

GGOS

Bureau of Networks and Observations

2015-2016 Implementation Plan

1.0 IMPLEMENTATION OVERVIEW

1.1 Introduction

As defined in the GGOS Terms of Reference (GGOS ToR. 2015), the Bureau of Networks and Observations develops a strategy to design, integrate and maintain the fundamental infrastructure in a sustainable way to satisfy the long-term (10-20 years) requirements identified by the GGOS Science Panel. Working groups are included in the Bureau in recognition of their synergistic role with Bureau activities. Both the geometric and non-geometric services are represented within the Bureau. The Bureau advocates for implementation of Core and Co-location network sites to satisfy GGOS requirements, monitors the present state of the networks and projects future status, and supports and encourages infrastructure critical for the development of data products essential to GGOS.

The Bureau of Networks and Observations (BN&O) is a redefinition of the GGOS Bureau for Networks and Communication (BN&C) which was established in 2003 to develop a strategy to design, integrate, implement and maintain the fundamental geodetic network of co-located instruments (VLBI, SLR, GNSS, and DORIS) and the supporting infrastructure in a sustainable way to satisfy the long-term (10 - 20 years) GGOS requirements (GGOS 2020, 2009). The original strategy was to exploit synergistic opportunities to better integrate or co-locate with the infrastructure and communications networks of the many other Earth observation disciplines organized under GEOSS. The Bureau constituted mainly from the geometric services (IGS, IVS, ILRS, IDS) to carry out most of its functions; efforts are now underway to integrate other services and techniques that would enhance geodetic products supported by GGOS.

The Bureau is being restructured to:

- Expand its role with the inclusion of other than the geometric services and techniques (gravity, tide gauges, etc.);
- Improve communication and information exchange and coordination with the space missions;
- Formally include the simulation activities;
- Formally include the site-tie component at co-located sites; and
- Include the Data and Information Systems activity.

These expanded activities are being implemented by incorporating the non-geometric measurement services (with proper definition of data products) and the pertinent GGOS working groups (Missions, Simulations, Data and Information Systems, IERS Working Group on Survey and Co-location) that were not fully integrated into GGOS so far and yet have a very synergistic role with the Bureau. The restructuring also gives the Bureau an opportunity for some tuning of its role, tasks, and priorities based on its over 10 years of experience.

The Bureau of Networks and Observations gives us a means of greater coordination among the services and provides a conduit for the point of view of the services to GGOS on policy and decision-making.

1.2 Goals and Objectives

The primary goal of the Bureau is to see the networks implemented; in support of this goal, the Bureau will advocate for ground system networks of sufficient global distribution and measurement capability to address the Earth science and societal benefit requirements set by the GGOS. Satisfying this goal requires development of a strategy to design, integrate, implement and maintain the core geodetic network of co-located instruments and supporting infrastructure in a sustainable way to satisfy the long-term (10-20 years) requirements identified by the GGOS Science Council. At the base of GGOS are the sensors and the observatories situated around the world providing the timely, precise, and fundamental data essential for creating geodetic products. Primary emphasis must be placed on sustaining the infrastructure needed to maintain the evolving terrestrial and celestial reference frames, while at the same time ensuring the broader support of the scientific applications of the collected data. Synergistic opportunities should be exploited to better integrate and co-locate with the infrastructure and communications networks of the many other Earth observation disciplines organized under GEOSS. Furthermore, additional measurements, such as those from the gravity field and from tide gauge networks, should be included.

Although the Bureau will get its primary direction from the GGOS Science Council and the Executive Committee, the Bureau and the services must also recognize scientific and societal benefits and important synergies that will accrue through connection with the other entities.

The Roles of the Bureau are to:

- Provide a forum for the services and working groups to share and discuss plans, progress, and issues, and to develop and monitor multi-entity efforts to address GGOS requirements;
- Actively promote, design and coordinate the global geodetic ground-based infrastructure needed to meet requirements for GGOS Earth science and societal benefits;
- Lead efforts for the integration of various ground observation networks under the GGOS umbrella; and
- Coordinate the international geodetic services' activities that are the main source of key data and products needed to realize stable global reference frames and other data products essential to study changes in the dynamic Earth System and characterize key Earth science parameters for the benefit of society.

1.3 Bureau of Networks and Observations Authority, Governance Structure, Management Structure, and Implementation Approach

1.3.1 Authority

The Bureau will be a consortium of representatives of the IAG Services, Commissions and Working Groups with a common goal of guiding the design, evolution and implementation of the observation-gathering networks. The Bureau will maintain a liaison with the GGOS themes. The Bureau will be self-managed following the guidelines, policies, and procedures put in place by the GGOS Coordinating Board. The Bureau will work with the services and working groups to formulate the tasks that will support these policies and procedures, implementing reporting procedures/plans in a reasonable manner to have direct impact on the Bureau goals, yet avoid extraneous and laborious activity. The Bureau is essentially a “consortium of the willing” benefitting from members’ implementation plans to satisfy programs enacted by their parent organizations, which are likely a component of GGOS. In many cases the Bureau task will be advocating, promoting, and/or measuring progress.

Elements within the Bureau will need to interact with entities outside the Bureau; some of these are spelled out in the working group briefs in Appendix 4.1. If direct contact does not prove fruitful then the Bureau and the working group will work through the Coordinating Board (CB).

Table 1.2-1: Bureau of Networks and Observations Goals and Objectives Mapping. The table identifies the primary (✓✓) and secondary (✓) Goals and Objectives that the Bureau of Networks and Observations will be supporting to meet the outcomes stated in the GGOS strategic plan. Primary goals and objectives are those that are aligned with the charter of the GGOS Entity in question and are not likely to be realized without its involvement. Secondary goals and objectives are those that the given GGOS Entity can support as part of its charter.

