2024

IAF SPACE COMMUNICATIONS AND NAVIGATION COMMITTEE (SCAN)

Introduction

The Space Communications and Navigation Committee (SCAN) deals with all aspects of space-based systems, services, applications, and technologies for communication and navigation. This includes fixed, broadcast, high-throughput, mobile, optical, and quantum 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 communication and navigation are also in the scope of this committee.

Summary

Space navigation is undergoing rapid evolution as advancements in Global Navigation Satellite Systems (GNSS), Regional Navigation Satellite Systems (RNSS), and Satellite-Based Augmentation Systems (SBAS) drive improvements in positioning, navigation, and timing (PNT) accuracy and resilience. Major GNSS constellations, such as GPS, GLONASS, Galileo, and BeiDou, are continuously upgrading their systems with new capabilities, including enhanced signal structures, inter-satellite links, and expanded services. Meanwhile, regional systems like QZSS and NavIC are moving towards greater independence and improved functionality. These advancements are crucial in an era where the susceptibility of satellite-based PNT systems to disturbance, by jamming and spoofing, has become increasingly evident. Concurrently, research and development into alternative PNT technologies, such as Low Earth Orbit (LEO) satellite-based systems and terrestrial innovations, are gaining momentum to ensure reliable navigation services are available.

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 the 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 ground, on water, and in the air.

Highlights

The current landscape of GNSS is marked by significant upgrades and expansions. GPS is in the process of launching its latest generation GPS-III satellites, featuring the new civilian L1C signal and other improvements. Galileo is progressing towards full deployment with a launch of 2 satellites on 28 April 2024 and 2 more planned for launch on 17 Sep 2024. The introduction of its next-generation Galileo 2.0 is expected to bring about increased accuracy and security through innovations such as inter-satellite links. BeiDou and GLONASS are enhancing their capabilities, with BeiDou introducing new services and GLONASS improving its signal diversity.

In addition to these GNSS advancements, the SBAS and RNSS sectors are witnessing the emergence of new systems and services. The expansion of QZSS to a 7-satellite constellation, the introduction of a Signal Authentications Service for QZSS in April 2024 and the inclusion of an L1 signal in NavIC underscore the trend towards more autonomous and interoperable regional navigation solutions. Furthermore, SBAS is evolving

with dual-frequency, multi-constellation services (SBAS-DFMC) and high-accuracy systems (SBAS+), providing enhanced positioning accuracy and integrity. The growing reliance on GNSS has also led to the exploration of complementary technologies, such as utilizing LEO satellites for navigation or the development of quantum sensors, to ensure continuous PNT services even in challenging conditions.

One of the most remembered satellite communications business news of 2024 is the SES announcement of Intelsat acquisition, both being top global telecom companies. This expands the multi-orbit capabilities of SES. SES Space & Defense partnered with Planet Labs (Planet), a provider of global daily Earth data using SES's O3b mPOWER satellite constellation in MEO and Planet's LEO flight-representative terminal in order to demonstrate data relay services for NASA. In the meantime, TTP is working with Surrey Satellite Technology Ltd (SSTL) to launch a new data relay terminal into space. The terminal can provide a constant link between LEO small satellites and Earth through a geostationary orbit (GEO) satellite relay. More GEO communications satellites are being developed and launched: CASC launched the second "High orbit internet satellite", Astranis is developing a "record-breaking" 50 Gbps Omega small satellite, and Thales will develop optical communication payload for Hellas Sat, while advancing its capabilities to deliver 1 Tbps capacity in collaboration with European agencies. New announcements from the field of optical and quantum communication are constantly arriving. On 16th August, the German quantum communication satellite, the QUBE was launched with SpaceX's Falcon-9 on the Transporter 11 mission. The aim of the research network "Quantum Key Distribution with CubeSat (QUBE)" is to develop and demonstrate core technologies for worldwide tap-proof communication using satellite-based quantum key distribution. The development of Eagle-1, the European Union's quantum communication satellite is ongoing with a planned launch date in 2026. Mynaric will develop Laser terminals for Finland-based ReOrbit's UKKO mission to demonstrate space-to-space and space-to-ground data transmission for Earth observation. Dutch research firm TNO and AAC ClydeSpace have successfully transferred data from a laser satellite communications terminal in space down to the optical ground station in The Hague at a maximum data rate of 1 gigabit per second. The Canadian-based Kepler has been working with a pair of prototype crafts and the automatic "cooperation" between telecom satellites is one of the main subjects. Another good example is the launch of Lockheed Martin's Pony Express 2 satellites to demonstrate the technology of mission automation and mesh networking for tactical communications.

