2025

IAF SPACE COMMUNICATIONS AND NAVIGATION COMMITTEE (SCAN)

Introduction

The International Astronautical Federation (IAF) Space Communications and Navigation Committee (SCAN) deals with all aspects of space-based systems, services, applications, and technologies for communications and navigation. This includes fixed, broadcast, high-throughput, mobile, optical, quantum, and deep space communications, as well as position, velocity, time determination and tracking for navigation. The Internet of Things (IoT), Machine-to-Machine (M2M) topics, and Artificial Intelligence (AI) / Machine Learning (ML) technologies related to communications and navigation are also in the scope of this Committee.

Summary

The space navigation sector is evolving with new PNT services in LEO and lunar domains, while traditional GNSS systems advance with upgrades by India, Russia, China, the U.S., and Europe. LEO-PNT initiatives are expanding beyond Satellites/Iridium's STL, with demonstrations from Xona, ESA, and others. LEO-PNT developments must be viewed in the context of considerable interest in improving the resilience and reliability of GNSS-based navigation services due to the demonstrated vulnerability of GNSS-based navigation due to the alarming increase in jamming and spoofing of GNSS signals. Deep-space navigation faces capacity limits but sees progress with new DSN antennas and lunar GNSS experiments. Standardization efforts, such as LunaNet specifications and UN coordination, aim to enable interoperable lunar navigation services.

Space communications is developing rapidly due to its wide commercial and strategic applications. While wide beam and High Throughput Satellites (HTS) are still in-orbit, Medium Earth Orbit (MEO) satellites now provide backup capabilities that expand the applications. On other hand, private communication services in LEO are no longer limited by voice and low-speed data. Mega-constellations like Starlink, designed to provide high-speed internet to both enterprise and private use, are now capable of communicating directly with mobile devices. The new tendency is to build Very LEO (VLEO) mega-constellations to increase speed for mobile use and close gaps in terrestrial mobile networks by enabling direct-to-device connectivity. The map of users of mega-constellations has expanded. Intersatellite links, IoT and laser communication technologies are also being improved in order to expand multi-orbit communications systems, increase data speed and enhance automation for satellites and devices on the ground, on the ocean, and in the air.

Highlights

The space navigation sector is undergoing a transition, with new PNT services being introduced in both Lunar and LEO, alongside renewed calls for greater resilience and high accuracies in service delivery. With regard to traditional GNSS infrastructure upgrades, India is extending NavIC with an L1 civil signal using the new signal modulation format SBOC, Russia's GLONASS program is fielding it's K2-generation with its most recent launch in 2025, and China continues to increase its constellation size exceeding over 50 satellites across multi-layer orbits.

To support resilience, the U.S. continues GPS M-code roll-out with IIIF bringing Regional Military Protection (RMP) beam-steering when those spacecrafts are on-orbit, alongside a more rapidly deployed GPS constellation through the R-GPS program. Galileo's Open Service Navigation Message Authentication (OSNMA) moved from long-running test mode to initial service this year, providing civilian receivers with a free signal-authentication option against spoofing (data-level authentication on E1 I/NAV).

New LEO-PNT infrastructure makes advances, with new contenders from USA, China, Europe, Japan and the UAE, with other regions and nations also seeking to participate. While Satelles/Iridium's STL remains the only operational LEO timing/positioning service at global scale today, Xona has demonstrated an in-orbit demo signal in the L1 and L5 bands. Other demonstrations have been proposed by Trustpoint, ESA, and ArkEdge Space, to develop signals in an extended band allocation towards VHF, S- and C-band, in addition to L-band.

Deep-space navigation infrastructure expands but remains capacity-constrained. NASA is adding DSN antennas (e.g., DSS-23) as loading pressures continue, while also ESA is bringing a new 35-m New Norcia dish online and upgrading sensitivity. LuGRE has however demonstrated the use of GNSS signals in the lunar domain, which would provide a pathway to alternative navigation systems alongside optical for lunar missions.

In January 2025, the LunaNet Interoperability Specification (Version 5) was released, providing a standard to how lunar communications & navigation providers could interoperate. This complements the signal-in-space draft ICD for a LunaNet signal, which are being developed by NASA, ESA and JAXA. India has proposed new pseudolite infrastructure for ground operations. UNOOSA's ICG has constituted a new working group WG-L dedicated to lunar PNT in an effort to coordinate various developments and to accelerate service delivery for lunar users.

A major highlight in the space communications field this year has been the rise of Direct-to-Device (D2D) and Direct-to-Cell (D2C) services. Last year, SpaceX launched Starlink satellites equipped for direct links to smartphones and successfully exchanged text messages using T-Mobile's network. Since then, it has begun offering direct communication services in collaboration with multiple telecom operators worldwide using Starlink satellites placed at an orbital altitude of 340 km, with data services expected to follow soon in addition to text messaging. Meanwhile, AST SpaceMobile launched five satellites under its BlueBird 1–5 mission in September 2024 and successfully deployed the antennas on all of them by October. In November of the same year, the company announced a next-generation plan to launch around 60 Block 2 BlueBird satellites and revealed multiple launch agreements with SpaceX, Blue Origin, and the Indian Space Research Organization (ISRO).