	Goal 1 – Geodetic Information and Expertise			Goal 2 – Global Geodetic Infrastructure		Goal 3 - Services, Standardization, and Support		Goal 4 - Communication, Education, and Outreach	
	<i>Objective 1-1 – Understand societal and scientific needs and deficiencies</i>	<i>Objective 1-2 – Position GGOS as the primary source for geodetic information and expertise</i>	<i>Objective 1-3 – Connect with the larger scientific community and integrate with other Earth observing</i>	<i>Objective 2-1 – Support and advocacy for infrastructure and associated elements</i>	<i>Objective 2-2 – Lead efforts for the integration of various ground observation networks within the GGOS network</i>	<i>Objective 3-1 – Standardization</i>	<i>Objective 3-2 – Coordination and Development of IAG Services</i>	<i>Objective 4-1 – Establish a Strong Internet/Online Presence</i>	<i>Objective 4-2 – Outreach to the Technical Community and General Society</i>
Coordinating Board	✓✓	✓✓	✓	✓	✓	✓	✓	✓	✓
Consortium	✓	✓	✓✓	✓	✓	✓	✓✓		✓
Coordinating Office	✓	✓	✓	✓	✓	✓	✓	✓✓	✓✓
Bureau of N&O			✓	✓✓	✓✓	✓	✓		
Bureau of P&S	✓	✓	✓	✓		✓✓	✓✓		
Science Panel	✓✓	✓	✓✓				✓		✓

The focus of the Bureau is primarily on the networks. At the moment we have the network requirements for the support of the Global Terrestrial Reference Frame (GTRF). The measurement requirements for other themes and focus areas must be defined. Once these are formulated, the Bureau will work with the Bureau of Products and Standard (BP&S), the themes, and focus areas to quantify the network requirements.

1.3.2 Governance Structure

Not Applicable

1.3.3 Management Structure

All resources to support the Bureau will be provided by its members; we do not anticipate that any external support funds will be available. As such the resources required to run the Bureau will be the personnel, travel, and other services provided by its participants through their support agencies/institutions. See Table 1.3-1. Some of the requests for designation of Service Representatives await responses.

Table 1.3-1: BN&O Resources.

Position	Resource	Entity Contributing
Director	Mike Pearlman	CfA (USA)
Deputy Director	TBD	TBD
Secretary	Carey Noll	NASA (USA)
Analysis Specialist	Erricos Pavlis	UMBC (USA)
IVS Service Representative	Hayo Hase Chopo Ma	BKG (Germany) NASA (USA)
ILRS Service Representative	Giuseppe Bianco Wu Bin	ASI (Italy) SHAO (China)
IGS Service Representative	Ruth Neilan Steve Fisher/Juan Ceva	JPL (USA) JPL (USA)
IDS Service Representative	Jérôme Saunier Pascale Ferrage	IGN (France) CNES (France)
IGFS Service Representative	Riccardo Barzaghi TBD	PM (Italy) TBD
PSMSL Service Representative	Mark Tamisiea Tilo Schöne (IGS TIGA-WG)	NOC (UK) GFZ (Germany)
Working Group on Performance Simulations & Architectural Trade-Offs (PLATO)	Daniela Thaller Richard Gross	BKG (Germany) JPL (USA)
Working Group on Data and Information	Bernd Richter Carey Noll	BKG (Germany) NASA (USA)
Working Group on Satellite Missions	Roland Pail Juergen Mueller	TUM (Germany) IfE (Germany)
IERS Working Group on Survey Ties and Co-Location	Sten Bergstrand	SP (Sweden)

The Services and the Working Groups will choose their member representative to the BN&O. Some rules may be formulated for succession.

The IGS, IVS, ILRS, IDS, IGFS, and PSMSL are represented in the new Bureau; the IERS and other services will be invited to join.

The Working Groups within the BN&O have formulated work plans in concert with the Bureau that address key issues for GGOS (see Appendix 4.1); The Working Group on Data and Information is formulating its plan. Our plan also assumes that the IERS Working Group on Site Survey and Co-location will join the GGOS activity through the participation of the IERS.

OVERSEEING AND COORDINATING THE DAY-TO-DAY OPERATIONS

The Bureau will work with each entity to develop a task plan with a projected schedule.

The Bureau does not oversee or coordinate the day-to-day operations of the services. The services are their own entities within the IAG, with representation in the Bureau. Day-to-day activities within the purview of the Bureau will be coordinated, and overseen by the individual entities, with periodic (TBD) review by the Bureau, working with the entity and recommending remedial action if necessary.

REPORTING OF TECHNICAL AND/OR SCIENTIFIC PROGRESS AGAINST SCHEDULE

All service and working group representatives will give oral and/or written reports periodically, as required, on progress, adherence to the task plan, forced deviations, and changes in circumstances and plans. They will also report at the Bureau meetings to be held during EGU, AGU and possible at a third opportunity at roughly mid-year (meeting or telecon). The Bureau will give summary reports at GGOS meetings and on the BN&O webpage on the GGOS website (www.ggos.org).

DESCRIBE ANY CONFIGURATION MANAGEMENT REQUIRED FOR MANAGEMENT

Each of the services and working groups will establish a page or a link (to a page elsewhere) on the GGOS Bureau section of the GGOS website to archive documents, and post plans and progress reports. The Bureau will provide summary reports and estimates of impact on schedule.

