International GNSS Service

IGS is a service of:

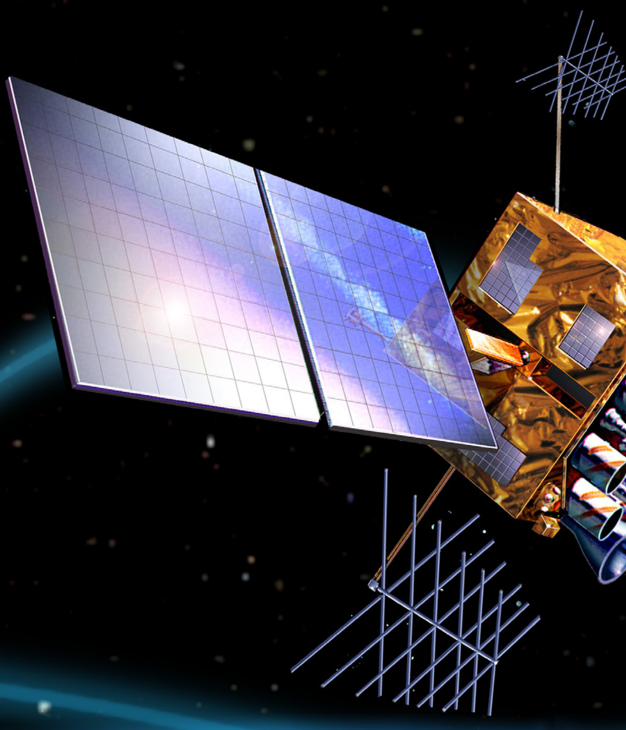
Global Geodetic Observing System
International Association of Geodesy

International Union of Geodesy and Geophysics

International Council for Science
World Data System

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



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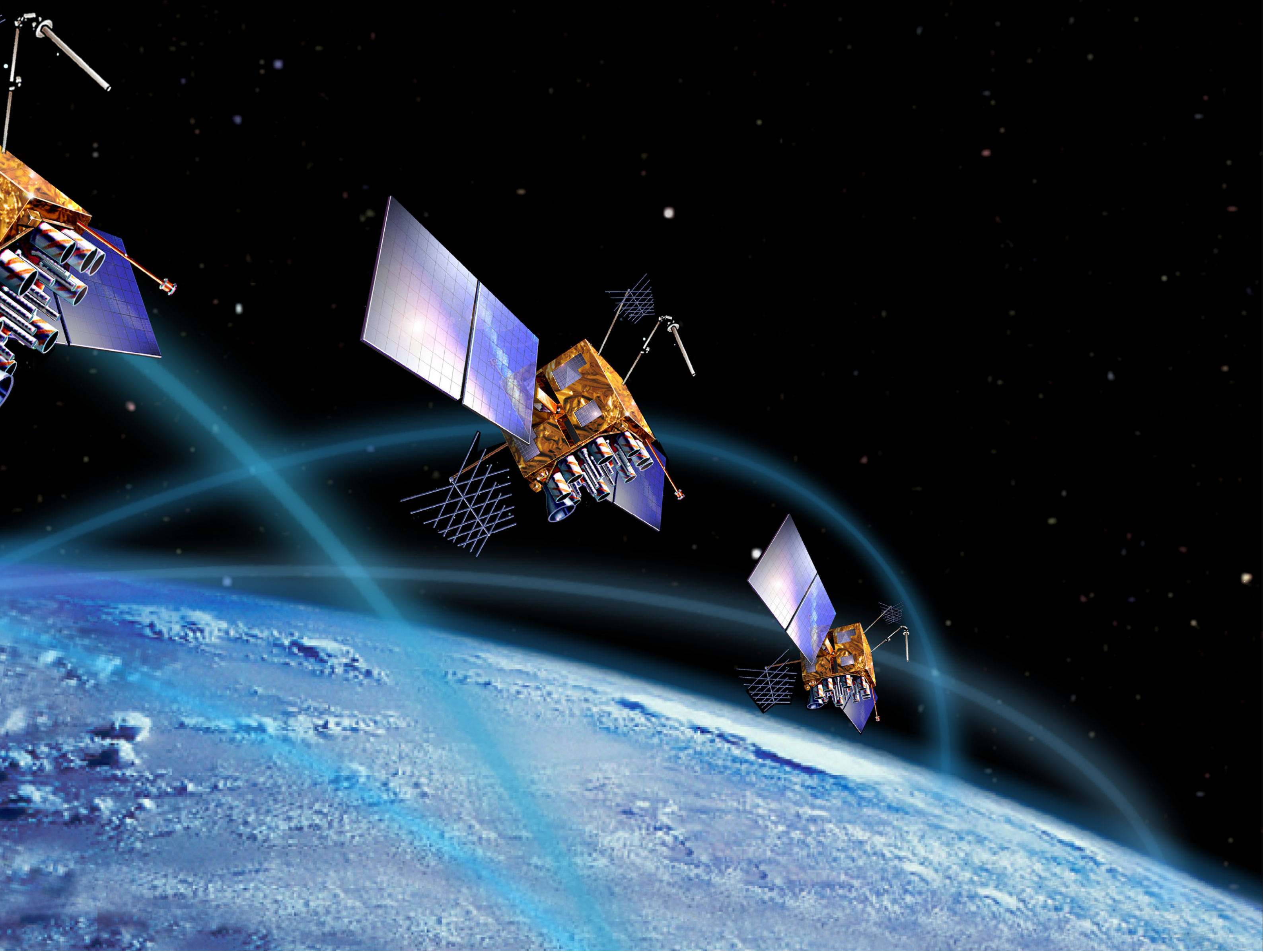
INTERNATIONAL GNSS SERVICE

Strategic Plan

2013-2016



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INTERNATIONAL GNSS SERVICE

Strategic Plan

IGS Central Bureau
December 2012

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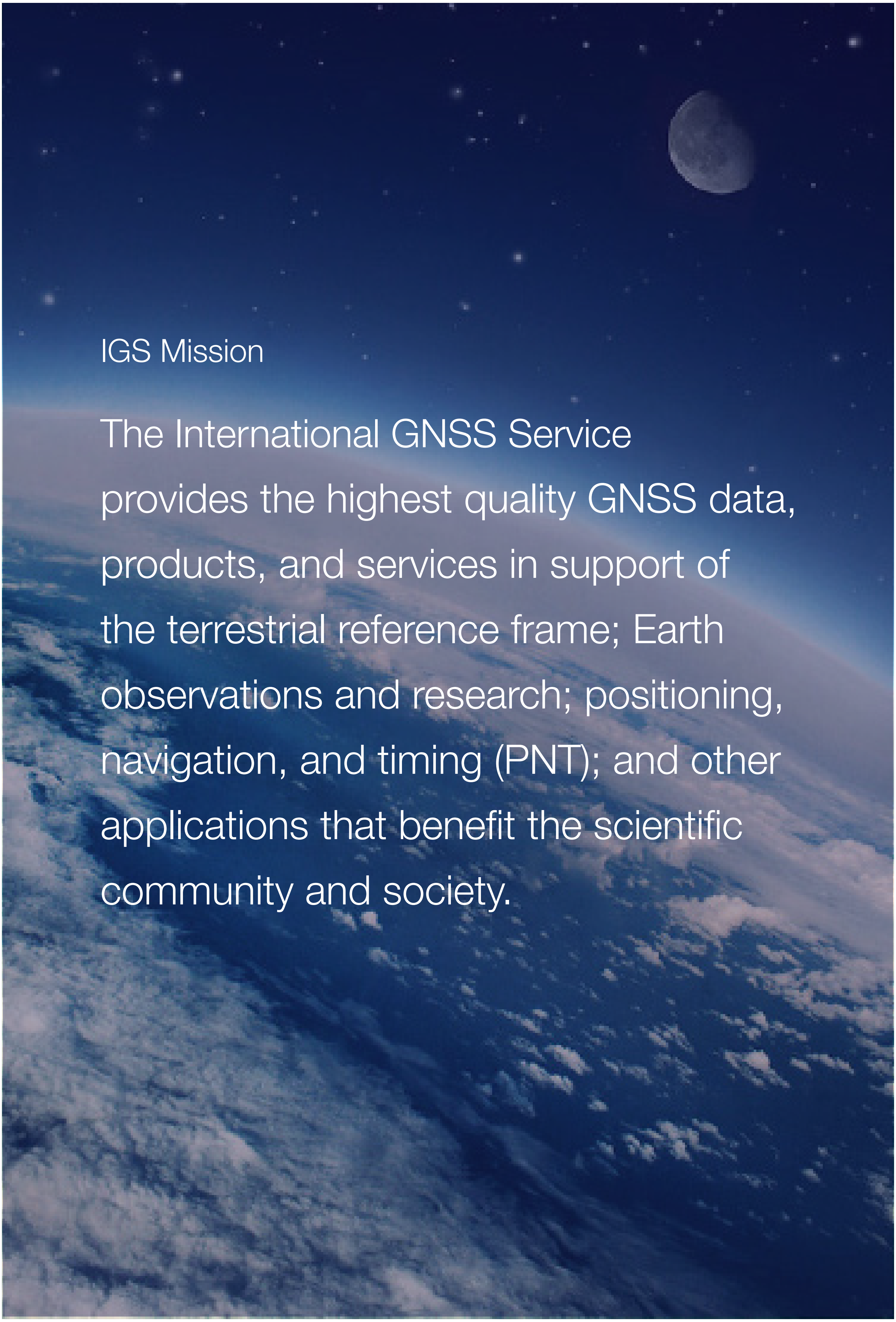


IGS Mission

The International GNSS Service provides the highest quality GNSS data, products, and services in support of the terrestrial reference frame; Earth observations and research; positioning, navigation, and timing (PNT); and other applications that benefit the scientific community and society.

