International GNSS Service (IGS)

Chair of the Governing Board: **Gary Johnston** (Australia)
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http://www.igs.org/

Background

For over twenty-five years, the International Global Navigation Satellite System (GNSS) Service (IGS) has carried out its mission to advocate for and provide freely and openly available high-precision GNSS data and products. IGS was first approved by its parent organization, the International Association of Geodesy (IAG), at a scientific meeting in Beijing, China, in August of 1993. A quarter century later, the IGS community gathered for a workshop in Wuhan, China, in October/November 2018 to blaze a path to Multi-GNSS through global collaboration.

The Mission of the IGS is to "provide on an openly available basis, the highest-quality GNSS data, products, services in support of the terrestrial reference frame; Earth observation and research; Positioning, Navigation and Timing (PNT); and other applications that benefit the scientific community and society."

In 2019, the IGS adopted an official slogan: "Providing openly available GNSS data and products that benefit science and society," as well as an official organizational vision: "A better understanding of the Earth through the application of GNSS."

Community Collaboration

At the heart of the IGS is a strong culture of sharing expertise, infrastructure, and other resources for the purpose of encouraging global best practices for developing and delivering GNSS data and products all over the world. The collaborative nature of the IGS community, which as of 2019 includes over 140 GNSS stakeholder organizations from 45 countries leverages this diversity to integrate and make full use of all available GNSS technologies while promoting further innovation. Over 15,000 product users, some of whom comprise the backbone of the worldwide geodetic community, ensure that new technologies and systems are integrated into routine IGS products. Responsive to this innovation, the IGS develops and publicly releases standards, guidelines, and conventions for the collection and use of GNSS data and products. The IGS strives to maintain an international federation with committed contributions from its members. To view the list of IGS Governing Board members, please visit: http://www.igs.org/about/gb

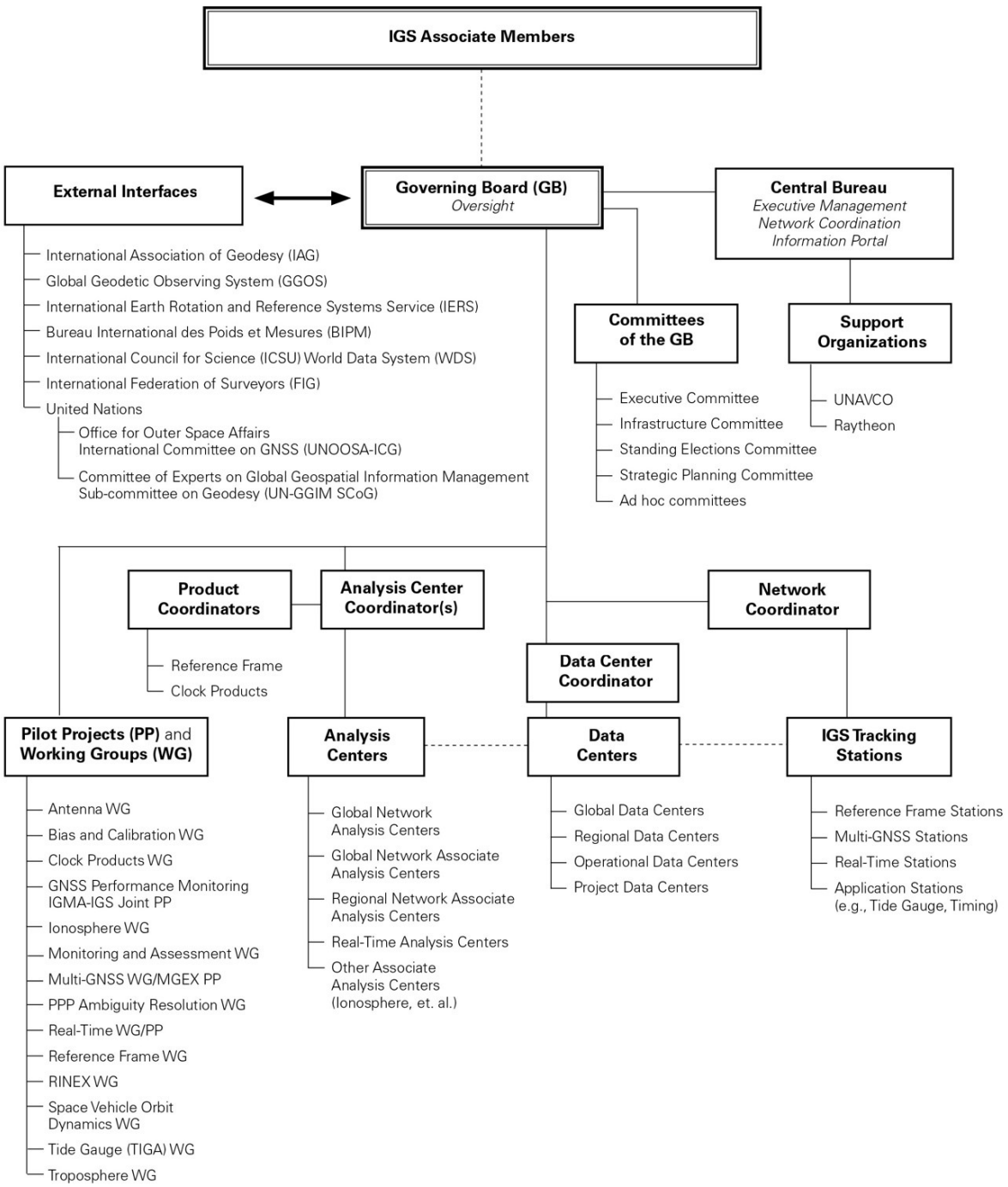
Underpinning Observing Systems and Reference Frames