Table 1.3-2: Bureau of Networks and Observations Plan. The table identifies the communications requirements of the BN&O

Communication Type	Purpose	Medium	Frequency	Audience	Owner	Deliverables
GGOS BN&O report at the GGOS EC meetings	Report in BN&O status, progress, issues, and action items	Video conference or telecon	Monthly or as decided by the EC	EC members	EC	Oral report
GGOS BN&O report at the GGOS CB Meeting	Report in BN&O status, progress, and issues; other reports as requested by the CB	Face-to-face; may include video conferencing	Twice per year (EGU, AGU); additional meetings as decided by the CB	CB members	CB	BN&O Presentations material and other material as requested by the CB
GGOS BN&O Meeting	Bureau and entity Status Review and issues	Face-to-Face; may include video conferencing	AGU, EGU and any other time set by the Bureau	Bureau members, invitees, and interested parties.	BN&O	Before: Agenda After: Presentation material posted on the website; meeting notes; action items.
GGOS Quarterly reports/updates from the BN&O entities	Reports from BN&O and entities on status/progress review/update	Written or telecon	Quarterly; out of phase with the BN&O meetings	Bureau member and invitees	BN&O	Status report posted on the website
Focused meeting	Review status on specific topics	Oral and written	Varying	Bureau and entity members involved	BN&O and involved entity	Oral and written report

1.3.4 Implementation Approach

The Bureau is a consortium of service representatives supported by the participating working groups. A member of each Bureau entity is a member of the Bureau leadership; thus each entity participates in the Bureau deliberations and decisions, and is expected to fully participate in the decision process and to fully represent his/her entity and report back to the other members of the entity the relevant information. The Bureau leadership will encourage members of each entity to attend and participate in functions/meetings/workshops of other entities. This overall structure will be implemented to provide close interaction among the entities to enhance cross-fertilization and communication.

The Bureau will define the near and long term objectives to support GGOS goals.

The Bureau will coordinate closely with the Bureau of Products and Standards (BP&S) and look to the BP&S, CB, and the EC for guidance in setting network requirements to address new data products (themes, new focus areas, etc.) and helping the Bureau to formulate decisions and trade-offs that need to be resolved.

The Bureau and its services may interact with some or all of the agencies and organizations that participate or will participate in the network or are key interface points for the missions.

We do not foresee any make-or-buy decisions to be made by the Bureau.

1.4 Stakeholder Definition

The network data are the basis for the development of the reference frame and many of the other data products that GGOS will facilitate. As such, GGOS is the main internal stakeholder along with its internal entities the Bureau for Products and Standards, the GGOS Portal, etc.

The data from the GGOS network are the basis for the reference frame, precision orbit determination, precise station positioning, Earth rotation, and all of the other data products to be formed. External stakeholders will include the IAG services, IERS, and other scientific organizations and research institutions. It will include the broad range of the external data and data product users including those working in navigation, civil engineering, surveying and mapping, precision timing applications, precision orbit determination, altimetry, monitoring environment, and global change phenomena, etc. The BN&O will work with the IGFS and the PSMSL/TIGA to advocate and promote network requirements of these communities in support of GGOS-endorsed data products.

Stakeholder advocacy will be done at the services, the Bureaus, and GGOS level.

The advocacy strategy seems to be a general GGOS task and shall be discussed within GGOS.

Table 1.4-1 summarizes the advocacy strategy for the identified internal and external stakeholders of the GGOS Bureau of Networks and Observations

2.0 GGOS BUREAU OF NETWORKS AND OBSERVATIONS BASELINES

The overall goal of the Bureau is the implementation of the ground network of sufficient global distribution and measurement performance capability to address the Earth science and societal benefit requirements set by the GGOS. The main focus of the Bureau is presently the reference frame and the evolution of the global geodetic networks over time. As the network improves, there should be commensurate steps in the improvement of the reference frame. The Bureau will regularly report at the CB meeting and public meetings on the evolution and plans for the network. Since the implementation of the full core sites network capability will be very costly, it may take many years to achieve; we are assuming a time frame of 10-20 years. In all likelihood there will be compromises in network design and capability that will be necessary to accommodate realistic constraints. In this connection, the Bureau will encourage the implementation and upgrade of sub-co-location sites to augment the core network.

As additional data products are developed and formalized, they will place additional requirements on the network.

Table 1.4-1: BN&O Stakeholders and Advocacy Strategies

STAKEHOLDERS	ADVOCACY STRATEGIES
INTERNAL STAKEHOLDERS	
GGOS Coordinating Board, GGOS Consortium, other GGOS entities including the GGOS Bureau of Products and Standards, GGOS Portal, Outreach, etc.	<p>As the observing system of the IAG, GGOS serves a unique and critically important combination of roles centering upon advocacy, integration, and international relations. The IAG relies upon GGOS and the GGOS BN&O to advocate for improvements in the ground-based geodetic infrastructure of GNSS and DORIS reference stations, VLBI and SLR space geodetic stations, and gravity observatories; it also supports the development of new satellite missions for altimetry, gravity mapping, and Earth observation. Overall, the Bureau promotes the importance of modern geodesy for addressing the needs of science and society for stable reference frames.</p> <p><i>Advocacy strategies will include monthly telephone conferences with the Executive Committee and the Coordinating Office, biannual (or more frequent) meetings with the GGOS Coordinating Board and Consortium, and written reports as required to report progress and issues to help support the GGOS role in CEOS, GEO, GIAC, and UN-GGIM and other international organizations</i></p>
IAG Services	<p>GGOS BN&O works with the pertinent IAG services (at the moment the IGS, IVS, ILRS, IDS, IGFS, and PSMSL) to advocate for and support the maintenance and upgrade of the network infrastructure necessary for monitoring the Earth system and for global change research.</p> <p><i>Each of the pertinent services has representation in the BN&O. Advocacy strategies will include frequent email and telephone conferences with these service representatives, a minimum of twice yearly Bureau meetings, as well as face-to-face meetings at major conferences and/or workshops (approximately two to three times per year) to discuss progress and issues.</i></p>
EXTERNAL STAKEHOLDERS	
IERS	<p>The IERS develops the final reference frame products and thus relies on the BN&O advocating role, coordination with the service networks, and status and network capability projections activities. The IERS Working Group on Survey Ties and Co-location supports BN&O activities.</p> <p><i>Advocacy strategies will include offering a position in the Bureau for a representative from the IERS, frequent email and telephone conferences with IERS personnel, a minimum of twice yearly Bureau meetings, as well as face-to-face meetings at major conferences and/or workshops (approximately two to three times per year) to discuss progress and issues.</i></p>