IGS Preface

The International GNSS Service (IGS) is a federation of more than 200 worldwide agencies and institutions in over 90 countries. This federation combines resources and expertise to provide the highest quality Global Navigation Satellite Systems (GNSS) data, products, and services in order to support high-precision applications of GNSS. The IGS is a service of the International Association of Geodesy (IAG), one of the associations of the International Union of Geodesy and Geophysics (IUGG), and a key component of the Global Geodetic Observing System (GGOS). IGS operates as a voluntary federation that is self-governed by its participants through an elected Governing Board. Each participating organization contributes its own resources, and there is no central source of funding.

The IGS operates a global network of GNSS ground stations, data centers, and data analysis centers to provide data and derived data products that are essential for Earth science research; multidisciplinary positioning, navigation, and timing (PNT) applications; and education.

IGS products include:

- GNSS satellite ephemerides
- Earth rotation parameters
- Global tracking station coordinates and velocities
- Satellite and tracking station clock information
- Zenith tropospheric path delay estimates
- Global ionospheric maps

These products support Earth science analyses and other efforts, such as:

- Improving and extending the International Terrestrial Reference Frame (ITRF) maintained by the International Earth Rotation and Reference Systems Service (IERS),
- Coordinated Universal Time (UTC),
- Measuring and monitoring the length of day,
- Monitoring deformation of the Earth,
- Monitoring Earth rotation,
- Monitoring the composition and state of the troposphere and ionosphere,
- Determining orbits of scientific satellites,
- Comparison of clocks,
- and other diverse applications.

IGS Executive Summary

The work of the IGS, and its constituent elements, continues to increase in relevance in the face of major global challenges such as climate change and sea level rise. Furthermore, ensuring an accurate, collaborative multi-GNSS service is becoming even more useful with the prediction, monitoring, and mitigation of severe natural disasters, such as earthquakes, tsunamis, and volcanic activity. The IGS Governing Board works in support of continuous improvement of the IGS suite of data and data products, made possible by the efforts of many dedicated contributors to the IGS. This Strategic Plan outlines key points of the IGS goals and the anticipated path to meet its objectives.

Since the IGS Governing Board adopted its previous Strategic Plan, a number of developments have taken place inside and outside the IGS that make it imperative to update the plan. While much of the Strategic Plan 2008–2012 remains valid, this new plan is developed for 2013–2016. Three key strategic goals were derived from extensive surveys and analyses:

- Establish IGS as the world benchmark for GNSS products and services with leading-edge expertise and resources; and the development, integration, and evolution of services and performance to meet user needs.
- Ensure that the IGS plays an expert advisory role on GNSS matters through expertise and policy advocacy.
- Maintain the highest level of governance of the IGS, and exercise funding development needed to maintain its infrastructure and operation.

The broad strategic lines remain as before, but a significant number of the derived actions are new, as described in this plan.

The IGS strategic planning process is an ongoing effort. The Governing Board completed a systematic update of the IGS Terms of Reference (ToR) and associated charters for coordinators, working groups, and pilot projects; adopting the new version in December 2010 — the first revision since 2005. Significant modifications included establishment of the IGS Infrastructure Committee; changes to the composition of the Governing Board, clarifying roles of the IGS Executive Committee; detailing Associate Member roles; incorporating strategic planning into the ToR to match strategic goals and objectives; and detailing expected outcomes of IGS workshops and follow-on recommendations.

In parallel with these IGS internal developments, the IGS has been working with the International Association of Geodesy (IAG) and its other scientific services and commissions to further develop the Global Geodetic Observing System (GGOS). This system is federating the activities and products of the IAG scientific services and commissions, and provides the geodetic contribution to the Global Earth Observing System of Systems (GEOSS). GEOSS is an activity of the intergovernmental ad hoc Group on Earth Observations (GEO) (see http://www.earthobservations.org/).

A central issue of the GGOS initiative is the International Terrestrial Reference Frame (ITRF), its future development, and its correct and consistent use. The IGS, with its prime concern for high precision, accuracy, and reliable processing of the signals of the GNSS constellations, and as the provider of the consolidated inputs of the GNSS contribution to the ITRF, is required to play a key role in GGOS and in the broader activities, such as the strengthening of GEOSS. IGS also contributes, through GGOS, to the Committee on Earth Observation Satellites (CEOS), which is facilitating a stronger and more formalized relationship with GEO/GEOSS.

The International Committee on GNSS (ICG) was officially established through the United Nations Office for Outer Space Affairs (UNOOSA) in December 2005, following extensive preparatory meetings and actions over several years, in which the has IGS played an active role since 2001. ICG members are GNSS national providers; also included in the ICG are associate members — consisting mainly of intergovernmental and nongovernmental organizations that are users of GNSS — and observers.

As the foregoing discussion reflects, the IGS is playing a prominent, ever-increasing role in the international GNSS arena. The field is changing rapidly, with the modernization of the GPS system (including the deployment of the GPS IIF, GPS III satellites, and new ground segments), the modernization of the Russian GLONASS, the European Galileo system of 30 satellites, the Chinese BeiDou Navigation Satellite System, Japan's Quasi-Zenith Satellite System (QZSS), as well as other regional and augmentation systems being developed by India, and potentially other nations.

Ensuring interoperability of these systems to the greatest extent possible, and as a minimum, intersystem compatibility where possible, is of high priority. The IGS will continue to take a leading role in monitoring these systems and their developments, and make the results of its experience and expertise, in particular high-level research and applications using the GNSS signals, readily available to all interested parties.

The IGS is also engaged with the newly established World Data System of the International Council for Science (ICSU-WDS) which integrates the former services within the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) and data centers of the World Data Center System (WDC). IGS provides a model of scientific service structure, organization, and complexity within this body.

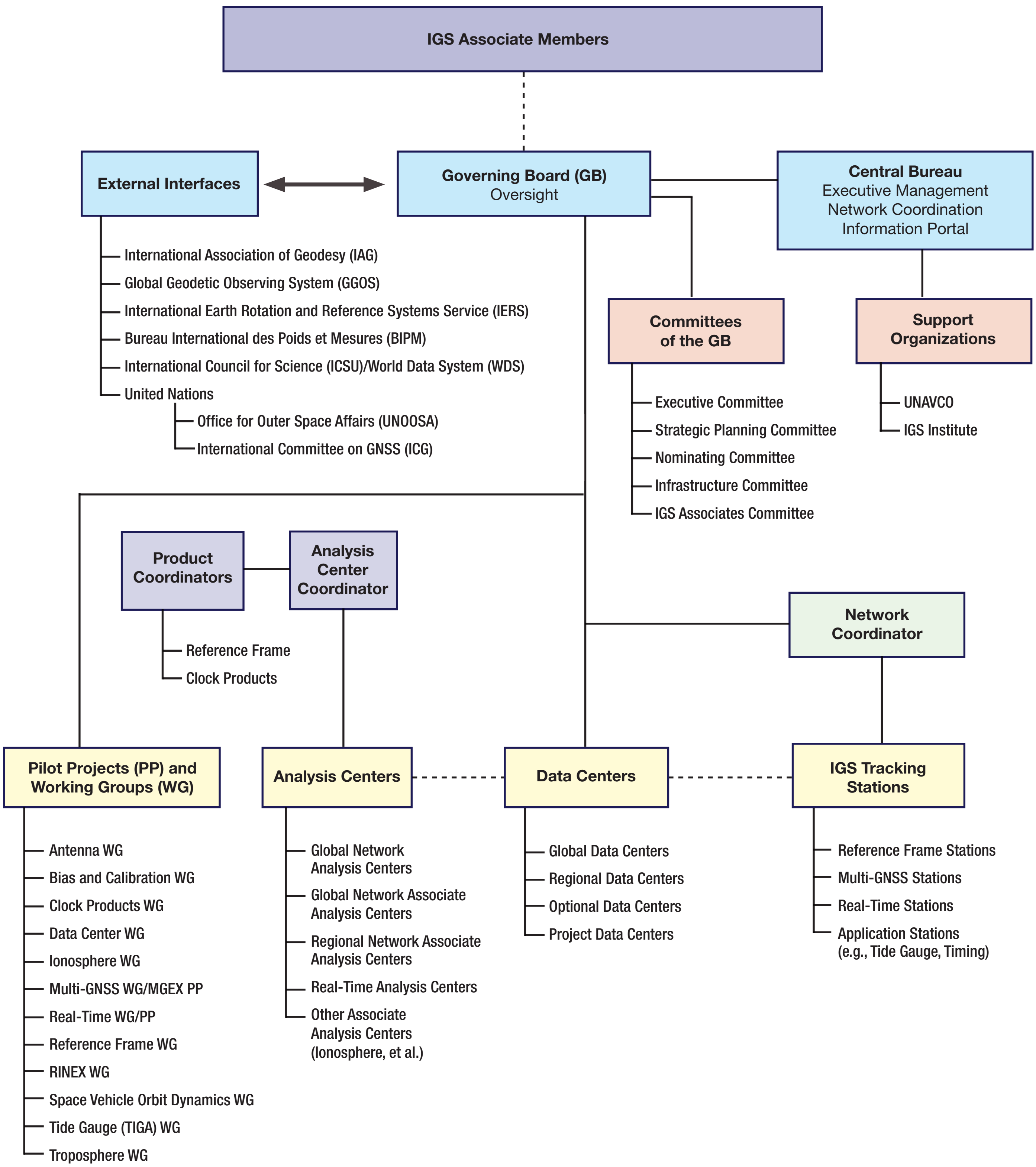
The purpose of this updated Strategic Plan is to place the IGS in a position to maximize its potential and utility in serving the scientific community and society in general. The implementation of this plan will be aided by the formulation and execution of goals and objectives, in which the principal targets for the various elements and projects will be accompanied by metrics designed to quantitatively monitor the progress of each objective toward its target.