The IGS is a critical component of the IAG's Global Geodetic Observing System (GGOS), where it facilitates cost-effective geometrical linkages with and among other precise geodetic observing techniques, including: Satellite Laser Ranging (SLR), Very Long Baseline Interferometry (VLBI), and Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS). These linkages are fundamental to generating and accessing the International Terrestrial Reference Frame (ITRF).

Engagement with the United Nations

IGS engages with diverse organizations that have an interest in geodetic applications of GNSS. Notably, the IGS has supported the development of the Global Geodetic Reference Frame (GGRF) resolution, roadmap, and implementation plan within the United Nations (UN) Global Geospatial Information Management (GGIM) Committee of Experts (http://ggim.un.org). IGS also participates in the United Nations Office for Outer Space Affairs (UNOOSA) International Committee on GNSS (ICG).

IGS Structure and Association with International Scientific Organizations, as of 2020



Data and Analysis Centers

The IGS ensures high reliability by building redundancy into all its components. Critical to this activity are three categories of data center – operational, regional, and global. At the "ground level" are operational data centers, which are in direct contact with IGS tracking sites, and are responsible for such efforts as station monitoring and local archiving of GNSS data. Operational data centers also validate, format, exchange, and compress data. Regional data centers then collect tracking data from multiple operational data centers or stations, maintaining a local archive and providing online access to their data.

The six global data centers (Crustal Dynamics Data Information System, Scripps Institution of Oceanography, European Space Agency /ESAC, Korean Astronomy and Space Science Institute, Institut National de l'Information Géographique et Forestière, and Wuhan University) receive, retrieve, archive and provide online access to tracking data from operational and regional data centers. The Data Center Coordinator ensures coordination among data centers, as well as global data centers archiving and backing up IGS data and products, and maintaining a balance of data holdings across the IGS network.

Analysis centers then receive and process tracking data from one or more data centers for the purpose of generating IGS products, including satellite ephemerides, Earth rotation parameters, station coordinates, and clock information. These products are produced in ultra-rapid, rapid, final, and reprocessed versions for each analysis center.

