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UNITED NATIONS COMMITTEE OF EXPERTS ON GLOBAL GEOSPATIAL INFORMATION MANAGEMENT

Subcommittee on Geodesy

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Position Paper on Sustaining the Global Geodetic Reference Frame

A plan to help achieve the long-term accuracy and accessibility of the Global Geodetic Reference Frame

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Terms and Definitions

Term	Definition
Core Observatory	A GGRF observatory hosting a combination of VLBI, SLR, GNSS, DORIS, gravity and other geodetic instrumentation, which are accurately connected to each other.
Doppler Orbitography Radiopositioning Integrated by Satellite (DORIS)	A global measurement technique that uses ground-based radio beacons emitting a signal, which is picked up by receiving satellites. DORIS is used for satellite orbit determination and positioning.
Geodetic Infrastructure	Includes VLBI, SLR, GNSS, DORIS, gravity meters and other global geodetic instrumentation, which underpin the GGRF. It includes sea-level tide gauges and dense networks of GNSS stations that support positioning services. It also includes the systems and human resources required to undertake geodetic analysis and the provision of services.
Global Geodetic Reference Frame (GGRF)	Authoritative, reliable, high accuracy and global spatial referencing infrastructure. The GGRF includes the celestial and terrestrial reference frame products, the infrastructure used to create it, and the data, analysis and product generation systems. The GGRF also includes gravimetric observations, products and height systems, which underpin measurements of height.
Global Navigation Satellite Systems (GNSS)	The collective name for satellite based positioning systems which include USA's GPS, Russia's GLONASS, Europe's Galileo, China's Beidou, Japan's QZSS and India's NavIC.
International Association of Geodesy (IAG)	The International Association of Geodesy (IAG) is a scientific association in the field of geodesy. It promotes scientific cooperation and research in geodesy on a global scale and contributes to it through its various research bodies.
International Federation of Surveyors (FIG)	A non-governmental organization of national member associations, cadastral and mapping agencies and ministries, universities and corporates from over 120 countries.
International Height Reference System (IHRS)	A proposed global height system used to define the height of a point above or below a reference surface of equal gravitational potential (e.g. geoid).
International Terrestrial Reference Frame (ITRF)	The standard terrestrial reference frame for positioning, satellite navigation and Earth science applications.

Term	Definition
Satellite Laser Ranging (SLR)	A global measurement technique that provides millimeter level range measurements, which are accumulated to provide accurate measurements of the Earth and satellite orbits. SLR uniquely defines the Earth's center of mass and along with VLBI, the scale of the reference frame.
Very Long Baseline Interferometry (VLBI)	A global measurement technique that uses radio astronomy observations. Signals from astronomical radio sources are collected at radio telescopes on Earth. VLBI provides the Earth orientation parameters and along with SLR helps to define the scale of the reference frame.

1. Introduction

1.1 Background

The Global Geodetic Reference Frame (GGRF) is the authoritative, reliable, high accuracy and global spatial referencing infrastructure. The GGRF includes the celestial and terrestrial reference frame products, the infrastructure used to create it, and the data, analysis and product generation systems. The GGRF also includes gravimetric observations, products and height systems, which underpin measurements of elevation.

The GGRF is the foundation for evidence-based policies, decisions and program delivery. The GGRF underpins the collection and management of nationally integrated geospatial information and is used to monitor our dynamic Earth. It is relied upon for social, environmental and economic initiatives, Earth science, the measuring and monitoring of progress of the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction, the Small Island Developing States Accelerated Modalities of Action (SAMOA) Pathway, and other global, regional and national development agenda and initiatives.

The GGRF underpins all aspects related to location. In addition to the traditional survey, mapping and navigation fields, location-based positioning applications are increasingly critical for civil engineering, industrial automation, agriculture, construction, mining, recreation, financial transactions, intelligent transport systems, disaster response and emergency management, environmental studies and scientific research. The GGRF enables accurate and robust alignment of spatial datasets – a key requirement for sustainable development in fields such as land use planning and administration, construction and hazard assessment. The GGRF is also an essential foundation for national height systems, which enable sustainable water management and monitoring of climate change and its impacts, such as sea-level rise, droughts, glacial retreat and ice-sheet melting.

Recognising the importance of the GGRF to an ever-increasing location-based society, the Committee of Experts on Global Geospatial Information Management (UN-GGIM) established a process aimed at improving the development and sustainability of the GGRF. The Committee of Experts established a UN-GGIM Global Geodetic Reference Frame Working Group (now the Subcommittee on Geodesy) and requested it to formulate a United Nations General Assembly (General Assembly) resolution.