IGS Organizational Values

Fundamental to the IGS are key values that are shared across the organization, these are:
Advocacy of an open data policy, with data and products readily available
Welcome contributions from and participation with all organizations
Effective reliability through redundancy of IGS components
Technical evolution through "friendly competition"
Dedicated engagement with policy entities to raise mutual awareness of IGS and geodesy in general

Through these shared values, IGS has established an unparalleled working international federation as well as a complex system of systems that have been making significant contributions to science and society since the 1990s.

IGS Structure and Association with International Scientific Organizations



IGS Goals and Objectives

The IGS has set forth the following general strategic directions outlined by three major Goals and their derived Objectives to best support the IGS mission in the next four years. These objectives are shaped by the results of the 2012 Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, of which a summary is available upon request to the IGS Central Bureau. All objectives are established with an associated metric, which facilitates ongoing performance measurements and allows the organization to monitor the progress of its efforts. This then influences the development of cross-objective initiatives and allows the organization to gauge their respective efficacy.

Goal 1 (World Benchmark) Set the world benchmark for GNSS nonprofit products and services. This goal aims to place the IGS as the premier nonprofit source of high-quality GNSS data, products, standards, and expertise in the world, with these resources made freely available to all user communities. To fulfill this goal, objectives have been formulated to ensure and increase service performance, deploy new services to meet evolving user needs, maintain the integration of GNSS into IGS and other organizations, and to generate and maintain GNSS standards. Each of these objectives has a target goal, and will be measured by a prescribed metric. The objectives are described as follows:

Objective 1.1 – Ensure and Increase Service Performance: Ensure that the quality of GNSS data, products and services meets or exceeds the established technical quality standards

OBJECTIVE 1.1 Ensure and Increase Service Performance	
Measure	**Availability of Products** (a combination of accuracy and continuity), as defined in the Product Availability Standards Appendix
Target	**Yearly Maintenance or Increase of Service Availability**, based on 2012 product/service baseline values, yearly

The IGS recognizes that to meet the ongoing changes and challenges associated with Earth-observing activities, it must ensure a high-quality service, and enhance service performance whenever possible. The availability of a product is defined by both accuracy and continuity; a service is "available" if the product meets its prescribed accuracy requirement and is continuously delivered with minimum specified disruptions.

This effort seeks to measure the objective efficacy in the overall availability of IGS products, as defined in the Product Availability Standards and Quality of Service matrix (Appendix E). The target of this objective is to maintain or increase service availability, based on current product and service baseline values, on a yearly basis.

Objective 1.2 — Deploy New Services to Meet Evolving User Needs: Incorporate and integrate new systems, technologies, applications, and ever-changing user needs into IGS products and services.

OBJECTIVE 1.2 Deploy New Services to Meet New User Needs	
Measure	**Product Integration Index:** the number of products or services released, as compared to the number requested or needed
Target	**Product Integration Index of at least one new, updated, or improved product or service per year,** as identified through surveys

To complement increasing service performance, new services must be regularly developed to meet the changing needs of IGS product users, and existing services must evolve to keep pace with demand.

The purpose of this objective is to spur the development of new products and services concurrent with the update and improvement of existing products and services.

The efficacy of this effort will be measured by the Product Integration Index (PI_{ix}), defined as the number of requested or needed products or services released per year (such as Real-time or Multi-GNSS service) as compared to the number of products or services requested or needed. The (PI_{ix}) has a target of providing at least one requested new, updated, or improved product or service each year. Furthermore, in order to identify and quantify the users of IGS products and their needs, a yearly survey of data centers should be conducted.

The outcome of this objective will be IGS products and services evolving in step with its users. This will be an organic style of growth, allowing for the ebb and flow of user needs, coupled with the often unpredictable shift in available technologies.

Objective 1.3 — Maintain Integration of GNSS into IGS and Other Earth-Observation Organizations, and the engagement/cooperation with Earth-oriented/ geoscientific and other organizations in order to broaden the IGS user community

OBJECTIVE 1.3 Maintain Integration of GNSS into IGS and Engagement with Earth-Oriented and Geoscientific Organizations	
Measure	**GNSS Integration Index:** the ratio of number of IGS GNSS products to GNSS systems available
Target	**GNSS Integration Index of greater than 50%**
Measure	**Integration within Organizations via the *EO Integration Index*:** the ratio of the number of Earth-observing organizations where IGS contributes to the number of Earth-observing organizations established
Target	**EO Integration Index of greater than 50%**

The efficient and ongoing integration of IGS products and services into existing global Earth-observing and navigation systems is of great importance to the IGS. At the time of this writing, a large majority of Earth-observing systems include IGS participation. Furthermore, the IGS processes data from all GNSS constellations as soon as enough information is available for initial engineering analyses, with a future goal of seamless integration into consistent multi-GNSS products.

The purpose of this objective is to facilitate the integration of all GNSS into IGS, as well as encourage the engagement and cooperation with Earth-oriented, geoscientific, and other organizations in order to broaden the IGS user community.

The first measure of this objective is the GNSS Integration Index (G_{ix}), which is defined as the ratio of the number of IGS GNSS products to total available GNSS constellations. For example, if there are two GNSS available, such as GLONASS and GPS, and IGS GNSS products only cover GPS, G_{ix} = (1/2) or 0.5. The target of this objective is to maintain a G_{ix} of at least 0.5, or 50% integration.

The second measure of this objective is the Earth-Observing Organizational Integration Index (EO_{ix}), which is defined as the ratio of the number of Earth-Observing Organizations where IGS is a contributor to the total number of Earth-Observing Organizations established that may potentially require IGS products. The target of this objective is to maintain an EO_{ix} of greater than or equal to 0.5, or 50% integration.

The outcome of this objective will be a finely networked web of product and organizational integration within and around the IGS. This will ensure the optimal use of organizational and technological resources, and broaden the general user community while integrating it internally.

Objective 1.4 — Generate and Maintain GNSS Standards: Establish, evolve, and disseminate continuously improving GNSS standards for the purpose of maintaining quality, supportability, and maintainability of IGS GNSS service utilization.

OBJECTIVE 1.4 Generate and Maintain GNSS Standards	
Measure	**Standardization Index:** The ratio of items that have a maintained accepted standard to the number of items that require evolution of, release of revised, or a new standard
Target	**Standardization Index of 75% at quarterly assessment**

Standards are the cornerstone of any engineering effort, and the establishment of clear, comprehensive standards is of utmost importance to the IGS. Standardization of GNSS and supporting elements will ensure the efficient use of resources for technological development, and provide a key foundational framework for future innovation.

This objective aims to promote quality of GNSS products and services while quantifying the continuous improvement of GNSS standards. This will be measured by a Standardization Index (S_{ix}), which is defined as the ratio of items that have, and continuously maintain, accepted standards to the number of items that require standardization. The target of this objective is to attain a S_{ix} of 0.75 or better, or 75% total standardized items, at quarterly assessments.

The outcome of this objective will be the steadily increasing integration of GNSS technology in all scientific endeavors facing the global society.

GOAL 2 (World GNNS Expertise and Policy Advisory) Promote the value and benefit of GNSS and the free availability of precise GNSS products to the broader scientific community, and in particular to policy makers and funding entities.

It is in the best interest of the IGS to ensure that its services are communicated to a wide variety of people and organizations that may benefit from these efforts. This goal is supported by objectives that seek to maintain or increase personnel expertise and IGS influence in policy advocacy.

Objective 2.1 — Maintain or Increase Expertise: Maintain and/or increase the technical expertise in all areas of IGS. Specifically, maintain Subject-Matter Experts (SMEs) in a growing majority of key technical and managerial expert areas associated with IGS.

OBJECTIVE 2.1 Maintain or Increase IGS Expertise	
Measure	**Expertise Index:** the number of subject matter experts within the ranks of IGS (self-assessed)
Target	**Maintain or Increase Expertise Index year to year;** IGS retains a list of experts in an Expertise Bibliography

As in many organizations, the people of the IGS are its greatest asset. The IGS recognizes that cultivating and having access to expertise within the organization is vital to the success of the organization. Establishing a database of expertise throughout the global IGS community will streamline future efforts across the goals of this plan and beyond.

The purpose of this objective is to better understand the levels of expertise held by IGS members and identify areas of strengths and weaknesses. This will help inform the incorporation of new members with particular desired expertise and assist in quickly forming expert teams to tackle new challenges. To assess the existing expertise, individuals will be prompted to self-assess their subject matter expertise levels in a number of topics and subtopics through an annual survey. An expertise database will be constructed.

SMEs shall be tallied into an Expertise Index (E_{ix}), which will be calculated by yearly self-assessment surveys of subject matter experts within the IGS. The target of this objective is to maintain or increase the E_{ix} yearly from its 2013 baseline.

The outcome of this objective will be a comprehensive database of graded levels of expertise throughout the IGS. This database will be used to manage and increase current IGS technical expertise, while highlighting and filling gaps. It will be made available for projects and other efforts that would benefit from expert advice.

Objective 2.2 — Maintain or Increase Policy Advocacy: Maintain and increase IGS presence in policy-making entities. Specifically, show small, sustained growth in lobbying presence over the next four years.

OBJECTIVE 2.2 Maintain or Increase IGS Influence in Policy Advocacy	
Measure	**Policy Advocacy Index:** the number of policy papers involving IGS combined with the number of policy meetings attended by IGS
Target	**Policy Advocacy Index should show small sustained growth on a yearly basis**

Policy advocacy and lobbying are critical to the ongoing success of the IGS. Numerous initiatives have been positively influenced by the IGS, and many more continue to, or will in the future, benefit from IGS affiliation or involvement. For example, through policy advocacy and engagement, the IGS has been able to achieve adoption of the ITRS within the ICG, and IGS timescale within the BIPM. Still other efforts benefit from the ongoing advocacy efforts taking place at meetings and workshops around the world.

