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Global geodetic reference frame

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Note by the Secretariat

Summary

The present paper contains the report of the Working Group on the Global Geodetic Reference Frame for consideration by the Committee of Experts on Global Geospatial Information Management.

At its fifth session, held in New York from 5 to 7 August 2015, the Committee of Experts adopted decision 5/102, in which it commended the considerable efforts of the Working Group on the Global Geodetic Reference Frame and expressed its appreciation to Fiji for its leadership in the preparatory process and in the final formulation and successful tabling of the resolution on the global geodetic reference frame for sustainable development to the General Assembly with the support of 52 co-sponsoring countries. Acknowledging the importance of the resolution and of the road map as critical enablers for sustainable development, the Committee of Experts encouraged Member States and the Working Group to gather inputs on the key elements of the development and sustainability of the global geodetic reference frame, including the need to address the imbalance in the distribution of geodetic infrastructure globally, in particular between the North and the South, and to commit to undertaking outreach programmes to ensure that experiences and best practices were communicated effectively, particularly in developing countries. In its report, the Working Group presents progress on the road map, which includes issues related to infrastructure; policy, standards and conventions; education, training and capacity-building; communication and outreach; and governance.

* E/C.20/2016/1

I. Introduction

1. The Global Geodetic Reference Frame (GGRF) is the foundation of virtually every aspect of the collection and management of national geospatial information and global monitoring of the Earth. 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 spatial data interoperability – a key requirement for sustainable development in fields such as land use planning and administration, construction and hazard assessment.

2. Recognising the importance of the GGRF to society, the Committee of Experts on Global Geospatial Information Management (UN-GGIM) established a process aimed at improving the awareness by Member States of the need for increased sustainability and enhanced accuracy of the GGRF, through the tabling of a resolution to the UN General Assembly, and the development of a road map for the GGRF.

3. The General Assembly adopted resolution 69/266 in February 2015, entitled 'A Global Geodetic Reference Frame for Sustainable Development'. In doing so, the General Assembly 'noted with appreciation the establishment of a Working Group by the Committee of Experts on Global Geospatial Information Management to develop a global geodetic road map that addresses key elements relating to the development and sustainability of the global geodetic reference frame'.

4. At its fifth session, held in August 2015, the Committee of Experts acknowledged the importance of the resolution and a road map as critical enablers for Member States to leverage the importance of geodetic data sharing, methods, sustainable funding and infrastructure to support growing societal needs, including those monitoring sustainable development progress. The Committee also took note of the various activities of the Working Group in its efforts to gather inputs from Member States on the key elements of the development and sustainability of the global geodetic reference frame to inform the planning and development of the road map, inclusive of the need to address the imbalance in the distribution of geodetic infrastructure globally, in particular between the north and south.

5. The Committee of Experts encouraged Member States and the Working Group to commit to undertake a programme of outreach which highlights experiences and best practices for the global geodetic reference frame, particularly in developing countries, in their efforts to develop the road map; and requested the Working Group to continue its efforts, building on global and regional experiences and initiatives, and report back to the Committee at its next session on its progress towards delivering the road map.

6. The current report presents the progress on the road map, including the consultation process by the Working Group with the global geodetic community. The report also introduces the key issues identified in the road map and describes communication and outreach activities. The Committee

of Experts is invited to take note of the report and to express its views on the road map and its recommendations. Points for discussion and decision are provided in paragraph 23.

II. Activities of the Working Group

7. The Global Geodetic Reference Frame Working Group (GGRF-WG) comprises 29 Member States, the International Association of Geodesy (IAG) and the World Health Organisation (WHO).

8. The Working Group encouraged the development of the road map to be as open and inclusive as possible by seeking broad involvement in the writing process. This was achieved by encouraging the Working Group members to engage with national geodetic experts, seeking their guidance on what global and regional issues should be included in the road map. The enlarged road map working group consisted of 44 participants. The enlarged working group was divided into writing teams to make the work more efficient. During the past year, the enlarged road map working group has had five teleconference meetings, and the writing team members were also invited to participate in the Working Group meetings in San Francisco and Vienna. The Working Group also informed stakeholders about the status of the road map work and gave presentations highlighting the importance of the road map.