Associate analysis centers produce specialized products, including ionospheric information, tropospheric parameters, or station coordinates and velocities for global and regional subnetworks. Regional and global network associate analysis centers complement this work as new capabilities and products emerge within the IGS.

Products from each analysis center are then combined into a single set of orbit and clock products by the Analysis Center Coordinator, who monitors and assists the activities of analysis centers to ensure IGS standards for quality control, performance evaluation, and analysis are successfully executed. The Analysis Center Coordinator also regularly collaborates with the International Earth Rotation and Reference System Service (IERS) on behalf of the IGS.

Growing a Multi-GNSS IGS Network

The foundation of the IGS is a global network of over 500 permanent and continuously operating stations of geodetic quality. These stations track signals from GPS, and increasingly also track signals from GLONASS, Galileo, BeiDou, QZSS, NavIC (IRNSS) as well as space-based augmentation systems (SBAS). As of late 2019, the IGS has 506 Stations, of which 308 are Multi-GNSS stations, and 259 Real-time stations. Central Bureau collaboration with the Infrastructure Committee ensures appropriate and timely addition and decommissioning of stations, along with collaboration with the Antenna Working Group for regular changes to station antennas and rcvr_ant.tab file. The percentage of multi-GNSS capable IGS network is expected to grow in the coming years.

The IGS Multi-GNSS Experiment (MGEX) was founded in 2012 to build a network of GNSS tracking stations, characterize the space segment and user equipment, develop theory and data-processing tools, and generate data products for emerging satellite systems. The stations within its network contain a diverse assortment of receiver and antenna equipment that are recognized and characterized by the IGS in equipment description files. Other than GPS and GLONASS, no combination process has yet been implemented within IGS for precise orbit and clock products of the other, newer, constellations. Despite this, inter-comparison among analysis centers, as well as utilizing Satellite Laser Ranging (SLR), has been used to assess the precision or accuracy for various products.

The growing role of multi-GNSS within the IGS network was benchmarked by the transition of MGEX to official IGS Project status in 2016. For the sake of consistency, and as a nod to its heritage, use of the acronym "MGEX" has been retained. MGEX and its associated Multi-GNSS Working Group recently published a comprehensive paper detailing its achievements in the last five years, future prospects, and challenges. The article, published in Advances in Space Research, Volume 59, Issue 7, 1 April 2017, Pages 1671–1697, discusses the multi-GNSS products derived from the IGS monitoring station network as well as progress made within the MGEX Project to include BeiDou, Galileo, and QZSS for precise point positioning, atmospheric research, and other applications.

Further improvements are expected through better characterization of spacecraft and respective refinements of radiation pressure models, antenna phase center variations, and other effects. In response to this, the Multi-GNSS Working Group released a White Paper, titled "Satellite and Operations Information for Generation of Precise GNSS Orbit and Clock Products." The paper discusses the parameters needed to ensure the highest possible performance of IGS products for all constellations and clearly articulates the need for open provision of satellite and certain other operations information by the GNSS providers.

A Multi-GNSS Future

Though the accuracy of current IGS multi-GNSS products lags standard IGS products for GPS and GLONASS, multi-GNSS paves the way for complete exploitation of new signals and constellations in navigation, surveying, geodesy, and remote sensing. For complete, current information about MGEX, please visit the MGEX part of the IGS website: http://mgex.igs.org/.

As it enters its second quarter-century, the IGS is evolving into a truly multi-GNSS service. In response to ever-growing applications for precise GNSS data as a public utility, the IGS conducts regular reviews of its activities, products, and services. The IGS also works with ICG to develop common understandings of the requirements for system monitoring through a joint pilot project with the ICG's International GNSS Monitoring and Assessment (IGMA) subgroup.

IGS also looks outward to other techniques through its participation in the IAG's GGOS, which has illuminated how SLR observations to GNSS satellites, as well as GNSS observation of non-GNSS satellites, has a key role to play in improving our understanding of observational errors and thus drive further improvement of IGS products.