In terms of satellite constellations, Starlink has continued to increase its fleet, reaching 9,925 satellites launched by October 2025. In the United States, as of July 2025, the network was achieving a peak-time median downlink speed of up to 200 Mbps and a peak-time median latency of 25.7 ms. Expansion of the D2D satellites described above has been another key highlight. Amazon's Project Kuiper launched 153 satellites in October 2025 as part of building its planned 3,236-satellite constellation and is preparing to begin initial service by the end of the year. In China, China Satnet's Guowang and Shanghai Spacecom Satellite Technology's (SSST) Qianfan are emerging, each planning constellations of more than 10,000 satellites. Guowang launched its first satellites in December 2024 and Qianfan in August 2024, and both have now placed roughly 100 satellites into orbit. At the level of national and regional flagship programs, the European Commission (EC) and the European Space Agency (ESA) signed a contract in December 2024 with the SpaceRISE consortium, comprising SES, Eutelsat, and Hispasat, for the IRIS² program. The program plans to deploy a 290-satellite multi-orbit network in Medium Earth Orbit (MEO) and two layers of Low Earth Orbit (LEO) and aims to begin service by 2030.

Regarding optical satellite communications, in December 2024, the French Space Agency (CNES) and Airbus demonstrated successful tracking, downlink and uplink tests between TELEO geostationary in-orbit demonstrator and ground stations. The tests used several optical ground stations, including ESA's facility on Tenerife in Spain and, in France, both the FrOGS station at the Côte d'Azur Observatory and ONERA's FEELINGS, to demonstrate that laser links can reliably transfer large volumes of data between space and Earth under real conditions. The Space Development Agency (SDA) in the U.S. has successfully demonstrated inter-vendor optical link interoperability between York Space Systems and SpaceX Tranche 0 satellites. In September 2025, it was reported that a successful bidirectional optical communication test had been carried out between an SDA Tranche 0–compatible Kepler satellite and an aircraft. In the private sector, SES and Cailabs announced plans to demonstrate satellite-to-ground optical communications with next-generation optical ground stations. Aalyria, a Google spin-off operating in the U.S. and U.K., announced that its Tightbeam system maintained a 100 Gbps optical link across 65 km of atmosphere under real-world conditions. These and other players are pushing optical links into practical use.

High-Altitude Platform Stations (HAPS) flying in the stratosphere at around 20 km altitude, capable of providing low-latency communications, are also seeing accelerated activity in Japan, aimed at disaster recovery and coverage expansion in mountainous and remote islands. SoftBank has announced its intention to start pre-commercial HAPS services in Japan in 2026. It is also investing in Sceye, which develops lighter-than-air (LTA) HAPS, alongside its ongoing work on heavier-than-air (HTA) HAPS to speed up deployment. Meanwhile, Space Compass and NTT DOCOMO have invested in Airbus subsidiary AALTO, and successfully demonstrated smartphone direct 4G connectivity using its Zephyr platform at 20 km altitude over Kenya.

Outlook

As we look to the future, there will be a heightened focus on strengthening the resilience and accuracy of PNT. The incorporation of LEO satellite signals as "signals-of-opportunity" or the deployment of dedicated LEO navigation constellations shows promise of enhancing PNT capability in specific scenarios. This shift will require the development of new receivers and technologies capable of managing the diverse signals from existing GNSS constellations and emerging LEO-based systems. Additionally, the distinction between military and civilian GNSS applications may lead to further advancements in the civilian sector to ensure secure and reliable PNT services.

Noteworthy progress is also being made in deep space navigation, particularly with the development of the Deep Space Atomic Clock (DSAC-2), which aims to offer unparalleled timing accuracy for interplanetary missions. The ongoing initiatives to establish a Coordinated Lunar Time system and advances in NASA's Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) highlight the increasing importance of precise navigation in cislunar space and beyond. As humanity prepares for more ambitious space exploration missions, these innovations will play a crucial role in enabling safe and efficient operations in increasingly challenging space environments.

The existing mega-constellations will continue to grow and upgrade, as more VLEO, LEO and MEO communication satellites will be launched. New capabilities provided by satellites may soon affect mobile devices standard functions, as in the case of GPS receivers introduced in the past. Cooperation between satellite and mobile network providers may grow as well. As satellite operators are entering multi-orbit business now, they may enter the mobile communications area in future.

Committee activities

The Committee approved updated session descriptions for IAC 2025 B2 symposium in Sydney and improved the abstract selection process by helping authors to properly identify the specific session for their submission. The International Astronautical Congress (IAC 2025) will be the second B2 symposium after the re-organization of each session and the Committee will monitor the situation and improve more for the next IAC.

The IAF SCAN Committee proposed the special session on "Building Bridges: Taking Optical Networks to Earth Orbit and Beyond" held at IAC 2025 in Sydney and sponsored by National Institute of Information and Communications Technology (NICT), Japan (Fig. 1). This interactive session brought the world of fiber-based communication technologies together with the space industry to explore how free-space optical communications is changing how we look at networks. The goal of this session was to explore technology roadmaps that could deliver the innovations needed to one day realize a truly interplanetary Internet.

Fig. 1. Special session on "Building Bridges: Taking Optical Networks to Earth Orbit and Beyond" organized by the IAF SCAN committee at IAC 2025 in Sydney and sponsored by NICT.