9. The development of the road map has created significant engagement and the contributions have been many and diverse, making it an extensive task to collate all contributions into one consistent document. During the Working Group meeting in Vienna in late April 2016, all major unresolved questions and topics were discussed and decided upon. The road map was open to minor changes until late June 2016.

III. Communication and Outreach

10. As encouraged by the Committee of Experts, during the last year the Working Group has undertaken a programme of outreach that highlights experiences and best practices for the global geodetic reference frame, particularly in developing countries. This was undertaken through collecting case studies from researchers and organisations and presenting these studies in newsletters, fact sheets, posters, oral conference presentations, rollups and multimedia presentations. The Working Group also developed a best practices slideshow "GGRF - Fundamental to Sustainable Development" especially focusing on case studies in developing countries. The social media, including twitter @unggrf (#GGRF) and the campaign site unggrf.org, have been important tools for the Working Group in its communication work.

11. The communication and outreach efforts have resulted in increased engagement and awareness of the importance of the global geodetic reference frame and the work with the road map. As an example, a roundtable session on the global geodetic reference frame was held at the World Bank Land and Poverty Conference in Washington DC, United States of America in March 2016. The value to nations, especially the considerably increased economic benefit of implementing the global geodetic reference frame, was highlighted alongside its role in underpinning the Sustainable Development Agenda. A number of key messages and impediments emerged in the discussion at the session.

Impediments to accessing the GGRF in developing countries include technical and human resource capacity limitations. Other impediments, including a lack of communications infrastructure, security issues, and ongoing funding for infrastructure maintenance, also exist. The need for a diagnostic tool for use by the World Bank Group (WBG) to assess the current geodetic infrastructure in individual countries and regions was noted. The WBG may want to give further consideration to how it addresses access to the global geodetic reference frame in developing countries.

12. At the Fourth High-Level Forum on UN-GGIM, convened in Addis Ababa, Ethiopia in April 2016, the Global Geodetic Reference Frame and accurate positioning systems were highlighted by the World Bank as one of three geospatial investments needed to underpin local, regional, national, and global issues.

13. Inter-regional activities on the global geodetic reference frame included: presentations at the UN-GGIM-AP and UN-GGIM: Europe plenary meetings in October 2015; presentations at the UN-GGIM: Americas and UN-GGIM: Africa meetings in November 2015; and presentation and workshops at the UN-GGIM: Arab States meetings in June 2015 and February 2016. A variety of other regional workshops were held on the global geodetic reference frame, including alongside the Fourth High-Level Forum on UN-GGIM in Addis Ababa where the AFREF working group on the global geodetic reference frame had presentations.

14. A number of presentations were given to IAG constituents including the Global Geodetic Observing System (GGOS) Coordinating Board, and the GGOS Bureau of Networks and Observations. A variety of other briefings and discussions on the road map process were also undertaken.

IV. Road Map for the Global Geodetic Reference Frame

15. As described in General Assembly resolution 69/266, the road map aims to address key elements relating to the development and sustainability of the global geodetic reference frame. The Working Group initiated the planning and development of the road map through the 2015 UN-GGIM Member State survey on the Global Geodetic Reference Frame. Through this consultation, the Working Group identified the audience and scope of the road map and 5 key categories of issues as follow: 1) infrastructure; 2) policy, standards, and conventions; 3) education, training, and capacity building; 4) communication and outreach; and 5) governance.

16. The main target audience of the road map is the Member States of the Committee of Experts. However, it is recognised that another important stakeholder is the broader geodetic community at large. The road map will serve as a principle-based briefing document for national political administrations, non-government development organisations who have an interest in the enhancement of the global geodetic reference frame, and more broadly, for the public. The Working Group has spent considerable effort in balancing the technical content of the road map to meet the needs of its target audiences, in order to both serve as a resource for the Committee of Experts as well as the geodetic specialists in each Member State.

17. When defining the scope of the road map, an inclusive interpretation of the term "Global Geodetic Reference Frame" was adopted. The Global Geodetic Reference Frame includes, but is not limited to, products that provide realisations of the celestial and terrestrial reference frames. It also includes the component technique observing systems, data centres, analysis centres, and combination and product centres. The Global Geodetic Reference Frame also includes gravimetric products and physical height systems. The road map addresses global geodetic capability development through education, research and innovation, and capacity building. Importantly the road map will additionally consider governance, collaboration, coordination, outreach and communication as fundamental facilitators to the sustainability of the global geodetic reference frame.

