetry frames of approximately 250 bytes are transmitted every second, while telecommands from the ground are issued unitary and acknowledged to ensure safe platform control.

Legacy communication systems previously used for balloon operations sometimes experienced temporary communication outages or even complete blockages during flight, limiting operational reliability. As CNES prepares a new generation of infrastructure for stratospheric flight operations compliant with higher safety standards, improving the reliability of the satellite communication link became a priority.

To address this challenge, CNES partnered with ATMOSPHERE to evaluate the PLANET LEO Satcom product line, which leverages the Iridium Certus™ Low-Earth-Orbit satellite constellation to deliver global connectivity with low latency and high reliability.

2. New PLANET LEO Solution

CNES and ATMOSPHERE worked together to develop a light PLANET LEO Satcom unit. The 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 9770 modem which delivers 88kbps MT and 22kbps MO.



Fig. 1: New light PLANET LEO Equipment

In addition to its enhanced communication performance, one of the key features of the solution is that it still operates with a small passive omnidirectional antenna. For high altitude operations a small ceramic helical antenna was selected [3]. The operation of the connectivity on a passive omnidirectional antenna means also that there is no satellite pointing system required, which greatly simplifies the design and does not introduce any coupling with other systems such as inertial reference system. The 700g PLANET unit has modest power requirement (10W). The complete solution is very easy to integrate on the Balloon payload structure. See all specifications in [1].

The evaluation was conducted through a CNES experimental programme, which included ground qualification tests, vacuum chamber validation and real stratospheric balloon flights. ATMOSPHERE delivered three PLANET LEO terminals and implemented a secure VPN interconnection between the Iridium gateway and CNES operational facilities, allowing seamless integration with the balloon ground control infrastructure.

During the ground test phase, ATMOSPHERE engineers worked closely with CNES teams to adapt the solution to the operational environment. This collaboration included the

development of additional networking capabilities such as NAT functionality, optimization of VPN stability, and implementation of a software update to mitigate a modem hang-up scenario detected during vacuum testing.

CNES and ATMOSPHERE had a first opportunity to install and test PLANET LEO solution, on an actual Stratospheric Balloon for a test campaign from Timmins (Canada) in August and September 2025.

The PLANET LEO unit is installed on the payload chassis. The antenna, connected with a low loss cable, is placed to maximize sky visibility. The interface with Balloon on-board system computer is implemented with Ethernet connection.



Fig. 2: Views of PLANET 9770 Equipment on Balloon Structure

In the context of Stratoflight use case, PLANET connectivity is meant to support monitoring and control of the platform, including flight termination capability, and support optionally payload data transfer.