2.1 Requirements Baseline

2.1.1 Geometric Space Geodesy Network

The reference frame baseline requirements are levied by the GGOS 2020 document. The most stringent requirement comes from sea level rise:

- Accuracy of 1 mm, and stability at 0.1 mm/yr, a factor of 10-20 beyond current capability;
- Accessibility: 24 hours/day; worldwide;
- The space segment is currently defined by LAGEOS-1 and -2, LARES, GNSS, DORIS, and the quasars;
- The ground segment is defined by a global distributed network of “modern technology”, co-located SLR, VLBI, GNSS, DORIS stations and other ground-based measurements (e.g., gravimeters, tide gauges, etc.), locally tied together with accurate site ties;
- A dense network of GNSS ground stations to distribute the reference frame globally to the users;

Simulations to date performed within the Bureau by Erricos Pavlis/UMBC have translated this requirement into a network-size specification:

- ~32 globally distributed, well positioned, new technology, co-location sites will be required to define and maintain the reference frame;
- ~16 of these co-location stations must track GNSS satellites with SLR to calibrate the GNSS orbits, which are used to distribute the reference frame.

Recognizing that many sites will not be at ideal locations nor have ideal conditions, core site deployment will occur over many years, and we will have a mix of new and legacy technologies for many years: we can assume that co-location sites (non-core sites) will continue to play a vital role in our data products and that the quality of our output will be the product of network core sites, co-location sites, mix of technologies, adherence to proper operational and engineering procedures, and making best use of the data once it leaves the field.

The “heavy lifting” in network deployment and upgrade will be conducted by the services. The GGOS BN&O will advocate for implementation of the global space geodesy network of sufficient capability to achieve data products essential for GGOS and will provide a multi-technique community for the services to work and plan together. The BN&O will monitor and project the status and evolution of the space geodesy network and project network performance capability to help guide the activities.

2.1.2 Gravity Field Network

Global gravity networks include sites with (1) fixed instruments (usually superconducting gravimeters) for continuous monitoring of local gravity variations with extremely high precision and (2) sites occupied infrequently by absolute gravimeters as part of a broader geographic effort to characterize the regional or global gravity field. High precision, continuous monitoring can reveal information

about temporal changes in height and the forces that cause these changes. Co-location of continuous monitoring instruments with the geometric space geodetic techniques like SLR, VLBI, GNSS, and DORIS can greatly enhance the study of the local static and temporally changing environment. Sites occupied occasionally with absolute gravimeters, are usually established as part of national or agency programs to map the regional gravity field, which can tell us information about the underlying structure. Data from both fixed and occupied sites are used to study the Earth's gravity field structure, variations caused by local loading due to atmospheric, oceanic and hydrological loads, Earth's response to various phenomena, e.g., the Chandler wobble, internal gravity waves, slow and silent earthquakes, tectonic motions, sea-level changes, post-glacial rebound and Earth's normal modes following moderate to large earthquakes. Surface gravimetric measurements are also used to validate spacecraft data derived models from missions such as CHAMP, GRACE, and GOCE, or the upcoming GRACE-FO.

2.1.3 Tide Gauge Network

Tide gauge data are being used to develop ocean circulation models, tidal models, warnings of hazards from tsunamis, monitoring long-term sea level changes, and help calibrate and validate satellite ocean surface altimeters. The two main issues with tide gauge networks are the large number of gauges that do not have local GNSS (or DORIS) receivers for accurate and continuous geo-location in the geodetic reference frame and the gaps over large coastal and oceanic expanses due to either inoperative units or lack of instrumentation entirely. The tasks within GGOS are to help encourage the geodetic community to properly deploy GNSS receivers where they are not already in close proximity to existing tide gauges, to make the resulting tide gauge and GNSS data publicly available within international data archives sanctioned by GLOSS, IGS, GGOS, etc., to establish ties between the GNSS receivers and tide gauges, to advocate for more absolute gravity sites at tide gauges, and to advocate for placement of tide gauges in regions void of such systems but of great scientific and societal interest. In accomplishing these tasks, we recognize that oceanographic, as well as geodetic, entities are involved (i.e., GLOSS, GOOS, IOC).

Table 2.1-1: GGOS BN&O Specifications and Requirements Allocation

REQUIREMENT REFERENCE	REQUIREMENT AND INTERPRETATION	GGOS ALLOCATION	IAG SERVICE (OR OTHER ENTITY) ALLOCATION
GGOS-Ops-1	Operate global networks of geodetic reference stations, gravimeters; support the long-term operation of tide gauges relevant for GGOS.	BN&O	IAG services
GGOS-Ops-2	Operate a global sub-network of core reference stations at which the techniques are co-located.	BN&O	IAG services
GGOS-Ops-3	Determine the survey ties between the co-located techniques.	BN&O/IERS WG ON ST&C	IAG services and space geodesy sites; individual institutions operating GGOS sites; IERS
GGOS-Ops-4	Process all geometric and gravimetric observations with an accuracy and consistency of at least 1 ppb.	BN&O	IAG services

2.2 Schedule Baseline

All of the services will focus on their respective network coordination, data acquisition, and data analysis to generate products for science and societal needs articulated by GGOS. The services will constantly strive to improve the robustness and quality of their data and the results through improved procedures, technologies, and modeling.