18. The road map for the Global Geodetic Reference Frame for Sustainable Development is provided as an Annex to this report, and has been structured to specifically address the 5 categories of issues. For each issue category, the Working Group has documented the current situation, measures of success, and recommendations. The measures of success ultimately represent our goals, as they are intended to describe in quantifiable terms what a "future state" would look like if the road map recommendations were successfully implemented.

19. The highlights of the 5 categories of action issues are:

a. Actions must be taken to maintain and upgrade current national infrastructure and secure all Member States accurate access to the Global Geodetic Reference Frame;

b. Member States are urged to support efforts to develop geodetic standards, and more openly share their data, standardised operating procedures, expertise, and technology;

c. Actions must be taken to raise geodetic competence and skills, as a lack of geodetic capability currently limits utilisation of the global geodetic reference frame in many countries, and hinders their achievement of the sustainable development goals. It also threatens the development and sustainability of the Global Geodetic Reference Frame;

d. Actions must be taken to raise the general awareness around the value proposition of the Global Geodetic Reference Frame, as this is necessary for its sustainability; and

e. Actions must be taken to improve the Global Geodetic Reference Frame governance mechanism, as this is needed to ensure the sustainability and improvement of the Global Geodetic Reference Frame.

20. In developing the road map, the Working Group has endeavoured to consult with other international groups that have an interest in the Global Geodetic Reference Frame and in accordance with liaisons listed in the Terms of Reference of the Working Group. The Working Group has further consulted regularly with the geodetic Working Groups under each of the five UN-GGIM regional committees. The work on the road map has also revealed a close link between issues in the road map and other UN-GGIM agenda items, which deal for instance with institutional arrangements, policy and legal implications, standards, and fundamental data themes. This opens opportunities for broader joint efforts within activities of the Committee of Experts.

21. In developing the road map, the Working Group has identified that there is a need to commence the development of an implementation plan to ensure the recommendations coming out of this exercise are truly linked to national policy developments in the area of geodesy. The Working Group has also identified that there is a need to prioritise and emphasise the need for enhanced governance in order to implement the road map effectively, particularly with respect to being owned and driven by Member States. Therefore, the Working Group proposes that the Committee of Experts agrees to the Working Group commencing the development of an implementation plan for the recommendations in the road map, and to develop and present a report that proposes a new governance structure, including an outline of an appropriate intergovernmental mechanism.

22. The road map is provided as an Annex to this report.

V. Points for discussion

23. The Committee is invited to:

(a) Take note of the report and the work completed by the Working Group;

(b) Express its views on the road map and the recommendations detailed within the road map with a view to its endorsement;

(c) Provide guidance on the planned activities of the Working Group, specifically: 1) commencing the development of a position paper that proposes an appropriate governance structure for the global geodetic reference frame; and 2) commencing the development of an implementation plan for the recommendations contained in the road map; with both being considered by the Committee of Experts at a future session.

ANNEX 1:

Road Map for the Global Geodetic Reference Frame for Sustainable Development

Developed by the UN-GGIM Working Group on the Global Geodetic Reference Frame

Executive Summary

This document contains the road map for the Global Geodetic Reference Frame (GGRF) for Sustainable Development.

It addresses each of the key areas of action described in the operational paragraphs of the UN General Assembly Resolution (A/RES/69/266). It briefly details the current situation and identifies blockages to GGRF development and sustainability. The road map also suggests qualitative measures of success that would indicate if an enhanced and sustainable GGRF was achieved, and recommends actions to assist in achieving these measures. The report builds on the work of the scientific geodetic community (IAG), the UN-GGIM regions, and other interested parties.

The GGRF is the foundation for all geospatial information and plays a fundamental role in Member States reaching the targets of the sustainable development goals and in our everyday lives. Accurately georeferenced spatial information is vital for policy development as it informs everything from urban planning to emergency service response. Importantly, the GGRF underpins land management which is fundamental for economic growth. It is also a key enabler of spatial data interoperability, supporting disaster mitigation and sustainable development.