The General Assembly adopted resolution 69/266[1] in February 2015, entitled ‘A Global Geodetic Reference Frame for Sustainable Development’. In doing so, the General Assembly ‘noted with

[1] https://ggim.un.org/documents/A_RES_69_266_E.pdf

appreciation the establishment of a Working Group by UN-GGIM to develop a global geodetic road map that addresses key elements relating to the development and sustainability of the global geodetic reference frame.'

At its seventh session in 2017, UN-GGIM adopted decision 7/103, in which it endorsed the formal establishment and composition of the Subcommittee on Geodesy (The Subcommittee), agreed with proposed terms of reference, and also expressed support for the development of appropriate governance arrangements for the GGRF. At its eighth session in 2018, UN-GGIM adopted decision 8/103, in which it endorsed the revised terms of reference for the Subcommittee, and noted the initial work and progress made on the position paper on governance towards improving the sustainability and enhancing the quality of the GGRF.

At the ninth session of UN-GGIM in 2019, the Subcommittee tabled a draft position paper on governance arrangements for sustaining the GGRF[2]. In adopting decision 9/104[3] UN-GGIM requested that the Subcommittee 'explore a number of modalities to balance the longer-term vision, stability and operational requirements of the GGRF, including the establishment of a global geodetic centre of excellence in cooperation with UN-GGIM.' Member States requested the Subcommittee 'to continue to ensure broad consultation on the progression and modalities of the position paper on governance, to establish global cooperation and to acquire a better understanding of how the practical and operational requirements of the GGRF could be implemented.'

Also in the ninth session, the Subcommittee was further encouraged 'to consult further on the practical implementation of the global geodetic centre of excellence, including modalities, function, financial arrangements and programme of work, in direct coordination with UN-GGIM and in coordination with other relevant geodetic stakeholders to avoid duplication of effort.'

1.2 Sustainability and quality of the GGRF

In a world increasing reliant on high accuracy measurements and location based services, the sustainability of the GGRF is more important than ever before. However, its quality, accuracy and accessibility are at risk of failure due a multitude of complex issues. These include a lack of geodetic infrastructure, poor accessibility in some regions, a reliance on in-kind contribution and insufficient collaboration and coordination.

[2] http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/GGRF_Position_Paper2019_24July_web.pdf

[3] http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/GGIM9-report-e.pdf

This paper builds on the ninth session position paper on governance arrangements for sustaining the GGRF and, as requested by the Committee of Experts, provides a plan to help achieve the long-term sustainability and quality of the GGRF by delivering improvement in five focus areas:

- Governance
- Geodetic Infrastructure
- Policies, Standards and Conventions
- Education, Training and Capacity Building
- Communication and Outreach

Section 2 of this paper describes the current state and future requirements of the GGRF, while Section 3 discusses a range of work packages developed by the Subcommittee which aim to address the critical gaps in the GGRF. Section 4 introduces and discusses the potential and role of a Global Geodetic Centre of Excellence (the Centre) to support in sustaining the GGRF.

The Subcommittee has consulted widely with Member States on the draft Position Paper through a range of forums including UN-GGIM global and regional forums to ensure the work plan is aligned with the requirements of Member States. The Subcommittee has also consulted, and is committed to working closely with the International Association of Geodesy (IAG), and the International Federation of Surveyors (FIG) and other geodetic organizations to avoid duplication of existing work programs and to enhance existing governance arrangements within the global geodetic community.

2. Global Geodetic Reference Frame

Sustaining the GGRF will require effort across all five focus areas:

2.1 Focus Areas

2.1.1 Governance

There are many parties involved in sustaining the GGRF including: Member States, UN-GGIM Regional Committees, the Private Sector and Academic Networks; IAG, FIG and many more (see Figure 1). Despite the important contributions made by these groups, there is a lack of global cooperation and coordination, in particular between Member States and between stakeholders. This is largely because the geodetic products were traditionally only accessed by a small specialist user group. With the advent of satellites and computers, geodesy became truly global and real-time applications are feasible; hence, geodesy and the GGRF now serve a far greater user base. Investment, however, in the governance, technology and people sustaining the GGRF have not kept up with demand. There is a need for improved governance across the range of invested parties to maximise the benefit of ongoing geodetic efforts, ensure coherence, and avoid duplication of effort.

2.1.2 Geodetic Infrastructure

The term Geodetic Infrastructure refers to the instruments, technology, data, data repositories, analysis, human resources, products and services required to observe and model the dynamic Earth. All these components are owned, operated and funded by a mix of Member States and organizations. The GGRF Resolution invites Member States to engage in multilateral cooperation that addresses infrastructure gaps and duplications towards the development of a more sustainable global geodetic reference frame. To improve the accuracy of, and access to, the GGRF there is a need for more, and higher quality, geodetic instruments. Furthermore, sustainable funding is required for analysis, research and product generation.