Satellites' support of IoT brings new applications for consumers. Iridium is designing its initial Narrow-Band-IoT offering to support 5G Non-Terrestrial Networks (NTN) messaging and SOS capabilities for smartphones, tablets, cars, and related consumer applications. With the launch of its first LEO satellite constellation with 5G standards for IoT and 100% global coverage, satellite operator Sateliot is entering into the commercial phase. Satellite constellations can be dedicated to specific areas of communications and navigation. Chinese automaker Geely Holding Group said it has launched 11 LEO satellites, as it expands its capacity to provide more accurate navigation for autonomous vehicles. Spire, in cooperation with Thales and European Satellite Services Provider (ESSP), will build more than 100 satellites that will collect Automatic Dependent Surveillance-Broadcast (ADS-B) messages broadcast from aircraft.

While the number of Starlink satellites keeps growing and counts more than 6000 now, other mega-constellation projects are progressing as well. ESA secured an investment for IRIS2. China recently launched the first batch of satellites for a mega-constellation of 14,000. Amazon rescheduled beta-service of Kuiper to the next year.

While the number of satellites in LEO increases exponentially, MEO also becomes busy. SES has announced that O3b mPOWER, its second-generation software-enabled satellite system, is now operational.
The recent trend in satellite communications direct-to-device services is becoming a reality.

SpaceX announced its Starlink unit successfully completed sending and receiving a text message using T-Mobile network spectrum through one of its recently launched direct-to-phone satellites. Many terrestrial broadband operators have already signed up for access to the satellites. Apple, which uses Globalstar's satellites, recently announced it is expanding satellite messaging beyond just emergency situations on the iPhone with iOS 18, and satellite messaging will be an option when cellular and Wi-Fi connections are not available. Omnispace is exploring how its proposed constellation of more than 600 LEO satellites could help connect phones and other devices subscribed to several mobile service providers.

In order to increase the capabilities of mega-constellations, companies are developing their VLEO systems. Redwire is one of them, with its Phantom spacecraft platform designed with Thales for ESA to stay below 300 km during 5 years of mission life. SpaceX also plans to significantly improve latency using VLEO. This will also help the enhancement of the direct-to-phone services.
Some other operators create devices capable of

connecting both to mobile and satellite networks. Thuraya Telecommunications Company revealed its new 'skyphone', a smartphone with satellite connectivity for consumers and businesses in dual mode.

Government and commercial customers are seeking innovative ground systems to communicate with large satellite constellations in LEO and with constellations that include spacecraft in different orbital planes. While L3Harris Technologies developed a compact Digital Beamforming Phased Array Antenna System, Requtech, a Swedish technology company, has unveiled the RESA L KA, a Ka-band multi-orbit land mobility terminal. Starlink has begun advertising community gateways as part of the business portfolio of Starlink services.

Future 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 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 dependable 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 Co-ordinated Lunar Time system and the advancements 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 intricate 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 GPS receivers have been introduced once. Cooperation between satellite and mobile network providers may grow as well. As satellite operators are entering the multi-orbit business now, they may enter into the mobile communications area in future.

Committee activities

The committee approved updated session descriptions for IAC 2024 B2 symposium in Milan and improved the abstract selection process by helping authors to properly identify the specific session for their submission. The IAC 2024 will be the first B2 symposium after the re-organization of each session and the committee will monitor the situation and improve more for the next IAC.

The first IAF SCAN Webinar on "Perspectives of Satellite-Based Quantum Communications" was organized by the committee and held on 3 April 2024. The recorded video of the IAF SCAN Webinar is available online on YouTube.

The synergy between laser communication and optical fiber industries was discussed, and a workshop will be considered in the future. The committee will also consider a Plenary or Special session to bridge the PNT and Space communities, to be sponsored jointly with B4 Small Sats.