The GGRF supports environmental monitoring and improving our understanding of the Earth and climate change. It provides valuable information to policy makers who strive for more sustainable development

Geodetic Infrastructure

The current global distribution of geodetic observatories is not homogeneous. It is particularly sparse in developing regions, such as Africa, Latin America and the Caribbean, and South-East Asia. This poor geometric coverage, coupled with under-performing instruments elsewhere, results in inconsistency and availability issues that jeopardise the GGRF accuracy and sustainability over time for all Member States. This is further exacerbated by geodetic observatories that rely on aging infrastructure, especially the legacy SLR and VLBI systems. This aging infrastructure will ultimately become unreliable and not fit-for-purpose, or fail to meet the emerging observational requirements.

The GNSS technique contributes significantly to the derivation of the GGRF. GNSS is also the most effective technology for accessing the GGRF. In the absence of appropriate GNSS infrastructure in many developing countries, the GGRF is weakened and becomes difficult to access, resulting in it being underutilised. As a consequence, interoperability of geospatial data is not easy to achieve in those countries, which in turn results in loss of competitiveness and societal disadvantage. This is further demonstrated in developing Member States that are at risk of natural disasters such as inundation due to sea level rise, tsunamis, and earthquakes. Addressing GNSS infrastructure gaps is required to help quantify and better manage these natural hazards and facilitate mitigation strategies.

Suggested actions include:

- Member States establish sufficient geodetic infrastructure to allow efficient and accurate access to the GGRF. Member States who have the capacity to assist those countries with less capacity do so through bi-lateral and multi-lateral agreements or other arrangements.
- Member States, which have the capacity, assist Member States with less capacity to establish sufficient geodetic infrastructure to efficiently and accurately access the GGRF.
- Member States, working within a coordinated science plan developed by the IAG, commit to maintain current investments in the existing Core Observatories in order to ensure the continuation of the provision of services.
- Member States make efforts to upgrade the current observing systems at geodetic observatories, in particular VLBI and SLR instruments to next generation technologies.
- Member States support the IAG's continued efforts to quantify through simulation the global distribution and specification requirements for geodetic observatories.
- Member States commit to fill the gaps where Core Observatories are needed in order to ensure an optimal geometry and coverage wherever they may exist. Efforts should be made to establish additional Core Observatories in developing regions such as Africa, South-East Asia, Latin America and the Caribbean, and in other areas where gaps exist.

Data Sharing, Policies, Standards and Conventions

The IAG, with input from the International Organisation for Standardisation (ISO), maintains and develops new standards that allow transparent and repeatable geodetic science to be undertaken. These standards also allow interoperability between technique-specific products.

This knowledge and expertise is of great value to countries wanting to develop capabilities, and more needs to be done to ensure that it is available to those in need.

Suggested actions include:

- Member States support the efforts already undertaken by IAG and standards organisations, including ISO, towards geodetic standards and make these standards openly available.
- Member States more openly share their data, standard operating procedures and conventions, expertise, and technology.
- Member States resolve their concerns that currently limit data sharing, as a valuable contribution to the enhancement of the GGRF.

Education, Training, and Capacity Building

Utilisation of the GGRF is a foundation for a country's development and sustainability. Lack of geodetic skills blocks this utilisation. Hence, lack of geodetic competence and capability hinders a country's development, sustainability, and the realisation of the sustainable development goals.

The skills required to install and operate geodetic instruments are very specific and possessed by only a small number of people, and the skills required to analyse and combine geodetic observations are even more difficult to obtain. Neither skill set is generally taught in mainstream higher education programs.

Suggested actions include:

- Development organisations consider investments in national and regional geodetic capacity building to ensure efficient access to and utilisation of the GGRF in developing countries.
- Member States in cooperation with the IAG establish a global geodetic technical assistance program.
- Member states with insufficient capacity to build and develop the necessary geodetic capabilities and infrastructure will be assisted by those Member States possessing the capacity to do so. This assistance will ensure efficient and accurate access and utilisation of the GGRF in order to realise sustainable development goals globally.
- Member States take actions to ensure educational institutions recognise the importance of geodetic science, and increase the availability of geodetic-focused degrees, as well as increase the number and availability of geodetic courses in other associated degrees.
- Member States openly share all geodetic skills.

Communication and Outreach

It is evident that general awareness around the value proposition of the GGRF is necessary for its sustainability. If decision makers do not understand the value of an investment in the GGRF, then they are unlikely to prioritise GGRF investments above other initiatives. There is a requirement for good communication to improve the sustainability of the GGRF.