2.1.3 Policies, Standards and Conventions

The GGRF Resolution urges Member States to implement open sharing of geodetic data, standards and conventions to contribute to the global reference frame. Appropriate policies, standards and conventions are fundamental to ensuring the robustness and sustainability of the GGRF. Furthermore, geodetic data currently rates poorly on the Findability, Accessibility, Interoperability and Reusability (FAIR) scale, being inconsistent across fields of geodesy and Member States. This is inhibiting the use of the GGRF for myriad economic, environmental and societal applications.

2.1.4 Education, Training and Capacity Building

The GGRF Resolution encourages Member States and organizations to enhance global cooperation in providing technical assistance, especially for capacity development in geodesy for developing countries, with the aim of ensuring the development, sustainability and advancement of the GGRF. A lack of geodetic capability hinders a country's development and sustainability. In all GGRF activities, thought needs to be given to education, training and capacity building to ensure Member States have sovereign competency and that they can realize the benefits of working in the GGRF.

2.1.5 Communications and Outreach

The GGRF Resolution invites Member States to develop outreach programmes that make the GGRF more visible and understandable to society. Geodesy often suffers from being a science which is difficult to describe. If decision makers and donors do not understand the value of an investment in the GGRF, then they are unlikely to prioritize GGRF investments above other initiatives.

Figure 1: Why we need to work together to sustain the GGRF, what needs to be done and who can help.

These five focus areas are mirrored in the three areas of influence (Governance, Technology and People) of the UN-GGIM Integrated Geospatial Information Framework (IGIF; Figure 2). The IGIF therefore provides a mechanism to implement change across the five focus areas towards effective leadership, mobilization of resources, advocacy and actions to ensure the long-term sustainability and quality of the GGRF.

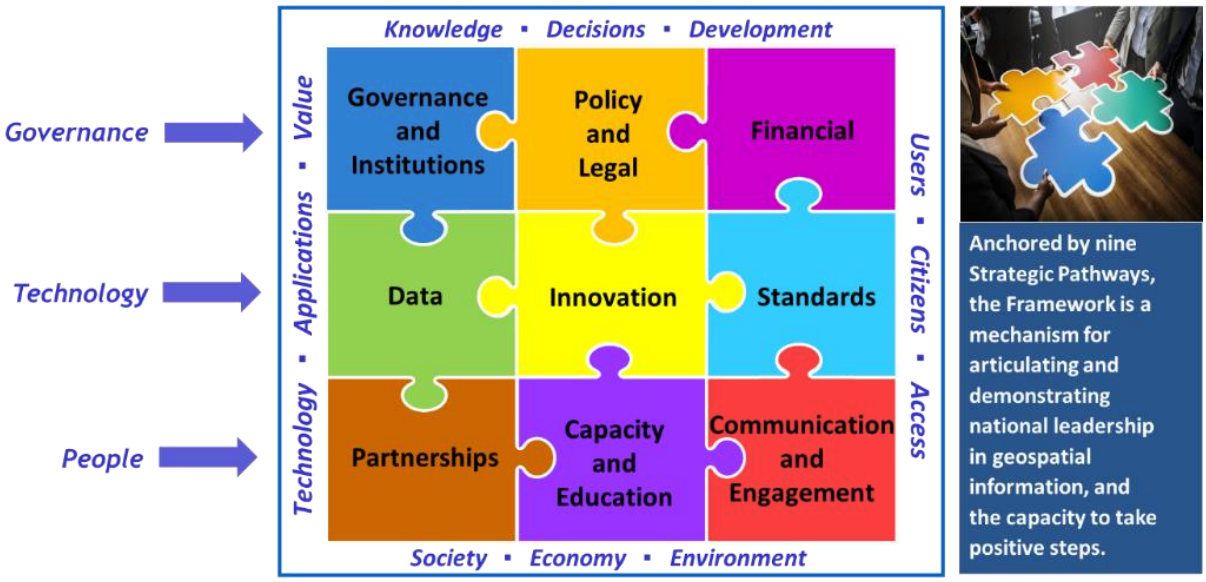

Figure 2: UN-GGIM Integrated Geospatial Information Framework.

2.2 A Global Geodetic Reference Frame for sustainable development

As data ecosystems become more complex, 80% of all information is expected to have a spatial component[4]. As a result, governments, industry, and scientists increasingly recognize the critical importance of geospatial information to measure progress and improve our decision-making capabilities.

The GGRF enables the accurate collection, management and alignment of nationally integrated geospatial information and Earth observations for:

- Earth and climate science (e.g. state of the atmosphere and oceans; measuring ice loss and sea level rise).
- Public safety and disaster management (e.g. assisting with weather monitoring and forecasting).
- Societal benefits (e.g. supporting positioning data in almost 3 billion mobile applications).