The purpose of this objective is to enhance the policy activities of the IGS, ranging from workshop attendance to active advocacy initiatives. This objective shall be measured using the Policy Advocacy Index (PA_{ix}), which is defined as the number of policy papers and IGS-attended policy meetings, combined. The target of this objective is sustained growth of the PA_{ix}.

GOAL 3 (Governance and Development) IGS will maintain the appropriate level of governance to ensure effective operation; and provide executive level, centralized advocacy for the continued and evolving operation of IGS elements.

This includes the development of resources to support the year-to-year implementation of this plan. Objectives in support of this goal are to strengthen governance and maintain and diversify funding sources. Both of these objectives act in support of the maintenance and regular operations of the IGS, and serve as building blocks to ensure the continued organizational success of the service.

Objective 3.1 — Strengthen Governance: IGS will continue to incorporate best practices to maintain and improve its organizational efficiency as measured by a continuous improvement in its best-practices audit assessment in the areas of Technical Performance, Governance and Management, Finances, and Customer Satisfaction.

OBJECTIVE 3.1 Strengthen IGS Governance	
Measure	**Best Practices Audit Assessment Score:** an external review of services by IAG, with accreditation within WDS.
Target	**1. Increase Audit Assessment year to year, to achieve 90% compliance by the 2016 audit** **2. Satisfactory IAG audit rating** **3. WDS accreditation**
Measure	**Member approval of governance**
Target	**Achieve 90% approval rating by internal annual survey of IGS membership**

Efficiency and efficacy in governance is a key element in the success of the IGS. In order to ensure that all segments of the organizational government are functioning properly and efficiently, internal and external audits will be conducted. The redundancy of these audits will ensure quality of the reported actions and credibility of the reports themselves.

This objective shall be measured by the Best Practices Audit Assessment Score ($BPAA_s$), which is defined by the results of the biennial third-party review, as well as internal audits. The $BPAA_s$ will be used to maintain quality as an alternative to mandatory legislated standards and will be calculated with accredited management standards such as those set out by the International Organization for Standardization (ISO). The target of this objective is to increase the $BPAA_s$ yearly so that there is a 90% value of the maximum score by the 2016 audit.

Furthermore, a supporting element of this objective is to ensure consistent member approval of IGS governance. This will be measured by internal annual surveys, with a goal of maintaining a 90% or higher approval rating by the 2016 audit.

The outcome of this objective will be to increase the maturity of processes and practices across the organization. This increased maturity of processes leads to increased quality of the services and products of the organization.

Objective 3.2 — Maintain and Diversify Funding Sources: IGS will increase its overall funding through supplemental and diversified income sources.

OBJECTIVE 3.2 Maintain or Increase the Diversity of IGS Resources	
Measure	**Maintain or increase current levels of IGS CB funding and resources**
Target	**An annual increase of 2–5% on top of 2012 funding and resource levels**
Measure	**Diversify IGS Central Bureau resources**
Target	**Increase diversification of IGS CB resources by 5% annually**
Measure	**Increase supplemental funding to the IGS Institute**
Target	**Increase supplemental funding and diversify funding sources by 10% annually**
Measure:	**Maintain or increase IGS component resources as a function of 2012 levels**
Target:	**An annual increase of 2–3% of 2012 component baseline resources**

Funding has a significant impact on the growth and success of the IGS. In order to successfully carry out its other goals and objectives, the IGS must secure funding for current and future projects as well as for its infrastructure. Furthermore, as the scale and scope of IGS activities broadens, so should the sources of income.

The IGS Central Bureau (CB) provides a home base to the efforts of the IGS. In order to ensure continued operation of the CB, its funding and resources should be increased by 2–5% of 2012 CB funding levels, annually. Additionally, CB sources of funding should increase in diversification by 5% of 2012 levels, annually. While the increase of funding in general is a necessary effort to sustain operations, diversification of funding is more relevant for long-term organizational sustainability. Organizationally diverse income sources will grant the CB additional financial stability, while geographically diverse sources of funding will represent the global work already carried out by the IGS.

The IGS Institute, the business arm of the IGS GB, serves as a nonprofit US legal entity (501.C3 US Corporation) established to complement the IGS GB and CB. The IGS Institute can conduct business with international organizations, industry, and the general public on behalf of the IGS and its many components. In order to ensure the stability and operability of the Institute, supplemental funding should be provided to diversify the financial support network of this nonprofit arm of the IGS. A target of increasing the overall supplementary funding by 10% of 2012 levels each year thereafter has been established.

Components of the IGS outside of the CB will also benefit greatly from increasing resources through supplementary and diverse funding sources. The commitment and stability of core component funding will be surveyed, and a target of increasing annual income by 2–3% of the 2012 resources has been established.

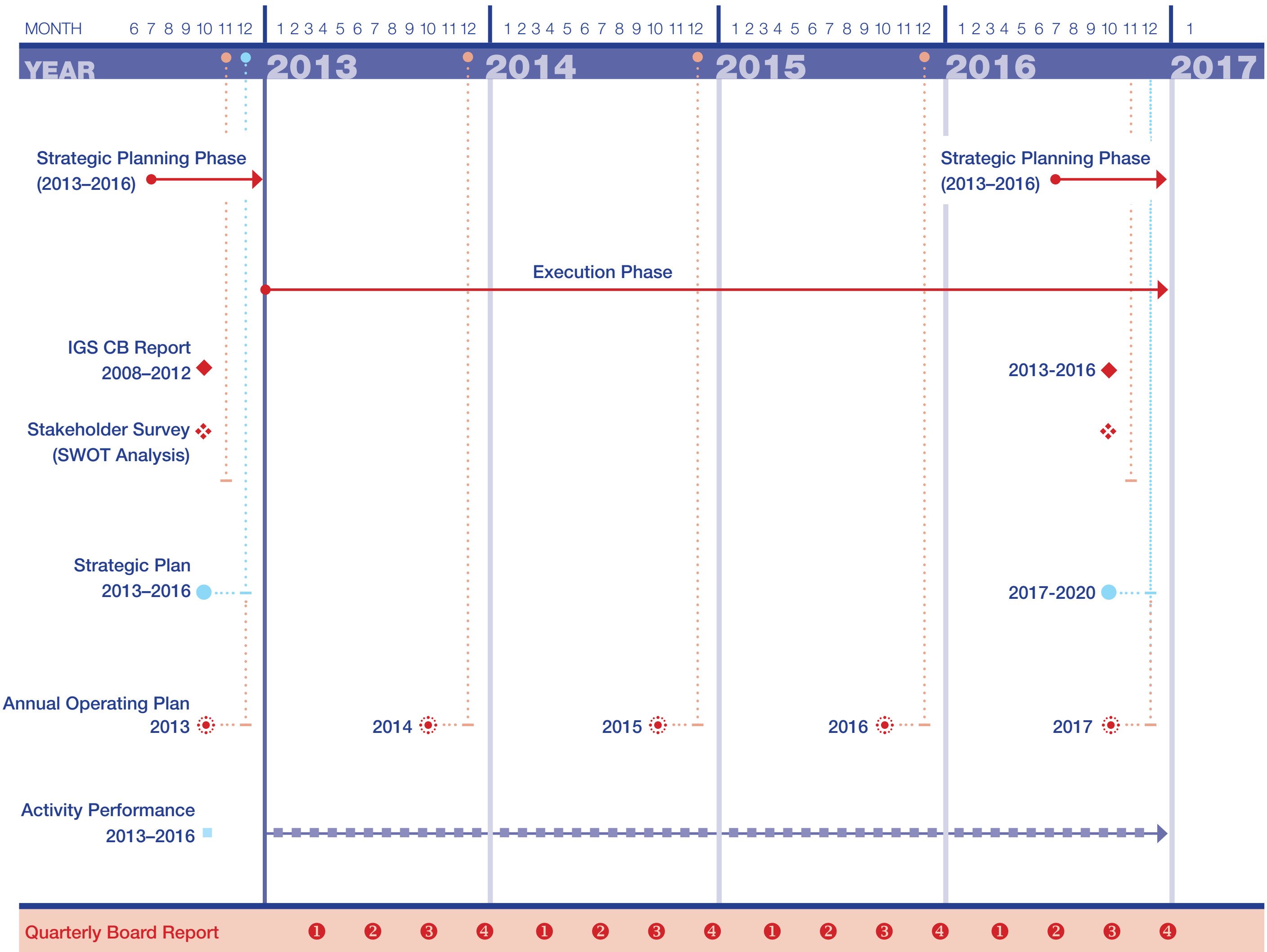
The output of this objective will be the financial stability of the IGS, its Institute, and components. Diversification of funding through supplemental sources will become a key factor in the sustainability of all IGS objectives and initiatives.

Appendix A
Implementation, Administration, and Monitoring of the Strategic Plan

Strategic Plan Implementation
As shown in Figure 1-1, the strategic plan formulation for a given period will take place six months prior to the conclusion of the period of performance of the operative strategic plan, and will guide the IGS in its next period of performance. For example, the 2013–2016 plan was prepared during the six-month period prior to closure of the year 2012, the end of the 2008–2012 plan.

The IGS Governing Board (GB) will appoint the Strategic Planning Committee (SPC) at the beginning of the formulation period. The SPC will be co-chaired by the Director of the IGS Central Bureau and the Chair of the Governing Board. This committee is tasked, through the IGS GB and with the support of the Central Bureau, to formulate the strategic plan for the next period of performance. This period of performance shall be dictated by the IGS Governing Board and will typically be four to five years.

IGS CB (Strategic Planning/Execution/Reporting) Lifecycle



The formulation phase will include: a) a SWOT analysis where key stakeholders help identify the strengths, weaknesses, opportunities and threats of the organization, and b) an initiative-based performance analysis of the preceding period of performance, in support of objectives and key goals. Two periodic documents will be produced at the end of a designated period of performance as a result of these two efforts: a SWOT analysis report and a progress report detailing past performance analyses. These documents will guide the formulation of the new strategic plan and aid in the architecture of its goals and objectives. These two reports shall be distributed to the members of the IGS GB prior to its year-end meeting, and may be distributed to other interested parties at the discretion of the chairs of the SPC.