Suggested actions include:

- Member States cooperate to establish an agreed and coordinated global geodetic outreach program.
- Member States support and enhance outreach in accordance with the global geodetic outreach program.
- Member States initiate, encourage, and promote better outreach cooperation between national communications experts and geodetic experts.
- Member States use the developed communication strategy and tools (including newsletters, animation video, unggrf.org and social media @unggrf) for the purpose of raising the base level of awareness around the benefits of the GGRF to society.
- If necessary, Member States translate communication tools to make them understandable nationally.

Governance

There are currently many governance mechanisms in place that loosely coordinate the maintenance and development of the GGRF. These are based on best-efforts collaboration, with no contractual guarantee of continuity in the long term. Improved governance, particularly with respect to being owned and driven by Member States, is required to address this weakness and ensure the sustainability and improvement of the GGRF.

Suggested actions to compensate this are:

a) The Member States note the importance of effective governance to the sustainability and enhancement of the GGRF
b) The Members States collectively commence the development of an implementation plan for the recommendations in the GGRF road map.

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Glossary of Terms

Global Geodetic Reference Frame (GGRF): An authoritative, reliable, highly accurate, and global spatial referencing infrastructure. The GGRF includes the celestial and terrestrial reference frame products and Earth Orientation Parameters (EOPs) that connect them, 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.

Geodetic Infrastructure: Includes VLBI, SLR, GNSS, DORIS, gravimetric, and other 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 Navigation Satellite Systems (GNSS): a generic term for satellite based positioning systems which include USA's Global Positioning System (GPS), Russia's GLONASS, Europe's Galileo, China's Beidou, Japan's QZSS and India's IRNSS. GNSS are used for precise positioning and navigation on the Earth and in space and – in its global application - to monitor polar motion and the length-of-day.

Satellite Laser Ranging (SLR): SLR is a global observing technique that provides laser range measurements to satellites, which are accumulated to determine satellite orbits and Earth parameters such as precise station positions, polar motion, and the gravity field of the Earth.

Very Long Baseline Interferometry (VLBI): VLBI is a global measurement technique that uses radio telescopes on the Earth to receive signals from extra galactic radio sources. VLBI is used to determine the baseline length between two stations of a network, the coordinates of the radio sources, and the rotation of the Earth around its axis and its orientation in space.

DORIS: Doppler Orbitography Radiopositioning Integrated by Satellite (DORIS) is 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 also for positioning.

Gravimetry: Is a technique for measuring the gravity of the Earth and its temporal variations. Instrumentation includes absolute and superconducting gravimeters.

Core Observatory: A geodetic observatory employing the four space geodetic techniques (DORIS, GNSS, SLR, VLBI) allowing the combination of all observation data to obtain a common terrestrial reference frame. At the core observatory, gravimetric instruments and, if possible, other geodetic and geophysical instrumentation should be established, enabling the connection between the space geodetic techniques used for the terrestrial reference frame and the gravity field of the Earth. Core Observatories are the backbone of the GGRF.

Co-location on ground: Terrestrial geodetic stations with more than one space geodetic technique (such as GNSS and SLR, or GNSS and VLBI) allowing the connection between the reference frames realised by the particular techniques.

Co-location in space: A combination of different space geodetic techniques on the same satellite.

Introduction

The Road Map Vision

Position, or location, is increasingly important in modern society as it describes where objects and people have been, where they currently are, and where they will be in the future. It allows rights and responsibilities associated with ownership of objects or property to be described. It also describes the relationships between objects. Expertise in location based information is the field known as Geospatial Information Management. The position of a point on or around the Earth is expressed as a set of numbers called coordinates, using a given coordinate system, such as Geographical (latitude, longitude, altitude) or Cartesian (X, Y, Z). The coordinates are ideally referred to a mathematically well-defined geodetic reference frame.

A consistent and stable geodetic reference frame allows the location of items to be monitored through time as they move. It also allows items from different locations to be compared. Thus data sets can be seamlessly merged into a single "image" of our earth. To extend this concept further, Geodetic reference frames serve as the basis for three-dimensional, time-dependent positioning at global, regional, national, and local scales, for geospatial applications such as land tenure, engineering construction, precise navigation, geo-information acquisition, geodynamics, sea level change monitoring, and other geoscientific studies.