[4] Future trends in geospatial information management: the five to ten year vision (un.org)

- Land and water administration (e.g. state of forests and ecosystems; modelling water flow).
- Economic development and sustainability (e.g. assisting to address Sustainable Development Goals).

The GGRF and geospatial information are vital to address the Sustainable Development Goals. As shown in Figure 3, the GGRF is at the core of a nation's capability to analyze and model conditions, create maps and other visualizations, evaluate impacts across sectors and regions, and monitor change over time in a consistent and standardized manner.

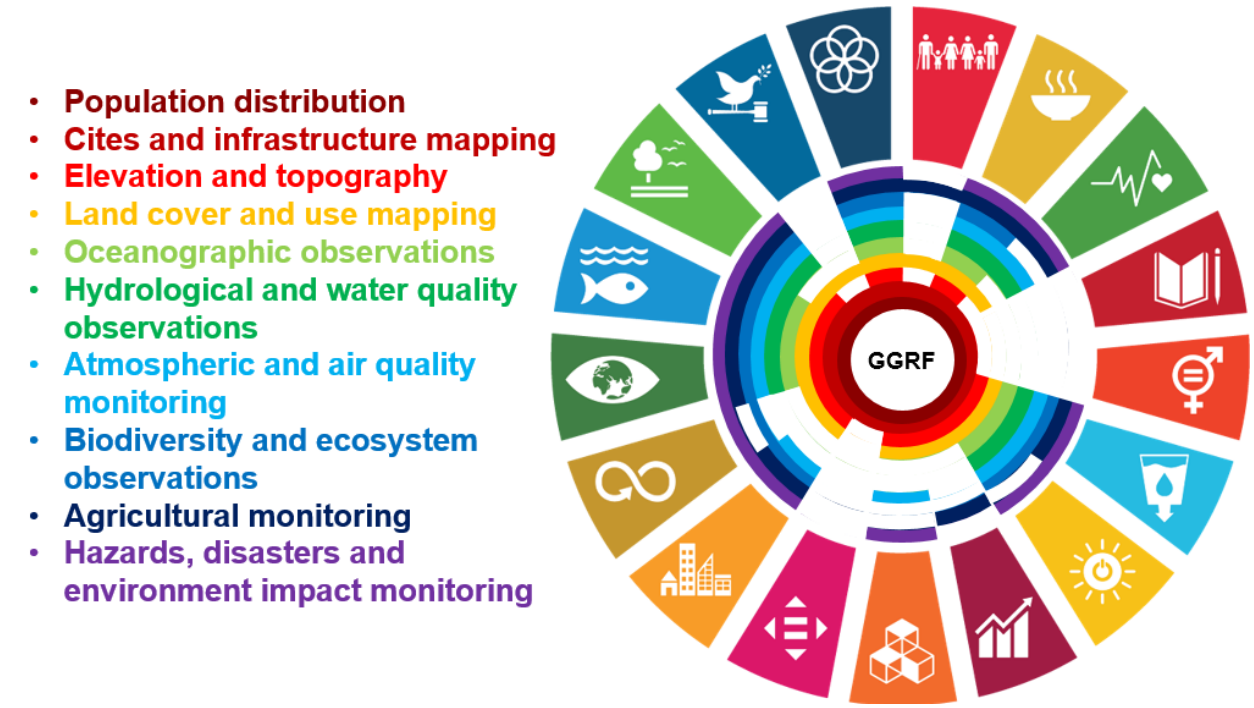

Figure 3: The GGRF is at the core of addressing the Sustainable Development Goals.

2.3 The economic value of the Global Geodetic Reference Frame

The most common way people access the GGRF is via Global Navigation Satellite Systems (GNSS) and its receivers, which are now embedded in cellphones and mobile devices around the world. In just ten sectors of the United States economy that utilize its Global Positioning System (GPS) in their day-to-day business activities (precision agriculture, financial services, location-based services, mining, surveying, telecommunications, telematics, electricity, maritime

navigation, and use in oil and gas industries), $1.4 trillion of economic benefit has been realized in its private sector alone[5] since GPS was made available to the private sector in the 1980s.

The GGRF also provides a foundation for precise information about dynamic parts of the Earth such as hydrology, which are the basis to monitor sea-level rise and are therefore essential to maintain and keep up-to-date. It has been estimated that the flood damage caused by sea-level rise could cost the world $14 trillion a year by 2100[6].

Only by Member States working together, can we sustain and improve the geometric and physical height systems, which help make up GGRF, to ensure we have a stable and accurate foundation for decision making.

2.4 Challenges

The GGRF is at the core of what all countries need. However, because it sits at the core, it is often unseen, ignored, unappreciated and under-resourced. As a result, there are significant sustainability, accessibility and quality issues related to the GGRF which have cascading economic, environmental and societal implications. Some of the challenges currently faced are described below.