Strategic Plan Approval
The IGS Governing Board will review the proposed goals and objectives, along with their associated targets and metrics, formulated by the planning committee during its year-end working meeting. Any changes agreed upon by GB consensus will be included in the strategic plan prior to its final approval.

The SPC will identify the most effective initiatives based on the approved objectives and associated targets, and informed by the SWOT and past performance analyses. The strategic plan may also incorporate an appendix detailing the initial list of activities and their anticipated impact on objectives. The final strategic plan will be presented to the IGS GB for final approval not later than the conclusion of the first month of the period of performance.

Strategic Plan Implementation
The strategic plan contains goals and supportive objectives. These objectives and associated performance targets are further decomposed in a number of activities. The core of the strategic plan implementation is to identify, assign, execute, and monitor the progress of these activities, which can be multiyear efforts depending on their nature. The IGS Central Bureau (CB) will create a yearly working plan containing all proposed activities and their scheduled periods of performance, with relevant associated budgets, for a given year. All identified activities will contain metrics to measure a) the progress of the activity and b) the contribution of the activity to fulfill the parent objective. Assignees to a given activity will provide performance reports to the CB on a semi-annual basis.

Strategic Plan Monitoring
The IGS CB Director will present a quarterly status report of the aforementioned activities to the Chair of the IGS GB and attending board members. This report will include the activity performance metrics and progress to achieving respective objectives and goals as reported by its assignee. It is desirable that this status be available online as the performance data is collected.

Appendix B
History of the International GNSS Service

The International GNSS Service (IGS) was established in January 1994 as a service of the International Association of Geodesy (IAG), and was originally named the International GPS Service for Geodynamics. In 1999, the name was shortened to International GPS Service, as the applications of GPS within the scientific community were extending well beyond geodynamics. The current name of the IGS—International GNSS Service — was officially adopted in 2005 to reflect IGS' intent to integrate not only the United States Global Positioning System (GPS), but also the significant contributions of other GNSS, such as the Russian GLONASS, European Galileo, Chinese BeiDou, and Japan's QZSS.

As the then-new GPS began to be used for research and science applications, many organizations recognized the enormous potential of the unprecedented level of positioning achievable with this technology, at relatively economical cost. In light of this, it was decided that no single entity could, or should, assume the capital investment and recurring operations costs for such a global system. It was at this point that key international players first considered joint partnerships to define international cooperative efforts and to set standards that would ensure the success of this endeavor and its ultimate goal of promoting high quality scientific achievements. By the late 1980s, many geodynamic and geodetic organizations recognized the potential of GPS, and at the 1989 International Association of Geodesy (IAG) Scientific Assembly meeting in Edinburgh, Scotland, it was recognized that a standardized civilian system for using GPS would be beneficial to all.

In 1991, a Call for Participation was organized by the IAG Planning Committee seeking participants and contributors who would develop a "proof of concept" of an international service. It requested interested groups to assume the role of station operations, networks, data centers, analysis centers, and a Central Bureau for coordination of the activity. Following a large, positive response, the International GPS Service Oversight Committee was formed at the International Union of Geodesy and Geophysics (IUGG)/IAG General Assembly meeting in Vienna in 1991. The Committee organized a successful pilot project in 1992 to demonstrate the potential of an international service based on GPS. The IGS was determined to be clearly viable, and its pilot project continued without interruption through 1993, while a proposal was prepared to the IAG seeking approval for the IGS as an IAG international service. Approval was received at the IAG Scientific Assembly in Beijing in 1993, and the IGS was officially established on January 1, 1994. Two years later, the IGS was granted membership in an inter-disciplinary body of International Council of Science (ICSU): the Federation of Astronomical and Geophysical Data Services (FAGS).

The IGS operates its global civilian GPS tracking system for science and research on a completely voluntary basis. Since the pilot project in 1992, the network has grown from approximately 30 permanent GPS stations to more than 400; and the 3-D WRMS accuracy of the IGS orbits has improved by more than an order of magnitude, from 50 cm to better than 3 cm. The IGS continues developing and improving traditional products such as orbits, clocks, station positions and velocities, Earth rotation parameters (ERP), as well as fostering projects and working groups that produce additional data products, such as wet troposphere zenith path delays (ZPD) and total electron content (TEC). These IGS projects and working groups are dependent upon the infrastructure of the IGS for scientific applications.

Projects that have been completed and are now incorporated into IGS routine processes include the Precise Time and Frequency Project — jointly with the Bureau International des Poids et Mesures (BIPM) — the International GLONASS Pilot Project (IGLOS PP), and the Tide Gauge Project (TIGA). It is the infrastructure of the IGS and innovative efforts of the IGS Analysis Centers that have driven the evolution and improvements of the IGS that, in turn, support these science-driven applications.

Through its Analysis Centers and Working Groups, the IGS continues to evolve and improve. The IGS has become the primary source for general access to, and continuous development of, the precise reference frame of the International Earth Rotation and Reference Systems Service (IERS): the International Terrestrial Reference Frame (ITRF). This is particularly due to the dense distribution of this geodetic technique and the economies of use.

The IGS provides the global framework for virtually all regional applications and networks, including:

- The United States Plate Boundary Observatory GPS Network (PBO), managed by a key IGS partner, UNAVCO.
- IAG Commission 1 Reference Frames, which includes: Subcommission for Europe (EUREF); Sistema de Referencia Geocéntrico para América del Sur (SIRGAS, the South American continental reference system); Unification of African Reference Frames (AFREF); and others.

The history, development, and current status of the IGS are captured online, particularly in workshop proceedings and their archives. All are maintained and available through the Central Bureau website, http://igs.org/.

And historically the IGS Annual Reports, Technical Reports, and Strategic Plans, noting the great success of the Astronomical Institute of the University of Bern, which assumed the responsibility for the IGS Technical Reports in 2012.

Appendix C
Components and Roles

Global Network of Tracking Stations
At the heart of the IGS is a network of hundreds of GNSS tracking stations that are operated by participating agencies from around the world. For an up-to-date list of the IGS tracking stations and station operators, please refer to the IGS website at http://igs.org.

All components of the IGS are critically dependent on the global network of precise GNSS tracking stations. The IGS network includes over 400 stations that operate continuously, delivering data in real time, near real time, high rate, hourly, or daily to data centers. A subset of the network is providing real-time data streams within the IGS Real-Time project. The IGS network today also includes 196 GLONASS tracking stations. The operation of the IGS Network is conducted by 213 different organizations around the world, and is coordinated by the Central Bureau to assure that consistent, organized, and high-quality data are provided to the Analysis Centers (ACs) and other users.

Data Centers
Since the inception of the IGS, archives of its Data Centers (DCs) have become increasingly important to a wide range of scientific and research applications. The distributed nature of the data flow supporting the IGS has been key to the successful archiving and availability of both IGS data and products. A hierarchy of DCs distributes data from the network of tracking stations: the Operational, Regional, and Global Data Centers. This scheme provides efficient access and storage of GPS and ancillary data, thus reducing network traffic as well as providing a level of redundancy allowing for security of the data holdings. There are currently four Global DCs, six Regional DCs, 17 Operational DCs, and one Project DC.

Global Data Centers
- Crustal Dynamics Data Information System, NASA Goddard Space Flight Center, USA
- Institut National de l'Information Géographique et Forestière, France
- Korean Astronomy and Space Science Institute,
- South Korea
- Scripps Institution of Oceanography, USA

Regional Data Centers
- Bundesamt für Kartographie und Geodäsie, Germany
- Geoscience Australia
- Hartebeesthoek Radio Astronomy Observatory, South Africa
- NASA Jet Propulsion Laboratory, California Institute of Technology, USA
- National Geodetic Survey, National Oceanic and Atmospheric Administration, USA
- Russian Data Analysis and Archive Center, Russia
- Incorporated Research Institutions for Seismology, USA

Operational Data Centers for Networks
- Centre National d'Etudes Spatiales, France
- Delft University of Technology, The Netherlands
- Deutsches GeoForschungsZentrum Potsdam, Germany
- European Space Agency, European Space Operations Centre, Germany
- Geodetic Survey of Canada, Natural Resources Canada
- Geospatial Information Authority, Japan
- Geological Survey of Canada, Natural Resources Canada
- Hartebeesthoek Radio Astronomy Observatory, South Africa
- Agenzia Spaziale Italiana
- Kort and Matrikelstyrelsen/National Survey and Cadastre, Denmark
- NASA Jet Propulsion Laboratory, California Institute of Technology, USA
- National Geodetic Data Centre, Geoscience Australia
- National Geodetic Survey, National Oceanic and Atmospheric Administration, USA
- Norwegian Mapping Authority
- Russian Data Analysis and Archive Center, Russia/Incorporated Research Institutions of Seismology, USA
- Scripps Orbit and Permanent Array Center, Scripps Institution of Oceanography, USA

Project Data Center
- Tide Gauges and GPS, Universite de La Rochelle, France

Analysis Centers and Associate Analysis Centers
The ACs form the operational and scientific backbone responsible for generating the IGS products. They provide, based on the available tracking data of the whole IGS network, a consistent set of high-quality products such as precise satellite orbits, station and satellite clock information, station coordinates, Earth rotation parameters, and atmospheric information. To fulfill the tasks of an IGS AC, all products have to meet the highest standards according to

IGS and IERS conventions and standards, and all submissions must be published in a timely and regular manner. Currently, the IGS ACs offer three types of solutions, which differ in accuracy and latency, to many kinds of scientific and engineering applications, specifically: ultra-rapid sub-daily products, daily rapid products, and weekly final products. A prototype real-time product is under development. Besides their routine work, the ACs continually strive to improve the model, crucial to the success of the IGS. There are currently 12 ACs that work with the Analysis Center Coordinator, currently at the US NOAA's National Geodetic Survey, in developing the IGS combined products.