In its role to support the services and better serve the users, the GGOS Bureau of Networks and Observations will:

- Advocate for implementation of the global space geodesy network of sufficient capability to achieve data products essential for GGOS;
 - Update the Bureau section of the GGOS website for public use including status, plans, and issues for the Bureau entities (September 30, 2015);
 - Provide status and plans reports from the Bureau at EGU, AOGS (August 2015), AGU (December 2015) and other public meetings; (April 2015),

- Continue to oversee the Bureau’s “Call for Participation in the Global Geodetic Core Network: Foundation for Monitoring the Earth System” and work with new potential groups interested in participating;
 - Meet with interested parties and encourage partnerships.
- Provide a forum for the services and working groups to meet, discuss status and plans, and examine common interests and requirements;
 - Organize meeting at EGU, AGU, and other opportunities.
- Maintain the “Site Requirements for GGOS Core Sites” document (with the IAG services) (September 30, 2015);
- Monitor and project the status and evolution of the GGOS space geodesy network in terms of location and performance (with the IAG services);
 - Issue next questionnaire and compile responses (August 31, 2015).
- Coordinate the effort of the services to implement procedures to provide test-based estimates of their data quality and report (first discussion at Bureau meeting at EGU 2015);
- Facilitate efforts to integrate relevant parameters from other ground networks (gravity field, tide gauges, etc.) into the GGOS network to support GGOS requirements; advocate for installation of GNSS receivers at appropriate tide gauges (progress report at EGU 2016);
- Support the technical services on the promotion of recommended technologies/configurations and procedures in the establishment of new sites and the upgrading of current sites, and in the evaluation of performance of new stations and new capabilities after they become operational;
- Working Group on PLATO: Project future network capability and examine trade-off options for station deployment and closure, technology upgrades, impact of site ties, etc.
 - Using simulation techniques already established, use the updated stations status and projections to project network capability over the next 5 and 10 years periods (first report EGU 2015; second report AGU 2015);
 - Based on the updated station projections, estimate the GNSS tracking load that the SLR network can sustain (Bureau meeting at AGU 2015);
 - Make recommendations on network configuration based on simulations and trade-off studies.
For more detail see Appendix 4.1.1.
- Working Group on Data and Information: Develop a metadata strategy for all ground-based measurement techniques (WG on Data and Information)
 - Organize a meeting of the interested parties to discuss how we can integrate/utilize the separate space geodesy metadata activities, and provide organizational oversight to carry it through (October 31, 2015);
 - Develop a document summarizing the need, the activities underway by independent groups, and the pertinent references (December 31 2015).
For more detail see Appendix 4.1.2
- Working Group on Satellite Missions: Improve Coordination and information exchange with the missions for better ground-based network response to

mission requirements and space-segment adequacy for the realization of GGOS goals;

- Agree in the content and develop a missions section on the GGOS website for public access; implement a procedure to keep the section up-to-date (September 2015);
- Review the inventory/repository of current and near-future satellite missions (Bureau meeting at EGU 2016);
- Evaluate the contribution of current and near-future missions to GGOS goals (Bureau meeting at AGU 2016);
- Finalize the Science and User requirements document for future gravity missions with IGFS and forward to the IUGG via ESA for formulation into a joint resolution (June 30, 2015).
For more detail see Appendix 4.1.3.
- IERS Working Group on Survey and Co-location: Standardize site-tie measurement, archiving, and analysis procedures, maintain a current site-tie archive; and encourage additional groups to help support the network site-tie task;
 - Develop a guidelines document of standard nomenclature (December 31, 2015);
 - Develop a plan for an outreach approach to station managers at co-location sites to stress the need for accurate local ties and the need for seeking local survey capability; stress outreach to surveying teams in China, Russia, and Japan in order to establish common guidelines (EGU 2016);
 - Coordinate the effort of the services to implement procedures to determine system reference points and their accuracies (first discussion Bureau meeting in EGU 2015).
For more detail see Appendix 4.1.4.
- Support GGOS submissions to GEO, CEOS, and other international organizations (ongoing).

The evolution of the networks will be a long-term endeavor (10-20 years), but the evolution in the networks, including both the core and participating co-location sites, new technology and legacy sites, and the associated modeling and analyses will provide steady and very useful improvements in the data products. The evolving data and data products will be a major driver for developing and validating the new models and analysis techniques.

2.3 Resources

The resources that make the Bureau possible are tabulated in Table 1.3-1. The participating institutions cover material resources, travel, and other costs such as meeting rooms and teleconferences. The Bureau plan recognizes that we can declare the ideal, we can issue guidelines and standards, and we can advocate, but we have very limited control over the allocation of resources except through persuasion. The realization of the infrastructure will depend upon the resources that our participants are willing to contribute, the cooperation that participants are willing to undertake,

geographic, political and other practical realities, and the influence that we as GGOS can exert.

3.0 CHANGE LOG

Table 3-1: Bureau of Networks and Observations Implementation Plan Change Log

VERSION	RELEASE DATE	SYNOPSIS OF RELEASE
0.1	141207	First draft for review
0.2	150326	Draft submitted to CB for review
0.3	150531	Second draft submitted to CB for review
0.4		

4.0 Appendices

4.1 Working Groups of the Bureau of Networks and Observations

4.1.1 Working Group on Performance Simulations & Architectural Trade-Offs (PLATO)

(Prepared by Daniela Thaller)

Chair: Daniela Thaller (Germany)

Co-Chair: Richard Gross (USA)

Role (Goals and Objectives)

- Use simulation techniques to assess impact on reference frame products of: network configuration, system performance, technique and technology mix, co-location conditions, site ties, and space ties (added spacecraft, etc.);
- Use and develop improved analysis methods for reference frame products by including all existing data and available co-locations (i.e., include all satellites and use all data types on all satellites);
- Make recommendations on network configuration based on simulations and trade-off studies.