2.4.1 Lack of formal commitments

There is no comprehensive international governance for the GGRF. There are some governance mechanisms in place that loosely coordinate the maintenance and development of elements of the GGRF (e.g. bilateral agreements between space agencies and national mapping organizations on geodetic infrastructure); however, these commitments are often based on 'best-effort' collaboration, with no guarantee of continuity in the long term. The informal manner of the governance mechanisms and lack of formal commitments jeopardizes the sustainability of the GGRF.

2.4.2 Lack of redundancy

The development and sustainability of the GGRF is dependent on the contributions from Member States and organizations; many of which are provided in-kind, and on a best-effort basis. The geodetic infrastructure which supports a myriad of societal, economic and environmental applications is therefore fragile and not sustainable. If, for some reason, some key agencies or organizations cease their GGRF contributions and activities, it not only degrades the GGRF but

[5] https://www.rti.org/sites/default/files/gps_finalreport.pdf

[6] Environmental Research Letters (2018). DOI: 10.1088/1748-9326/aacc76 , http://iopscience.iop.org/article/10.1088/1748-9326/aacc76

also jeopardizes the activities of industry, science and society that are dependent on the availability of the GGRF.

2.4.3 Need for global coordination

Member States, organizations and industries play a role in providing access to, and accuracy of, the GGRF through the development and maintenance of infrastructure, undertaking geodetic data collection, processing, and product analysis, and the provision of education, training and capacity development. As the GGRF has grown from being a scientific endeavor to an important foundation for good policy and decision making, the geodetic community requires long-term funding and improved global coordination to maximize the benefits of the work being done, and to limit duplication of efforts. To address this, coordinated efforts must be initiated to enhance operational capacity, capability and research related to the GGRF.

2.4.4 Low benefits realisation of education, training and capacity development

The education, training and capacity building (ETCB) efforts by Member States, institutions and organizations have been substantial over the years. However, recent surveys and assessments of responses by Members States indicate that most countries still require additional capacity development to make the best use of the GGRF, and to also play a role in its ongoing sustainability. This is largely due to lack of geodetic knowledge and/or capacity in some regions and countries.

2.5 What needs to be done to sustain the GGRF?

To some extent, funding, capability, capacity, or a combination of the three, is required to sustain the GGRF for all Member States across the five focus areas. We need:

- **More geodetic infrastructure and newer geodetic infrastructure**. The current distribution is not evenly distributed around the world which makes it hard to measure the Earth accurately. Also, more than 50% of the infrastructure we use is based on old technology. This means it provides relatively poor precision measurements compared to sites around the world with new technology.
- **Adequate resourcing for the organizations who operate geodetic infrastructure and produce geodetic products and services**. Most of the geodetic infrastructure is owned and operated by a mix of academic institutions and government agencies all around the world. Owning and operating the infrastructure is largely a voluntary commitment. As a result, nations can, and do, stop operating due to a lack of funding and political support. This issue of in-kind contribution and non-binding agreements extends to data analysis. The reliance we currently have on scientific organizations like IAG and in-kind contributions is dangerous.

- **Dedicated resources for research, innovation and development.** Dedicated research is required to develop modern, efficient, semi-autonomous and accurate geodetic observatories to improve geodetic data and products.
- **Modern standards and formats for our geodetic data and products to ensure it is Findable, Accessible, Interoperable and Reusable.** The users of geodetic products and services is changing rapidly. We have a duty to ensure our data can be used by the new users.
- **Improved access to geodetic products and services**, particularly in developing countries to ensure no-one is left behind.
- **Improved communication on the importance of geodesy**, especially to decision makers. If they don't understand what we do, they won't recognise the value, and geodesy will not receive the resourcing it needs to be sustained.
- **Assistance for developing countries in the form of education, training and capacity development** to improve their national reference frames and align them to the GGRF.

2.6 Who needs to sustain the GGRF?

The range of Member States and organisations currently working to sustain the GGRF are presented in Figure 1. For example:

- Member States provide geodetic infrastructure and assist with their operation in other countries around the globe.
- IAG Services are responsible for working with Member States on the operation of the geodetic infrastructure product delivery and provide leadership on geodetic standards.
- FIG play a key role in education, training and capacity development in developing countries.
- The United Nations (through the UN-GGIM Secretariat) works with Member States to implement nationally integrated geospatial information management leveraging the nine strategic pathways of the IGIF as a mechanism for national leadership that will also strengthen and sustain national geodetic infrastructure, capacity and capabilities.

Despite the excellent work and good will of Member States and organisations currently working to sustain the GGRF, there are critical gaps across the five focus areas. This inherently implies there is insufficient funding, capacity and capability to ensure the long-term sustainability and quality of the GGRF.