Associate Analysis Centers are organizations that produce specialized products, such as ionospheric information or station coordinates and velocities for a global or regional subnetwork. These ACs are generally linked to a corresponding IGS Pilot Project or Working Group. Currently, there are 28 of these Associate Analysis Centers.

Analysis Centers

- Center for Orbit Determination in Europe, Astronomical Institute, University of Bern, Switzerland
- Deutsches GeoForschungsZentrum Potsdam, Germany
- European Space Operations Centre, European Space Agency, Germany
- Geodetic Observatory Pecny, Czech Republic
- Groupe de Recherche de Géodésie Spatiale (GRGS), France
- Massachusetts Institute of Technology, USA
- NASA Jet Propulsion Laboratory, California Institute of Technology, USA
- National Geodetic Survey, National Oceanic and Atmospheric Administration, USA
- Natural Resources Canada
- Scripps Institution of Oceanography, USA
- US Naval Observatory, USA
- Wuhan University, China

Associate Analysis Centers

- Global Network Associate Analysis Centers (GNAACs) for the Densification of the Global Reference Frame
- University of Newcastle upon Tyne, UK
- Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, USA

Regional Network Associate Analysis Centers (RNAACs) for the Densification of the Terrestrial Reference Frame

- Deutsches GeoForschungsZentrum Potsdam, Germany
- EUREF European Reference System, Global and European Regional Geodetic Networks
- Bundesamt für Landestopographie, Switzerland
- Center for Orbit Determination in Europe, Switzerland
- Geodetic Observatory Pecny, Czech Republic
- Bundesamt für Kartographie und Geodäsie, Germany
- International Commission for Global Geodesy of the Bavarian Academy of Sciences, Germany
- Nordic Geodetic Commission, Scandinavia
- Nuova Telespazio S.p.A., Space Geodesy Center, Italy
- Observatory Lustbuehel Graz, Austria
- Royal Observatory of Belgium
- University of Padova, Italy
- Warsaw University of Technology, Poland
- Geospatial Information Authority of Japan
- Geophysical Institute of the University of Alaska, USA
- Geoscience Australia
- Onsala Space Observatory, Sweden
- Pacific Geoscience Center, Canada
- SIRGAS — Sistema de Referencia Geocéntrico para las Américas (South American Geocentric Reference System)
- Deutsches Geodätisches Forschungsinstitut, Germany

Analysis Center Coordinator

The IGS Analysis Center Coordinator (ACC) has overall responsibility for generating the official IGS combined products. Specifically, the ACC assures quality control of the IGS products, evaluates performance, develops analysis standards, and assembles the outputs from all Analysis Centers into a single set of official IGS products.

Working Groups and Pilot Projects

The work of supporting and developing the IGS components is carried out by Working Groups that may be tasked with the execution of various Pilot Projects or experiments. Working Groups focus on selected topics related to the IGS components, according to goals and schedules specified in the working group's charter. Pilot Projects or demonstration experiments aim to develop particular IGS products or services that rely on the IGS infrastructure.

Current IGS Working Groups

- Antenna Working Group
- Bias and Calibration Working Group
- Clock Products Working Group
- Data Center Working Group
- Multi-GNSS Working Group
- Ionosphere Working Group
- Real-Time Working Group
- Reference Frame Working Group
- RINEX Working Group
- Space Vehicle Orbit Dynamics Working Group
- Tide Gauge (TIGA) Working Group
- Troposphere Working Group

Former Working Group

- Low Earth Orbiters (LEO)

Institutions or Organizations of Current Working Group Chairpersons

- Antenna WG, Deutsches Geodätisches Forschungsinstitut, Germany
- Bias and Calibration WG, Astronomical Institute, University of Bern, Switzerland
- Clock Products WG, US Naval Research Laboratory, USA
- Data Center WG, NASA Goddard Space Flight Center, USA
- Multi-Global Navigation Satellite Systems (Multi-GNSS) WG, German Aerospace Center (DLR), Germany
- Ionosphere WG, University of Warmia and Mazury, Poland
- Real-Time WG, Natural Resources Canada
- Reference Frame WG, Institut National de l'Information Géographique et Forestière, France
- RINEX WG, Natural Resources Canada
- Space Vehicle Orbit Dynamics WG, University College London, United Kingdom
- Troposphere WG, United States Naval Observatory, USA

Pilot Projects

- Multi-GNSS Experiment (MGEX) Pilot Project
- Real-Time Pilot Project

Previous Pilot Projects, which were concluded successfully and integrated into the mainstream IGS activities

- Precise Time and Frequency Project, jointly with the Bureau International des Poids et Mesures (BIPM), is now the IGS Clock Products Working Group with a specific coordinator located at Naval Research Laboratory
- International GLONASS Service Pilot Project (IGLOS-PP) which is now fully integrated into IGS processing, and hence the catalyst for renaming IGS as the GNSS service
- Tide Gauge (TIGA), now actively providing links from tide gauges to the IGS network as a method for contributing to measuring sea-level change
- IGS Governing Board

Central Bureau

The Central Bureau (CB) is the executive arm of the IGS and is responsible for the general management and coordination of IGS activities and external affairs consistent with the directives, policies, and priorities set forth by the Governing Board (GB), whose principal role is to set policy and to exercise broad oversight of all IGS functions and components. The GB also controls IGS efforts to maintain efficiency and reliability.

The CB coordinates with IGS tracking station operators to assure consistent delivery of high-quality standardized data to Analysis Centers. Additionally, the CB facilitates critical assessments of infrastructure components through the IGS Infrastructure Committee, which is tasked with making recommendations to the GB to improve the overall service. The CB is also the primary outreach organization for communication and coordination of the IGS activities with broader GNSS initiatives around the world. The Central Bureau Information System (CBIS) is the main information portal for all of the IGS components and is also operated by the CB.

See discussion in Goal 3 above for additional information regarding the IGS Governing Board and Central Bureau.

The IGS Institute

The IGS Institute serves as a nonprofit US legal entity (501.C3 US Corporation) established to complement the IGS GB and CB. The IGS Institute can conduct business with international organizations, industry, and the general public on behalf of the IGS and its many components. It was established as a nonprofit public benefit corporation in September 2008. The IGS Institute, Inc., is located in California and is structured to conduct business as needed for the IGS.

Supporting Organizations

Analysis Center Coordinator
National Geodetic Survey, National Oceanic and Atmospheric Administration, USA

Reference Frame Coordinator
Institut National de l'Information Géographique et Forestière, France

Clock Products Coordinator
US Naval Research Laboratory, USA

Infrastructure, Operations, and Network Coordinator
IGS Central Bureau, NASA Jet Propulsion Laboratory, California Institute of Technology, USA

Central Bureau
NASA Jet Propulsion Laboratory, California Institute of Technology, USA

Appendix D Board Members

Governing Board Members

Name	Affiliation	Role	Years in Service
Zuheir Altamimi	*Institut National de l'Information Géographique et Forestière, France*	IAG Representative	2011-2015
Felicitas Arias	*Bureau International des Poids et Mesures, France*	BIPM/CCTF Representative	---
Claude Boucher	*Institut National de l'Information Géographique et Forestière, France*	IERS Representative to IGS	---
Carine Bruyninx	*Royal Observatory of Belgium, Observatoire Royal de Belgique (ORB), Belgium*	IGS Network Representative	2011-2014
Mark Caissy	*Natural Resources Canada / Ressources naturelles Canada*	Real-time Working Group, Chair	2001-2012
Yamin Dang	*Chinese Academy of Surveying and Mapping, Beijing*	Appointed (IGS)	2012-2015
Shailen Desai	*Jet Propulsion Laboratory, USA*	Analysis Center Representative	2012-2015
Steven S. Fisher	*IGS Central Bureau, Jet Propulsion Laboratory, USA*	IGS Central Bureau, Secretariat	2008-2010; 2012-2013
Bruno Garayt	*Institut National de l'Information Géographique et Forestière, France*	IGS Reference Frame Coordinator	2010-2013
Jake Griffiths	*NOAA, National Geodetic Survey, USA*	Analysis Center Coordinator	2012-2015
Christine Hackman	*United States Naval Observatory, USA*	Troposphere Working Group, Chair	2011-2013
Urs Hugentobler[EC]	*Technische Universität München, Germany*	Board Chair, Analysis Center Representative	2011-2014
Gary Johnston	*Geoscience Australia*	Network Representative	2010-2013
Andrzej Krankowski	*University of Warmia and Mazury in Olsztyn, Poland*	Ionosphere Working Group, Chair	2007-2012
Ken MacLeod	*Natural Resources Canada / Ressources naturelles Canada*	RINEX-RTCM Working Group, Chair	2012-2013
Charles Meertens[EC]	*UNAVCO, USA*	Appointed (IGS)	2011-2014
Oliver Montenbruck	*Deutsches Zentrum für Luft- und Raumfahrt e. V., Germany*	GNSS Working Group, Chair	2012 - 2014
Ruth Neilan[EC]	*IGS Central Bureau, Jet Propulsion Laboratory, USA*	Director of IGS Central Bureau	---
Carey Noll	*NASA Goddard Space Flight Center, USA*	Data Center Representative, Data Center Working Group, Chair	2006-2013
James Park	*Korean Astronomy and Space Science Institute, South Korea*	Appointed, IGS	2010- 2013
Chris Rizos[EC]	*University of New South Wales, Australia*	President of IAG	2004-2015
Ignacio Romero	*ESA/European Space Operations Centre, Germany*	Infrastructure Committee, Chair	2010-2012
Stefan Schaer	*Federal Office of Topography, Switzerland*	Calibration & Bias Working Group, Chair	2007-2012
Ralf Schmid	*Deutsches Geodätisches Forschungsinstitut, Germany*	Antenna Working Group, Chair	2008-2012
Tilo Schöne	*DeutschesGeoForschungsZentrum Potsdam, Germany*	TIGA Working Group, Chair	2001-2012
Ken Senior	*Naval Research Laboratory, USA*	IGS Clock Products Coordinator	2003-2012
Tim Springer[EC]	*ESA/European Space Operations Center, Germany*	Analysis Center Representative	2008-2015