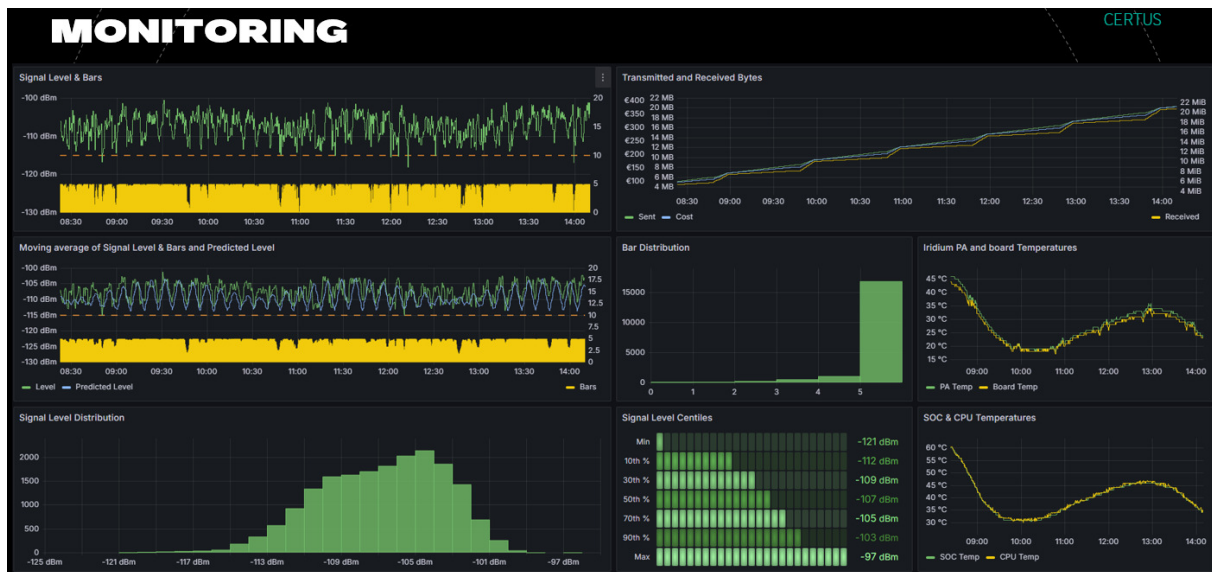


Fig. 3: PLANET LEO Equipment Monitoring example

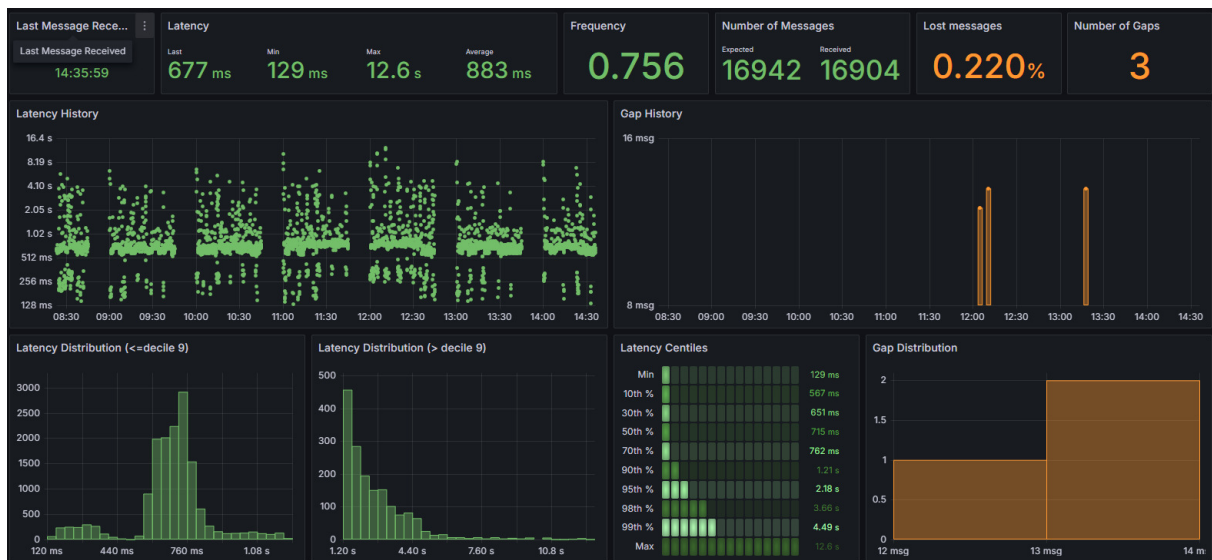


Fig. 4: PLANET LEO Communication Performance Monitoring example

In practice, each telemetry frame, roughly 250 bytes, is sent once per second and carries navigation data alongside system health information such as battery voltage, temperature and subsystem status. Uplink telecommands are issued individually and acknowledged by the platform, providing the operator with confirmation of every control action.

In the flight test campaign, the user traffic submitted to PLANET system was emulated. Test software collected and recorded PLANET system monitoring and performance data.

The equipment monitoring included continuous measurement of Iridium signal reception, communication traffic volume handled by the equipment, and several temperature measurements within PLANET unit (Power

Amplifier, transceiver electronics board, terminal computer board).

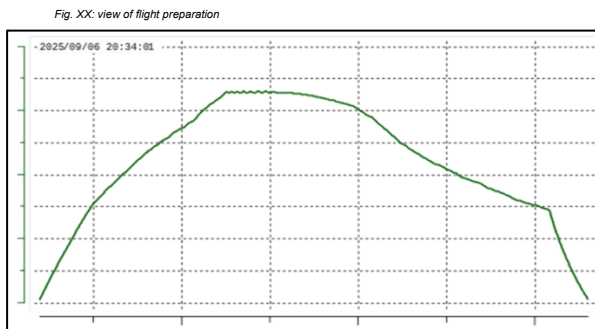
With the emulated communication traffic, it was possible to measure network performance, such as packet latency and packet loss, and derive statistical metrics such as latency and gaps distributions.

In addition to operational traffic emulation, throughput tests were alternatively performed. During those periods, latency measurements were not performed (this explains latency plot gaps visible in Fig. 4).

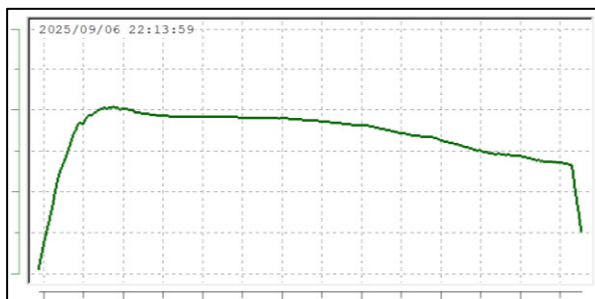
Two flights on Stratospheric Balloons have been performed by CNES and ASC from Timmins, Canada, performed between 10th of August and 12th of September 2025.



Fig. 5: view of flight preparation



Date 2025-08-19 - Around 6h of flight
 Max. altitude ~32km (105kft)
 Min. temperature -50°C
 Fig. 6: Flight Profile n°1



Date 2025-09-02 - Around 13h of flight
 Max. altitude ~20km (65kft)
 Min. temperature -60°C
 Fig. 7: flight n°2

PLANET LEO equipment operated nominally on both flights, and signal reception was good.