Tasks

- Develop optimal methods of deploying next generation stations, and estimate the dependence of reference frame products on ground station architectures;

- Estimate improvement in the reference frame products as co-located and core stations are added to the network;
- Estimate the dependence of the reference frame products on the quality and number of the site ties and the space ties;
- Estimate the improvement in the reference frame products as other satellites are added, e.g., cannonball satellites, LEO, GNSS constellations;
- Estimate the improvement in the reference frame products as co-locations in space are added, e.g., use co-locations on GNSS and LEO satellites; add special co-location satellites (GRASP, NanoX, etc.);
- In support of the SLR tracking of GNSS satellites, use an agreed measure of SLR ranging performance, to examine optimal tracking strategies, and to develop the optimal deployment of the tracking data for reference frame products;
- Conduct simulations for co-location satellites – how much would it help us? How many data do we need? How accurately do we need to know the dimensions on the satellite and other s/c-related parameters (e.g., ties between instruments on board, satellite attitude);

Organization

The WG will have a Chair, a Co-Chair and WG team members who will be involved with the planning and conduct the simulations and the extended analysis methods. The WG will define the roles for its members' participation. Associate members may attend meetings, provide information, and contribute to the discussion.

The Chair and Co-Chair are Daniela Thaller and Richard Gross.

The working group will establish liaisons with the networks entity, the other GGOS working groups (e.g., Satellite Missions), the themes to enhance communication and coordination, and other GGOS and IAG entities as necessary, especially the IERS WG on Site Survey and the ILRS LARGE Study Group.

Reporting

The working group will give oral (PP) reports on accomplishments, tasks underway, plans, and current obstacles at each of the Bureau meetings. Written reports may sometimes be needed for Bureau reporting as required by the GGOS leadership. The WG will maintain a page on the GGOS website to keep the community aware of progress and work underway.

The WG members will give presentations at scientific conferences about their individual contributions to fulfill the WG tasks. Publications in appropriate journals are also envisaged.

4.1.2 Working Group on Data and Information

(Prepared by Carey Noll and Bernd Richter)

Chair: Bernd Richter (Germany)

Co-Chair: Carey Noll (USA)

Role (Goals and Objectives)

- Promote the use of metadata standards and conventions and recommend implementations of metadata management for GGOS in the pursuit of a metadata policy;
- Promote interoperability among participating data centers with other databases and services;
- Develop strategies to protect the intellectual properties on data and products;
- Align metadata standards with the GEOSS approach and methodology, interface on data standards with GEO and ICSU.

The current focus of the WG is on developing standards for metadata that can be utilized by the space geodesy community. Metadata typically encompass critical information about the measurements that are required to turn these measurements into usable scientific data. Metadata also includes information that supports data management and provides a foundation for data discovery. Data centers extract metadata from incoming data sources and also augment that metadata with information from other sources. It is typical for data centers to store the metadata in databases in order to manage the data in their archives and to distribute both data and metadata to data users. Metadata can further be utilized by data discovery applications to allow users to find data sets of interest. In order to be effective, metadata need to be simple to generate and maintain. They must be consistent and informative for the archivist and the user.

GGOS is seeking a metadata schema that can be used by all of its elements for standardized metadata communication, archiving, and retrieval. First applications would be the automated distribution of up-to-date station configuration and operational information, data archives and catalogues, and procedures and central bureau communication. Several schemas that show promise have been under development by SOPAC (Scripps Institution of Oceanography), GML (Australia/New Zealand), and others. The intent is that data need be entered only from an initial source (a station, a data center, an operations center, data products, etc.) and would then flow to and be integrated into those metadata files where users would have access.

One plan is to organize a meeting, probably in early August 2015 at UNAVCO in Boulder, for representatives from the services, the data centers, the science community, etc. to give each of the schema developers an opportunity to preach his wears and allow discussion on the pros and cons of each. The objective is to try to come to closure on a schema that we could as a community adopt for general implementation. Groups would not be obligated to a rapid implementation schedule, but would commit to the agreed schema when they are ready to begin the process.

Tasks

- Develop a document summarizing the need, the activities underway by independent groups, and the pertinent references (June 2015);
- Organize a meeting of the interested parties to discuss how we can integrate/utilize the separate space geodesy metadata activities, and provide organizational oversight to carry it through (August 2015).

Gary Johnston has agreed develop a white paper to spell out the need and the plan to use as a basis for a Call for Participation in the meeting to be issued by the BN&O. This workshop is currently planned for August 2015 in Boulder, CO.

Organization

The WG will have a Chair, a Co-Chair and WG team members who will be involved with the planning and WG activities. The WG will is currently chaired by Bernd Richter with co-chair Carey Noll. Additional members with interest in data management within the services perform necessary research, provide material for the website, presentation material, and other documentation.

Reporting

The working group will give oral (PP) reports on accomplishments, tasks underway, plans, and current obstacles at each of the Bureau meetings. Written reports may sometimes be needed for Bureau reporting as required by the GGOS leadership. The WG will maintain a page on the GGOS website to keep the community aware of progress and work underway.

A report summarizing the planned metadata workshop and including actions and plans will be issued.

4.1.3 Working Group on Satellite Missions

(Prepared by Roland Pail)

Chair: Roland Pail (Germany)

Co-Chair: Jürgen Müller (Germany)

The GGOS Satellite Mission Working Group (SMWG) is established in December 2008, under the lead of C.K. Shum, and more than 20 members agreed to serve on this working group. In December 2010, Isabelle Panet was appointed as new Chair, and in December 2013 Roland Pail took over the role of WG Chair.