Name	Affiliation	Role	Years in Service
Richard Wonnacott	*Chief Directorate: National Geo-spatial Information, South Africa*	Appointed (IGS)	2006-2013
Marek Ziebart	*University College London, UK*	Satellite Vehicle Orbit Dynamics Working Group, Chair	2011-2012

Former Governing Board Members

Name	Affiliation	Years in Service
Yoaz Bar-Sever	*Jet Propulsion Laboratory (JPL), USA*	2003-2011
Norman Beck	*Natural Resources Canada*	2003-2009
Gerhard Beutler	*University of Bern, Switzerland (Founding Chair)*	1994 -2011
Mike Bevis	*University of Hawaii, USA*	1998-2001
Geoff Blewitt	*University of Nevada - Reno, USA*	2008-2011
Yehuda Bock	*Scripps Institution of Oceanography, USA*	1994-1999
Henno Boomkamp	*ESA/European Space Operations Center, Germany*	2003-2010
Nicole Capitaine	*Paris Observatory, France*	2004-2008
Loic Daniel	*Institut Géographique National, France*	2002-2005
John Dow	*ESA/European Space Operations Center, Germany (Fmr. Chair)*	1994-2011
Bjorn Engen	*Norwegian Mapping Authority (Statens Kartverk), Norway (Retired)*	1994-2001
Peng Fang	*Scripps Institution of Oceanography, USA*	2004-2005
Martine Feissel	*International Earth Rotation Service, France*	1994-1995
Joachim Feltens	*ESA/European Space Operations Center, Germany*	1998-2002
Remi Ferland	*Natural Resources Canada*	1999-2009
Weijun Gan	*China Earthquake Administration, Crustal Motion Observation Network of China*	2007-2010
Gerd Gendt	*GeoForschungsZentrum Potsdam, Germany (Fmr. ACC)*	2003-2007
Manuel Hernandez	*Universitat Politecnica de Catalunya, Spain*	2002-2007
Tom Herring	*Massachusetts Institute of Technology, USA*	1999-2003
Teruyuki Kato	*Earthquake Research Institute, University of Tokyo, Japan*	1994-1995
Bob King	*Massachusetts Institute of Technology, USA*	2008-2011
Jan Kouba	*Natural Resources Canada (Fmr. ACC)*	1994-1999
Bill Kuo	*University Consortium for Atmospheric Research, USA*	2006-2009
Gerald Mader	*National Geodetic Survey, National Oceanic and Atmospheric Administration, USA*	1994-1997
John Manning	*Geosciences Australia (formerly Australian Survey and Land Information Group), Australia*	1996-2003
Bill Melbourne	*Jet Propulsion Laboratory (JPL), USA*	1994-1999
Angelyn Moore	*IGS Central Bureau, Jet Propulsion Laboratory, USA*	1998-2007
Ivan Mueller	*Ohio State University, USA*	1994-1999
Paul Paquet	*Royal Observatory of Belgium*	1999-2002
David Pugh	*Southampton Oceanography Centre, UK*	1996-2004
Jim Ray	*National Geodetic Survey, National Oceanic and Atmospheric Administration, USA (Fmr. ACC)*	1997-2003; 2008-2011
Christoph Reigber	*GeoForschungsZentrum Potsdam, Germany (Fmr. Chair)*	1994-2005

Name	Affiliation	Years in Service
Markus Rothacher	*GeoForschungsZentrum Potsdam, Germany*	2000-2007
Bob Schutz	*Center for Space Research, University of Texas-Austin, USA*	1994-1997
Robert Serafin	*National Center for Atmospheric Research, USA*	1998-2005
Jim Slater	*National Geospatial – Intelligence Agency, USA*	1997-2005
Michael Watkins	*Jet Propulsion Laboratory (JPL), USA*	1999-2001
Robert Weber	*Vienna University of Technology, Austria*	2003 - 2012
Pascal Willis	*Institut Géographique National, France*	1999
Peizhen Zhang	*China Earthquake Administration, Institute of Geology*	2002-2005
Jim Zumberge	*Jet Propulsion Laboratory (JPL), USA*	2000-2007

Associate Members

Name	Affiliation
Pedro Alfaro	*European Space Agency, European Space Operations Centre, Germany*
John Beavan	*Institute of Geological and Nuclear Sciences (IGNS), Gracefield Research Centre, New Zealand*
Eduardo Bergamimi	*Instituto Nacional De Pesquisas Espaciais, ATSME/INPE, Brazil*
Willy Bertiger	*Jet Propulsion Laboratory (JPL), USA*
Graeme Blick	*Land Information New Zealand (LINZ), New Zealand*
Heike Bock	*Astronomical Institute, University of Bern, Switzerland*
Fran Boler	*UNAVCO Inc., USA*
Elmar Brockmann	*Swiss Federal Office of Topography, Section Satellite Geodesy, Switzerland*
Alessandro Caporali	*University of Padova, Dipartimento di Geologia, Paleontologia e Geofisica, Italy*
Sungki Cho	*Korea Astronomy and Space Science Institute, South Korea*
Peter Clarke	*University of Newcastle upon Tyne, United Kingdom*
Ludwig Combrinck	*Hartebeesthoek Radio Astronomy Observatory, HartRAO, South Africa*
Michael Craymer	*Natural Resources of Canada, Geodetic Survey Division*
Rolf Dach	*Astronomical Institute, University of Bern, Switzerland*
Florian Dilssner	*European Space Agency, European Space Operations Centre, Germany*
Brian Donahue	*Natural Resources of Canada, Geodetic Survey Division*
Jan Dousa	*Research Institute of Geodesy, Topography and Cartography (VUGTK), Czech Republic*
Herb Dragert	*Geological Survey of Canada, Pacific Geoscience Centre, Natural Resources Canada (NRCan)*
Hermann Drewes	*Deutsches Geodaetisches Forschungsinstitut (DGFI), Germany*
Maurice Dube	*NASA / Goddard Space Flight Center, USA*
Robert Dulaney	*National Geodetic Survey (NGS), NOAA, USA*
Dozie Ezigbalike	*Geo–information Systems Section, UN Economic Commision for Africa, Ethiopia*
Hussein Farah	*Regional Centre for Mapping of Resources for Development (RCMRD), Kenya*
Roman Galas	*Technische Universität Berlin (TUB), Germany*
Carlos Garcia–Martinez	*European Space Agency, European Space Operations Centre, Germany*
Maorong Ge	*Deutsches GeoForschungsZentrum (GFZ), Germany*
Ramesh Govind	*GeoScience Australia*
Richard Gross	*Jet Propulsion Laboratory (JPL), USA*
Heinz Habrich	*Bundesamt fuer Kartographie und Geodaesie (BKG), Germany*
Bruce Haines	*Jet Propulsion Laboratory (JPL), USA*
Rune Hanssen	*Norwegian Mapping Authority (Statens Kartverk), Norway*
Yuki Hatanaka	*Geographical Survey Institute, Japan*
Pierre Heroux	*Natural Resources of Canada, Geodetic Survey Division*
Matt Higgins	*International Federation of Surveyors (FIG) & Department of Environment & Resource Management, Australia*
Stephen Hilla	*National Geodetic Survey (NGS), NOAA, USA*
Larry Hothem	*US Geological Survey, USA*
Ken Hudnut	*US Geological Survey, USA*
Caroline Huot	*Natural Resources of Canada, Geodetic Survey Division*
Tetsuro Imakiire	*Geographical Survey Institute, Ministry of Construction, Japan*
Mike Jackson	*UNAVCO Inc., USA*
Norbert Jakowski	*Deutsches Zentrum fuer Luft– und Raumfahrt (DLR), Deutsches Fernerkundungsdatenzentrum (DFD), Germany*
Paul Jamason	*Scripps Institution of Oceanography (SIO), University of California – San Diego, USA*
Jan M. Johansson	*Chalmers University of Technology, Sweden*
William Kass	*National Geodetic Survey (NGS), NOAA, USA*
Mark Kaufman	*IMVP (Institute of Metrology for Time and Space), Russia*
Robert Khachikyan	*IGS Central Bureau, Jet Propulsion Laboratory (JPL), USA*
Matt King	*University of Newcastle upon Tyne, United Kingdom*