For example, many of the services provided by the IAG are provided on a voluntary basis. While geodetic infrastructure like gravimeters, radio telescopes and analysis centers can be established and operated on national investments there are some pivotal components which are single points of failure. In these cases, the sustainability of the GGRF is highly dependent on the goodwill of a few stakeholders with no guarantee for sustainable operations.

2.7 A path to a sustainable GGRF

To address challenges and the deficiencies across the five focus areas, the Subcommittee has developed a range of work packages (Section 3) which aim to address the critical gaps in the GGRF. The work packages are designed to balance the longer-term vision for the GGRF, while ensuring its short and medium-term accuracy and stability, and hence, its quality.

3. Subcommittee work packages to sustain the GGRF

The Subcommittee has developed a range of work packages aimed to sustain the GGRF, and address the lack of funding, capacity and capability across the five focus areas in the GGRF. The work packages are designed to balance the longer-term vision for the GGRF, while ensuring its short and medium-term requirements for accuracy and stability. Importantly, work packages to sustain the GGRF is a collaboration between Member States, organizations such as the IAG and FIG, industry and relevant geodetic stakeholders. The Global Geodetic Centre of Excellence (the Centre; Section 4) is expected to assist on a number of these tasks, however, in many cases the contribution from the Centre will be to improve the collaboration and governance, including tracking progress and evaluating success. By playing this role, the Centre will help maximize the success of the work package, ensure value for money, and avoid duplication of effort.

3.1 Governance

ID	Goal
GOV 1	Ensure that short, medium and long-term goals exist for the five focus areas in order to: i. Enhance global cooperation across Member States and relevant geodetic stakeholders, including IAG and FIG ii. Ensure coherence across the on-going efforts of all parties and avoid duplication of effort iii. Develop policy guidance, adoption and implementation of standards iv. Ensure robust data analysis and product services, and infrastructure v. Assist with education, training and capacity building vi. Improve communications and outreach
GOV.2	Assist Member States in identifying their geodetic needs, and pathways to meet these needs in line with the Integrated Geospatial Information Framework.

ID	Goal
GOV.3	Consider how to encourage Member States to offer contributions to the UN-GGIM Global Geodetic Centre of Excellence to help fill critical gaps identified in INF.1 and INF.2. This will include identifying potential donors, raising awareness and communication.

3.2 Geodetic Infrastructure

ID	Goal
INF.1	Global Geodesy Needs Assessment Undertake a needs assessment study to define, and document, the geodetic infrastructure required to provide an accurate, sustainable and accessible GGRF. The study should seek to understand the requirements for geodetic instruments, technology, data, data repositories, analysis, human resources, products and services required to answer economic, societal and environmental questions / challenges such as: i. Sustainable Development Goals ii. Sendai Framework for Disaster Risk Reduction iii. Monitoring and adapting to climate change (incl. sea level rise) iv. Real time applications (e.g. location-based services, intelligent transport services) v. High integrity applications (e.g. aviation) vi. Requirements of the land administration systems vii. Requirements of industry to help them grow and innovate *NOTE: This study should build on the geodetic infrastructure questionnaire completed by IAG Services in 2019/2020.*
INF.2	Global Geodesy Development Plan Develop, implement and communicate a Global Geodesy Development Plan in cooperation with relevant stakeholders for geodetic infrastructure based on results from INF.1.

ID	Goal
	The initial Global Geodesy Development Plan should: i. Describe the accuracy and access requirements of the GGRF on a global and regional scale ii. Identify paths to mitigate the critical gaps / lack of redundancy in the GGRF in each region iii. Communicate plans from IAG services to be used to modernize / improve geodetic infrastructure iv. Recognize regional differences in requirements, political, social, security and regulatory impediments to adoption, capability and capacity v. Assist Member States to define and document existing (and where required, historical), geodetic infrastructure and geospatial reference systems. vi. Provide guidance for Member States on the steps to develop a modern coordinate reference system; vii. Promote and facilitate multilateral cooperation that addresses infrastructure gaps and duplications, in order to ensure an optimal geometry and coverage viii. Include a mechanism for Member States to build capacity and capability in foreign countries
INF.3	Develop and make available a business case and educational materials to assist Member States densify their geodetic infrastructure to improve access and sustainability to geodetic infrastructure in countries (based on [INF.1] and [INF.2]).
INF.4	Provide a pool of geodetic equipment (GNSS, gravimeters, total stations including software) which can be borrowed by developing countries to measure new data to improve the accuracy and accessibility of the GGRF in their region.
INF.5	Embed, or develop affiliations with organizations who can provide, dedicated personnel with geodetic expertise within the Centre who would assist developing countries observe, compute, analysis and implement modern geodetic reference frame and vertical datums aligned with GGRF.