Role (Goals and Objectives)

The purpose and scope of the SMWG is the coordination, advocating, and information exchange with satellite missions as part of the GGOS space infrastructure, for a better ground-based network response to mission requirements and space-segment adequacy for the realization of the GGOS goals.

The SMWG is set-up as an international panel of experts, with consultants of national and international space agencies.

Satellite missions are a prerequisite for monitoring change processes in the Earth system on a global scale with high temporal and spatial resolution. Therefore, beyond purely scientific objectives they meet a number of societal challenges, and they are an integral part of the GGOS infrastructure and essential to realize the GGOS goals. The role of the SMWG is to monitor the availability of satellite infrastructure, to propose and to advocate new missions or mission concepts, especially in case that a gap in the infrastructure is identified.

Activities

- Assessment of current and near-future satellite infrastructure, and their compliance with GGOS 2020 goals;
 - An inventory of the GGOS satellite infrastructure has been finalized, and a list of satellite contributions to fulfill the GGOS 2020 goals is close to finalization. First steps towards identifying gaps in the future GGOS satellite infrastructure, to gather needs for future mission in order to achieve the GGOS 2020 goals, have been done.
- Support of proposals for new mission concepts and advocating needed missions;
 - SMWG initiated and discussed an IUGG resolution (Melbourne, 2011) regarding the importance of future potential field missions, and initiated a letter from IUGG, signed by the IUGG president, to NASA and ESA headquarters to emphasize this resolution.
 - Initiation and organization of an International Workshop on the “Consolidation of Science and User Requirements for a next gravity field mission configuration”, which was organized and held in Herring, 26 - 27. September 2014. Under the umbrella of IUGG and GGOS, a working team of more than 50 international lead scientists in the disciplines continental hydrology, cryosphere, ocean, and solid Earth agreed on consolidated science and user requirements for a sustained future satellite gravity observing system. This document is input to a joint ESA/NASA working group on a next generation gravity mission constellation (beyond GRACE-FO).
- Interfacing and outreach.
 - The SMWG serves as a consultant for the GGOS EC concerning CEOS issues. Close cooperation exists to the Bureau of Standards and Products, and the Sub-Commissions 2.3 and 2.6 of IAG. Additionally, there are strong interfaces to national and international space agencies.

Tasks

- Work with the Coordinating Office to set up and maintain a Satellite Missions WG section on the GGOS website;
- Set-up and maintain an inventory/repository (accessible through the GGOS website and/or portal) of current and near-future satellite missions;
- Evaluate the contribution of current and near term satellite missions to the GGOS 2020 goals;

- Work with the themes and the Science Committee to establish the required mission roles and to identify the critical gaps in mission infrastructure;
- Work with GGOS Executive Committee, themes, and data product development activities (e.g., ITRF) to advocate for new missions to support GGOS goals;
- Support the Executive Committee and the Science Committee in the GGOS Interface with space agencies;
- Support the GGOS position at the next CEOS/GEO, etc. meeting.

These tasks will require interfacing with other components of the Bureau; especially the ground networks component, the simulation activity (PLATO), as well as the Bureau of Standards and Products.

Organization

The WG will have a Chair, a Co-Chair and a close team of members to do the necessary research, provide material for the website, presentation material, and other documentation. These members will define a role for their participation. The WG will also have a larger group of associate members who attend meetings and contribute information and studies relevant to the WG's tasks.

The working group will establish liaisons with the networks entity, PLATO Working Group to influence simulations, the themes to enhance communication and coordination, and other GGOS and IAG entities as necessary. Not all of the members have been active; membership will need to be examined.

Action no.	Action	KO + 6 m	KO + 12 m	KO + 18 m	KO + 24 m
001	Set-up of Satellite Mission WG section on GGOS website				
002	Maintenance of Satellite Mission WG section on GGOS website				
003	Review of inventory/repository of current and near-future satellite missions				
004	Maintenance of inventory/repository of current and near-future satellite missions				
005	Evaluation of contribution of current and near-future mission to GGOS 2020 goals				
006	Interfacing with themes and GGOS Science Committee to identify critical gaps in the satellite infrastructure				
007	Finalization and publishing (outreach) of Science and User Requirements Document for future gravity field mission				
008	Support advocating of new missions				
009	Supporting GGOS EC and SC in the interfacing with space agencies				
010	Supporting GGOS positions in preparation to CEOS/GEO meetings				

Reporting

The working group will give oral (PP) reports on accomplishments, tasks underway, plans, and current obstacles at each of the Bureau meetings. Written reports may sometimes be needed for Bureau reporting as required by the GGOS leadership.

Publications and Presentations

Pail R., Bingham R., Braitenberg C., Eicker A., Horwath M., Longuevergne L., Panet I., Rolstad-Denby C., Wouters B. (2015): Consolidated science and user requirements for a next generation gravity field mission. Geophysical Research Abstracts, Vol. 17, EGU2015-1648, EGU General Assembly 2015.

Pail R., Bingham R., Braitenberg C., Eicker A., Floberghagen R., Haagmans R., Horwath M., Johnson T., Longuevergne L., Panet I., Rolstad-Denby C., Wouters B. (2014): Consolidated science requirements for a next generation gravity field mission. 5th International GOCE User Workshop, Paris, 28.11.2014.

4.1.4 IERS Working Group on Survey Ties and Co-location

(Prepared by Sten Bergstrand)

Chair: Sten Bergstrand (Sweden)

Co-Chair: John Dawson (Australia)

Role (Goals and Objectives)

- Work with the IGN to maintain a comprehensive site survey and site tie data base;
- Standardize site-tie measurement procedures, standards and analyses techniques;
- Work with the data centers to have results from all of the site tie measurement;
- Work with the IERS, the services and GGOS to encourage more groups to gain site tie survey and analysis capability;
- Help set site tie measurement priorities.