Name	Affiliation
Elisabeth Klaffenboeck	*Austrian Research Promotion Agency, Austria*
Mikhail G. Kogan	*Columbia University, Lamont–Doherty Earth Observatory, USA*
Oddgeir Kristiansen	*Norwegian Mapping Authority (Statens Kartverk), Norway*
Francois Lahaye	*Natural Resources of Canada, Geodetic Survey Division*
Christopher Lane	*Jet Propulsion Laboratory (JPL), USA*
Richard Langley	*University of New Brunswick, Canada*
Kristine Larson	*University of Colorado, Boulder, USA*
David Lavallee	*University of Newcastle upon Tyne, United Kingdom*
Jing–Nan Liu	*Wuhan University, China*
Maria Lorenzo	*European Space Agency, European Space Operations Centre, Germany*
Sylvain Loyer	*Centre National D'Etudes Spatiales (CNES)–Collecte de Localisation Satellite, France*
Simon Lutz	*Astronomical Institute, University of Bern, Switzerland*
Finn Bo Madsen	*National Survey and Cadastre of Denmark (KMS), Geodetic Department*
Salah Mahmoud	*National Research Institute of Astronomy and Geophysics (NRIAG), Egypt*
E.C. Malamani	*National Geophysical Research Institute, India*
Zinovy Malkin	*Russian Academy of Sciences (RAS, Institute of Applied Astronomy)*
Dennis D. McCarthy	*U.S. Naval Observatory, USA*
Michael Meindl	*ETH Zurich, Institute of Geodesy and Photogrammetry, Switzerland*
Yuanxing Miao	*Yunnan Observatory, Chinese Academy of Sciences*
Yves Mireault	*Natural Resources of Canada, Geodetic Survey Division*
Vladimir Mitrikas	*Russian Space Agency, Satellite Navigation Department, Mission Control Center*
Philip Moore	*University of Newcastle upon Tyne, United Kingdom*
Thomas Nischan	*Deutsches GeoForschungsZentrum (GFZ), Germany*
Zhijun Niu	*China Earthquake Administration (CEA)*
Susan Owen	*Jet Propulsion Laboratory (JPL), USA*
Pil–Ho Park	*Korea Astronomy and Space Science Institute, South Korea*
Nigel Penna	*University of Newcastle upon Tyne, United Kingdom*
Felix Perosanz	*Centre National D'Etudes Spatiales, France*
Peter Pesec	*Institute for Space Research, Graz, Austria*
Gerard Petit	*Bureau International des Poids et Mesures, France*
Mike Piraszewski	*Natural Resources of Canada, Geodetic Survey Division*
Hans Peter Plag	*University of Nevada, Reno, USA*
Markku Poutanen	*Finnish Geodetic Institute*
Markus Ramatschi	*Deutsches GeoForschungsZentrum (GFZ), Germany*
Paul Rebischung	*Institut Geographique National ,ENSG/LAREG, France*
Svein Rekkedal	*Norwegian Mapping Authority (Statens Kartverk), Norway*

Name	Affiliation
Sergey Revnivykh	*Russian Space Agency, Satellite Navigation Department, Mission Control Center*
Chris Rocken	*University Corporation for Atmospheric Research, UCAR, USA*
James Rohde	*National Geodetic Survey (NGS), NOAA, USA*
Oivind Ruud	*UNAVCO Inc., USA*
Alvaro Santamaria Gomez	*Instituto Geográfico Nacional – Ministerio de Fomento, Spain*
Michael Schmidt	*Geological Survey of Canada, Pacific Geoscience Centre, Natural Resources Canada (NRCan)*
Giovanni Sella	*National Geodetic Survey (NGS), NOAA, USA*
Robert Sherwood	*Herstmonceux Space Geodesy Facility, United Kingdom*
Victor Slabinski	*US Naval Observatory, USA*
Janusz Sledzinski	*Warsaw University of Technology, Institute of Geodesy & Geodetic Astronomy, Poland*
Dru Smith	*National Geodetic Survey (NGS), NOAA, USA*
Richard Snay	*National Geodetic Survey (NGS), NOAA, USA*
Luiz Paulo Souto Fortes	*Brazilian Institute of Geography and Statistics (IBGE), Brazil*
Grigory Steblov	*Russian Data Archive and Analysis Center*
Peter Steigenberger	*Technische Universitaet München (TUM), Germany*
David Stowers	*Jet Propulsion Laboratory (JPL), USA*
Cecep Subarya	*Bakosurtanal, Indonesia*
Suriya Tatevian	*Astronomical Institute, Russian Academy of Sciences, Russia*
Pierre Tetreault	*Natural Resources of Canada, Geodetic Survey Division*
Gottfried Thaler	*University of Technology, Vienna, Department of Advanced Geodesy, Austria*
Daniela Thaller	*Astronomical Institute, University of Bern, Switzerland*
Ian Thomas	*University of Newcastle upon Tyne, United Kingdom*
Jeffrey Tracey	*US Naval Observatory, USA*
Robert Twilley	*GeoScience Australia*
Hans van der Marel	*Technical University of Delft, The Netherlands*
Francesco Vespe	*Italian Space Agency, Agenza Spaziale Italiana (ASI), Italy*
Frank Webb	*Jet Propulsion Laboratory (JPL), USA*
Georg Weber	*Bundesamt fuer Kartographie und Geodaesie (BKG), Germany*
Jan Weiss	*Jet Propulsion Laboratory (JPL), USA*
Barbara Wiley	*National Geospatial–Intelligence Agency (NGA), USA*
Brian Wilson	*Jet Propulsion Laboratory (JPL), USA*
Guy Woeppelmann	*Universite de La Rochelle, France*
Fumin Yang	*Shanghai Astronomical Observatory, Chinese Academy of Sciences*
Shu–Hua Ye	*Shanghai Astronomical Observatory, Chinese Academy of Sciences*
Ta–Kang Yeh	*National Measurement Laboratory, Industrial Technology Research Institute, Taiwan*
Vjacheslav Zalutsky	*East–Siberian Research Institute for Physics, Technical and Radiotechnical Measurements, Russia*
Susanna Zerbini	*University of Bologna, Italy*

Appendix E
Product Availability Standards and Quality of Service

IGS Quality of Service

The IGS continuously monitors the accuracy of its products through intercomparison of results between Analysis Centers. IGS strives to deliver its products on a highly available basis as shown below. Due to the volunteer nature of IGS, availability of products is not guaranteed.

GPS Satellite Ephemerides / Satellite and Station Clocks		Sample Interval	Accuracy	Latency	Continuity	Availability
Broadcast (for comparison)	Orbits	1s	~100 cm	real time	Continuous	99.99%
	Sat. Clocks		~5 ns RMS; ~2.5 ns Sdev			
Ultra-Rapid (predicted half)	Orbits	15 min	~5 cm	predicted	4x daily, at 03, 09, 15, 21 UTC	95%
	Sat. Clocks		~3 ns RMS; ~1.5 Sdev			
Ultra-Rapid (observed half)	Orbits	15 min	~3 cm	3-9 hours	4x daily, at 03, 09, 15, 21 UTC	95%
	Sat. Clocks		~150 ps RMS; ~50 ps Sdev			
Rapid	Orbits	15 min	~2.5 cm	17-41 hours	daily, at 17 UTC	95%
	Sat. & Stn. Clocks	5 min	~75 ps RMS; ~25 ps Sdev			
Final	Orbits	15 min	~2 cm	12-18 days	weekly, every Thursday	99%
	Sat. & Stn. Clocks	Sat: 30 s; Stn.: 5 min	75 ps RMS; 20 ps Sdev			
Real-time	Orbits	5-60 s	~5 cm	25 seconds	Continuous	95%
	Sat. Clocks	5 s	300 ps RMS; 120 ps Sdev			

Note 1: *Orbit accuracies are 1D mean RMS values over the three XYZ geocentric components. IGS accuracy limits, except for predicted orbits, are based on comparisons with independent laser ranging results and discontinuities between consecutive days. The precision is better.*

Note 2: *The accuracy (neglecting any contributions from internal instrumental delays, which must be calibrated separately) of all clocks is expressed relative to the IGS timescale, which is linearly aligned to GPS time in one-day segments. The standard deviation (SDev) values are computed by removing a separate bias for each satellite and station clock, whereas this is not done for the RMS values.*

Note 3: *Availability: percentage of time that accuracy and continuity of service meet stated specification.*

GLONASS Satellite Ephemerides	Sample Interval	Accuracy	Latency	Continuity	Availability
Final	15 min	~3 cm	12-18 days	weekly, every Thursday	99%

Geocentric Coordinates of IGS Tracking Stations (over 250 Sites)		Sample Interval	Accuracy	Latency	Continuity	Availability
Final Positions	Horizontal	weekly	3 mm	11-17 days	weekly, every Wednesday	99%
	Vertical		6 mm			
Final Velocities	Horizontal	weekly	2 mm/yr	11-17 days	weekly, every Wednesday	99%
	Vertical		3 mm/yr			

Earth Rotation Parameters						
Ultra-Rapid (predicted half)	Polar Motion	daily integrations at 00, 06 12, 18 UTC	~200 µas	real time	4x daily, at 03, 09, 15, 21 UTC	99%
	Polar Motion Rate		~300 µas/day			
	Length-of-day		~50 µs			
Ultra-Rapid (observed half)	Polar Motion	daily integrations at 00, 06, 12, 18 UTC	~50 µas	3-9 hours	4x daily, at 03, 09, 15, 21 UTC	99%
	Polar Motion Rate		~250 µas/day			
	Length-of-day		~10 µs			
Rapid	Polar Motion	daily integrations at 12 UTC	~40 µas	17-41 hours	daily at 17 UTC	99%
	Polar Motion Rate		~200 µas/day			
	Length-of-day		~10 µs			
Final	Polar Motion	daily integrations at 12 UTC	0.03 mas	~11-17 days	weekly, every Wednesday	99%
	Polar Motion Rate		~150 µas/day			
	Length-of-day		0.01 µs			

Note 1: *100 µas = 3.1 mm of equatorial rotation; 10 µs = 4.6 mm of equatorial rotation.*

Note 2: *The IGS uses VLBI from IERS Bulletin A to partially calibrate for LOD biases over a 21-day sliding window, but residual time-correlated LOD errors remain.*

Atmospheric Parameters	Sample Interval	Accuracy	Latency	Continuity	Availability
IGS Final Tropospheric Delay: *zenith path delay (ZPD) plus north, east gradients*	5 min	~4 mm for ZPD	~ 3 weeks	daily	99%
Ionosphere TEC Grid	2 hours; 5 deg (Lon.) x 2.5 deg (Lat.)	2-8 TECU	~11 days	weekly	99%
Rapid ionosphere TEC Grid	2 hours; 5 deg (Lon.) x 2.5 deg (Lat.)	2-9 TECU	<24 hours	daily	95%