3.3 Policies, Standards and Conventions

ID	Goal
PSC.1	Develop and assist with implementing a data-sharing strategy and promote making geodetic data Findable, Accessible, Interoperable and Reusable (FAIR) so it can be shared globally and used to improve decision-making. Efforts would include: i. Ensuring Member States existing data is FAIR and in existing portals in multiple forms (e.g. web services, download) ii. Develop data sharing policy templates for Member States to use in preparing their national data sharing policies iii. Ensuring metadata records comply with international standards iv. Establish training events / workshops (e.g. side events at plenary meetings UN-GGIM Regional Committees) to develop capability, especially for developing countries v. Document and share case studies of data sharing, the benefits that have arisen and strategies for overcoming barriers
PSC.2	Work with Member States to apply standards, policies and conventions for the generation of consistent geodetic products for the GGRF. Efforts would include: i. Ensuring Member States have access to standard operating procedures for geodetic networks and products developed under a global governance model ii. Continued updating of the inventory of standards and conventions used for the generation of IAG products iii. Compilation of an inventory of standards, conventions and standard operating procedures used by UN-GGIM Member States to identify inconsistencies among their data and products a. Providing recommendations on resolving these inconsistencies and supporting Members States for implementing refined procedures b. Establish training events and workshops to develop capability and expertise in this field, especially for developing countries iv. Document and share case studies to demonstrate the benefits of applying consistent standards and conventions for the generation of products for the GGRF
PSC.3	Publish authoritative reference system definitions and transformations in the ISO Geodetic Registry and other such registries as required to facilitate sharing of data and the interoperability of data and products with the GGRF.
PSC.4	Work with International Telecommunication Union, UN Member States, and radio astronomy service representatives to protect geodetic observing frequencies against radio frequency interference at geodetic core sites.

3.4 Education, Training and Capacity Building

ID	Goal
ETCB.1	Conduct reference frame competency and educational needs assessments to assess long-term geodesy training needs of Member States, as well as capacities of Member States to assist and contribute to capacity building efforts. This needs assessment should be prioritized into short, mid and longer-term training needs, their objectives, and required resources for fulfilling these needs.
ETCB.2	Develop a capacity development program based on UN Development Program guidelines[7], and in alignment with the UN-GGIM-World Bank Integrated Geospatial Information Framework, Strategic Pathway 8: Capacity and Education. The program should provide education, training and capacity development on topics including: i. Geodesy training program (spanning from one-day courses to certification) ii. Development and communication of technical workshops and material iii. Provision of research stipends, scholarships, sponsored secondments, or other means of supporting participants from developing Member States *NOTES:* *i. Must provide balanced regional representation in the development of the program; and* *ii. Actively search for contributions from developing or historically under-represented Member States.*
ETCB.3	Develop a Geodesy and Positioning "Thematic Layer" for the UN-GGIM-World Bank Integrated Geospatial Information Framework that identifies components of IGIF Strategic Pathways that are relevant or applicable to the sustainable development of geodetic infrastructure and capacity.
ETCB.4	Develop collaborative arrangements or agreements with scientific institutions / academia / government, the private sector and international Services to develop and deliver geodesy ETCB resources.

[7] https://www.undp.org/content/dam/aplaws/publication/en/publications/capacity-development/support-capacity-development-the-undp-approach/CDG_Brochure_2009.pdf

ID	Goal
	Based on the findings from ETCB.1 and ETCB.2, the ETCB resources may need to be based centrally, or could be from a range of scientific institutions / academia / governments around the world. This would be a federated ETCB model.
ETCB.5	Develop an ETCB "resource hub" as a sub-section of the Subcommittee on Geodesy webpage. This "resource hub" will facilitate consolidation, vetting, translation, and dissemination of technical training materials and other relevant capacity building information, sourced from ETCB contributors around the world.

3.5 Communication and Outreach

ID	Goal
CO.1	Develop and implement a communication and outreach strategy for the UN-GGIM Subcommittee on Geodesy with possible deliverables including: i. Improved capability for geodetic experts to communicate, advocate and explain why geodesy is important to policy makers ii. Development and dissemination of case studies, news stories, social media posts, promotional and communication materials to improve understanding of GGRF iii. Development of a communications network including communication professionals from the whole geospatial community iv. Liaise with stakeholder communicator networks in international organizations and Member States v. Descriptions and examples of how geodesy underpins UN initiatives such as Sustainable Development Goals (SDGs), Sendai Framework on Disaster Risk Reduction and climate change adaptation vi. Collaboration space providing communications tools such as newsletter templates, social media strategies, infographics, animations, videos, photos, narratives/ case studies and collection of quotes in all UN languages
CO.2	Create strategic messages, develop communications methods including social media, in accordance with UN-guidelines and practice
CO.3	Select critical user requirements (e.g. from INF.1 study) and demonstrate how geodesy can play a key role in resolving / achieving change. e.g. measuring sea level change.