Communication performance has been tested with TCP and UDP, and with MO and MT traffic. The communication performance results show a stable behaviour in whichever mode it was tested. The two flights experienced similar results.

With operational traffic, latency in MO is higher than in MT. This is due to the underlying resource allocation of Iridium Certus™ 100. With the submitted traffic pressure, a C2 carrier is allocated by the system to the terminal, providing

a limited throughput. If traffic pressure grows (as when performing throughput tests), the system allocates a C8 carrier, to deliver full performance.

Latency (s)	Avg	95%	99%	Loss
Flight 1 MO	0.88	2.2	4.5	0.2%
Flight 1 MT	0.46	0.64	2.0	0.3%
Flight 2 MO	0.79	1.8	4,2	0.2%
Flight 2 MT	0.42	0.57	2.0	0.2%

Fig. 8: Latency and Loss Summary

The throughput tests demonstrated that maximum speeds were achieved in flight (cf. Fig. 9 and 10).

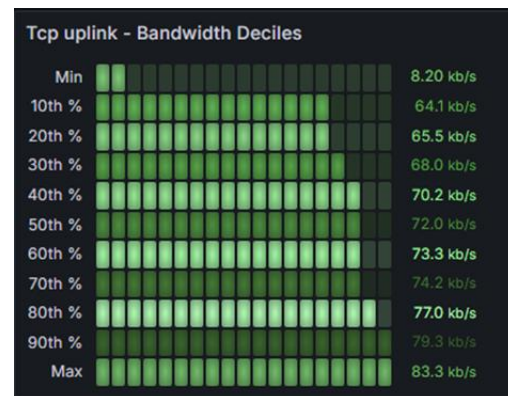


Fig. 9: MT throughput distribution

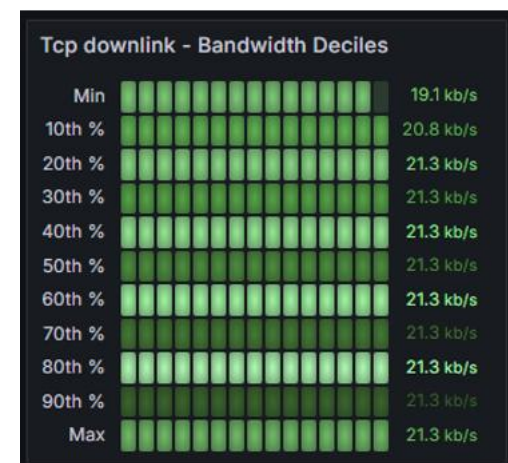


Fig. 10: MO throughput distribution

3. Return On Experience

The CNES experimental qualification programme successfully demonstrated that ATMOSPHERE's PLANET LEO terminal combined with Iridium Certus™ connectivity can provide a highly reliable communication link for monitoring and controlling stratospheric balloon platforms.

Performance results from the flight campaign included:

- Stable throughput and latency throughout the mission

- Low packet loss (~0.3%) for UDP telemetry traffic
- Zero packet loss in TCP communications, with more than 100,000 telecommands successfully transmitted
- Continuous connectivity in high-altitude and low-pressure environments

These results confirmed that the solution meets the requirements for command and control (C2) and flight termination system traffic, supporting critical balloon operations.

The test campaign allowed CNES to validate the performance of the PLANET connectivity solution in real operational conditions. By combining ATMOSPHERE's PLANET terminals with the Iridium Certus™ global satellite network, CNES now has a proven communication solution capable of supporting the next generation of safe, flexible and reliable stratospheric balloon operations.

4. Perspectives

In recent years, multiple new offers in terms of mobile satellite connectivity have been brought to the market, providing higher capacity and cheaper service. Hence, beyond PLANET LEO solution, CNES is currently studying how to exploit new satellite communication options in the context of Balloons flights. Following the successful experimental campaign, CNES confirmed that PLANET satellite connectivity meets the requirements for future stratospheric balloons infrastructure, currently under development.

On its side, based on Balloon 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 or Rocket 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

Through an extensive qualification programme, involving chamber tests and in-flight tests, it was demonstrated that PLANET LEO solution is a

viable option for future CNES Balloon infrastructure. CNES and ATMOSPHERE plan to further collaborate on the industrialization of the solution.

Acknowledgement

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References and links

Reference documents, publications and web links are listed here-after:

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Glossary

ASC:	Agence Spatiale Canadienne
BSO:	Ballon Stratospherique Ouvert
DLR:	Deutsches Zentrum für Luft- und Raumfahrt
FTI:	Flight Test Instrumentation
FTS:	Flight Termination System
HAPS:	High Altitude Platform Station
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
MO: Mobile Originated
MT: Mobile Terminated
NAT: Network Address Translation
PNT: Positioning, Navigation, Timing
SME: Small and Medium Enterprise