Tasks

- The IGN is working on a guideline document of standard nomenclature to overcome the present confusion among survey groups and between survey groups and users;
- Survey responsibilities have been too widespread and uncoordinated; knowledge on procedures and processing must be shared; dedicated point of contact with each of the Services have been assigned, The WG will try to reach out to surveying teams in China, Russia and Japan in order to establish common guidelines. The WG is discussing an outreach approach to station managers at co-location sites to stress the need for accurate local ties and the need for seeking local survey capability;

Issue: Do we need a policy shift for local ties?

As long as there are researchers performing measurements and they thrive on publications, how can we increase the number of local ties? Publications rely on novelty, production on consistency. A remake of a local tie survey should ideally use exactly the same procedure and hopefully produce equivalent results. How do you publish local tie number two?

Organization

The WG will have a Chair, a Co-Chair and WG team members who will be involved with the planning and WG activities. The WG will define the roles for its members' participation.

The working group will establish liaisons with the networks entity, the other working groups and the themes to enhance communication and coordination, and other GGOS and IAG entities as necessary.

Reporting

The working group will give oral (PP) reports on accomplishments, tasks underway, plans, and current obstacles at each of the Bureau meetings. Written reports may sometimes be needed for Bureau reporting as required by the GGOS leadership. The WG will maintain a page on the GGOS website to keep the community aware of progress and work underway

4.2 Abbreviations

AGU	American Geophysical Union
AOGS	Asia Oceania Geosciences Society
ASI	Agenzia Spaziale Italiano, Italy
BKG	Bundesamt für Kartographie und Geodäsie, Frankfurt/Main, Germany
BN&C	Bureau of Networks and Communication
BN&O	Bureau of Networks and Observations
BP&S	Bureau of Products and Standards
CB	Coordinating Board
CEOS	Committee on Earth Observation Systems
CfA	Center for Astrophysics, USA
CHAMP	Challenging Mini-Satellite Payload
CO	Coordinating Office
CRF	Celestial Reference Frame
DORIS	Doppler Orbitography by Radiopositioning Integrated on Satellite
EC	Executive Committee
EGU	European Geosciences Union
ESA	European Space Agency
FTE	Full-Time Equivalent
GEO	Group on Earth Observation
GEOSS	Global Earth Observation Systems of Systems
GFZ	GeoForschungsZentrum, Germany
GGIM	Global Geospatial Information Management
GGOS	Global Geodetic Observing System
GIMS	GGOS Integrated Master Schedule
GGOS	Global Geodetic Observing System
GLOSS	Global Sea Level Observing System
GML	Geography Markup Language
GNSS	Global Navigation Satellite System
GOCE	Gravity field and steady-state Ocean Circulation Explorer
GOOS	Global Ocean Observing System
GPS	Global Positioning System

GRACE	Gravity Recovery And Climate Experiment
GRACE-FO	Gravity Recovery And Climate Experiment Follow-On
GRASP	Geodetic Reference Antenna in Space
GSFC	Goddard Space Flight Center, USA
GTRF	Global Terrestrial Reference Frame
IAG	International Association of Geodesy
IAU	International Astronomical Union
ICSU	International Council for Science
IDS	International DORIS Service
IERS	International Earth Rotation and Reference Frame Service
IfE	Institut fuer Erdmessung, University of Hannover, Germany
IGFS	International Gravity Field Service
IGN	Institut Géographique National, France
IGS	International GNSS Service
ILRS	International Laser Ranging Service
IOC	Intergovernmental Oceanographic Commission
ITRF	International Terrestrial Reference Frame
IUGG	International Union of Geodesy and Geophysics
IVS	International VLBI Service
JPL	Jet Propulsion Laboratory, USA
LAGEOS	LASer GEODynamics Satellite
LARES	LASer RELativity Satellite
LARGE	LASer Ranging to GNSS s/c Experiment
LEO	Low Earth Orbiter
NASA	National Aeronautics and Space Administration, USA
NOC	National Oceanography Centre, UK
PLATO	Performance Simulations & Architectural Trade-Offs
PM	Polytechnic University of Milan, Italy
PP	PowerPoint
PSMSL	Permanent Service for Mean Sea Level
s/c	Spacecraft
SLR	Satellite Laser Ranging
SMWG	Satellite Missions Working Group

SOPAC	Scripps Orbit and Permanent Array Center, USA
SP	SP Technical Research Institute of Sweden
ST&C	Survey Ties and Co-location
TBD	To Be Determined
TIGA	IGS Tide Gauge Working Group
ToR	Terms of Reference
TRF	Terrestrial Reference Frame
TUM	Technical University of Munich, Germany
UMBC	University of Maryland, Baltimore County, USA
UN	United Nations
VLBI	Very Long Baseline Interferometry
WG	Working Group

[CONSIDER CREATING A GGOS-COMMON LIST OF ABBREVIATIONS ON-LINE AT THE GGOS PORTAL/WEBSITE]

4.3 Glossary

[LIST ANY DEFINITIONS RELEVANT TO THE PLAN USING TABLE 4.3-1]

[CONSIDER CREATING A GGOS-COMMON LIST OF DEFINITIONS ON-LINE AT THE GGOS PORTAL/WEBSITE]

Table 4.3-1: Terms and Definitions

TERM	DEFINITION
[Term goes here]	[Definition goes here]
[Term goes here]	[Definition goes here]

4.4 References

[GGOS 2020]: Global Geodetic Observing System: Meeting the Requirements of a Global Society on an Changing Planet in 2020", H.-P. Plag and M. Pearlman (editors), Springer, 2009

[GGOS ToR] Terms of Reference of the Global Geodetic Observing System (GGOS), IAG Executive Committee, IUGG XXV General Assembly, Melbourne, Australia, July 2011.