ID	Goal
CO.4	The UN-GGIM Subcommittee on Geodesy Members help strengthen the position of UN-GGIM and geospatial information with the objectives to: • be more visible and active on all UN-GGIM arenas; • engage actively in the UN-GGIM working groups; and • work more closely with the UN-GGIM regional committees.

4. The Global Geodetic Centre of Excellence

To sustain the GGRF, the Subcommittee has proposed establishing a United Nations Global Geodetic Centre of Excellence (Centre) and was encouraged by UN-GGIM at its ninth session to consult further on the practical implementation of the Centre [8], including modalities, function, financial arrangements and programme of work. This section introduces and discusses the potential and role of a Centre to support sustaining and ensuring the quality of the GGRF considering the challenges and growing reliance on the GGRF, and the challenges identified above.

The Concept Paper for the establishment of a United Nations Global Geodetic Centre of Excellence accompanies this position paper.

4.1 Role of the Global Geodetic Centre of Excellence

The role of the Centre is to assist in sustaining the GGRF by implementing operational paragraphs of UN General Assembly resolution 69/266. Among other activities, the Centre will do this by developing a work plan aligned with the work packages identified in Section 3. This can be paraphrased as:

- enhance **global cooperation and coordination** across Member States and relevant geodetic stakeholders to maximise the benefit of ongoing geodetic efforts, ensure coherence, and avoid duplication of effort
- strengthen **geodetic infrastructure**
- assist Member States in making their geodetic data Findable, Accessible, Interoperable and Reusable in line with **standards, policies and conventions**
- support **education, training and capacity building**
- improve **communication and raise awareness**

By fulfilling these roles, the Centre would address many of the critical gaps in capacity and capability across the five focus areas.

[8] https://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/GGIM9-report-e.pdf

4.2 Functional Arrangements

The Centre will be established and operationalized through a Memorandum of Understanding (MoU) between the United Nations and a host Member State(s), who are also donors. This MoU would be established in accordance with Host Country Agreement/s (HCA) between the United Nations and the Government/s of the host Member State/s. In this regard, the United Nations will establish a Trust Fund for this project in accordance with prevailing rules, guidelines and practices of the United Nations.

The Centre will be established and operated as a United Nations Centre, and will therefore be led and managed by the United Nations via well-established mechanisms. A range of operational models are available including:

- Single centre hosted by one Member State as the only donor, or
- A **Federated** Centre **(preferred option) –** multiple Member States to co-host the Centre. This could be:
    - A single Centre which is funded by a number of Member States, or
    - A network of Centres hosted by various Member States working under a coordinated governance model.

In August 2020, UN-GGIM Committee of Experts 10th session, the German offer to host the Centre was acknowledged and supported by many Member States. It is planned to establish the Centre in Bonn, Germany, with additional virtual secondment by Norway. The work plan and priorities of the Centre will be adapted to the available workforce, with possible future extensions. Member States and organisations may contribute to the Centre in a number of ways including, in-kind staff contributions (in person and virtual), organizing dedicated workshops for education, training and capacity building, providing geodetic instruments and expertise, or contributions for a longer period of time to coordinate and organize specific tasks and activities of the Centre. In-kind staff contributions may be formalized through MoUs or Letters of Collaboration.

Contribution to the UN Trust Fund which fund the operation and work program of the Centre are also welcome. Any funding provided can be have specific focus, for example, multiple Member States could contribute to establishment and maintenance of a geodetic observatory in Member State A or finance a levelling campaign in Member State B, or sponsor a summer school in Member State C, etc.

The Subcommittee strongly encourages any Member State interested in contributing to the Centre, no matter how small, to discuss options with the UN-GGIM Secretariat about how to be involved.

Irrespective of the operational model, the funding and operational modalities of the Centre is stipulated in an MoU with the host country/s. The operational model will require, in coordination with relevant geodetic stakeholders, the establishment of a steering committee (to assist with governance of the Centre), and an advisory committee (to provide scientific and operational guidance). Furthermore, the Centre will have a framework plan, operational budget, governance, management and funding arrangements.

4.3 Framework plan and operational budget

The framework plan of the Centre (either a Federated Centre or a single Centre) will be based broadly on the work packages discussed in Section 3. The details of the framework plan, including the operational budget, will be subject to the provisions in the MoU between the UN and the donor Member State/s. The operational budget covers the costs of the establishment of the Centre for the initial period of the operation of the Centre, in line with existing United Nations procedures.

Acknowledging that the Global Geodetic Reference Frame depends on the participation of countries all around the globe, and the need to take action to strengthen international cooperation[9], the Centre overarching goal is to deliver a programme of work to achieve the long-term sustainability and quality of the GGRF.

[9] https://ggim.un.org/documents/A_RES_69_266_E.pdf