A geodetic reference frame is necessary to consistently reference or tag features with coordinates. Increasingly, the use of the Global Positioning System (GPS) and other Global Navigation Satellite Systems (GNSS) to derive those coordinates means that a global geodetic reference frame is required. One of the most common uses for this technology is currently smart phones, which allow users to interface their current position with a multitude of applications (apps). A global geodetic reference frame also provides the platform from which Earth Sciences (such as Global Change studies) can be undertaken, monitoring changes in the planet on which we live and rely.

The Global Geodetic Reference Frame (GGRF) is underpinned by an infrastructure that consists of globally distributed observatories and satellite tracking stations. The physical infrastructure of the GGRF is complemented by an internationally organised effort of data centres and analysis teams within governments and the scientific community that, on an ongoing basis and often in real-time, provide products, corrections, and models that enable the establishment of, or access to, the GGRF.

The GGRF has supported all Earth observations from space as well as a range of scientific endeavours that improve the understanding of the Earth system and global science. It is also a critical enabler of geospatial data interoperability, thus enabling imagery, environmental and other mapping data to be located on the ground and seamlessly integrated with other data systems to inform government policy and decision making. Therefore, the importance of the GGRF is growing as new geospatial applications in location-based services, intelligent transport, precision agriculture, and industrial automation emerge globally.

The GGRF enables the interrelationship of georeferenced measurements taken anywhere on the Earth and underpins many Earth science and societal applications, including sea level

and climate change monitoring, natural hazard and disaster management, and industry applications where precise positioning enables efficiencies, including mining, agriculture, transport, and construction. It supports environmental monitoring and improving our understanding of the Earth and climate change, is essential for effective decision-making, and finds applications in geospatial information management, mapping, and navigation.

Geospatial information services and platforms, including those that are space derived, have become critical technologies to support national development, economic growth, improved decision making, enhanced policy formulation, and contribute to global challenges. These technologies provide an important platform from which sustainable development can be measured. The systemic nature of geospatial capabilities means that they impact a very broad range of endeavours outside the classical field of surveying, for instance routine health services delivery, disease surveillance, as well as health and emergency response.

Given the significant value and benefit of the GGRF to society, it is surprising that it is so poorly understood by non-specialists, and that a more sustainable maintenance and development program is not regimented within the UN member states. The GGRF relies on global observations and international data sharing. Consequently, international cooperation is vital to realise the GGRF. No one country or organisation can do this alone.

This road map aims to enhance the sustainability of the GGRF by recommending the establishment of appropriate governance, policies, education and capacity building, infrastructure investment, and communication and outreach activities.

Road Map Audience and Scope

The audience of the road map is intended to be the Member States of the UN GGIM Committee of Experts. It is however noted that the road map will also serve as a briefing document to national political administrations, and more broadly for public education.

For the purposes of the road map, an inclusive interpretation of the term GGRF has been adopted. The GGRF includes, but is not limited to, products that provide realisations of the celestial and terrestrial reference frames and the EOPs that connect them. It also includes the component technique observing systems, data centres, analysis centres, and combination and product centres. The GGRF also includes gravimetric products and physical height systems. The road map addresses global geodetic capability development through education, research and innovation, and capacity building. Importantly the road map will also consider governance, collaboration, coordination, outreach and communication as fundamental facilitators to sustainability of the GGRF.

Geodetic Infrastructure

Current Situation

The progress made by Member States over the past three decades in developing and delivering high quality geodetic products is reliant on the best-effort contributions of several hundred individual organisations. The term “best-effort” is intended to reflect the collaborative nature of these contributions which generally lack formal agreements to

continue participation or achievement of desired performance levels. Participation in the GGRF is currently through voluntary collaboration, largely under the auspices of the International Association of Geodesy (IAG) and its Global Geodetic Observing System (GGOS)[1].

Noting the societal reliance on the GGRF and the positive impact on economic development of its use, it is of concern that very few formal agreements that ensure GGRF sustainability are in place.

The key element of the GGRF is the availability of both a sufficient number and global distribution of Core Observatories. The current global distribution of existing Core Observatories is not homogeneous, and is particularly sparse in developing regions, such as Africa and South-East Asia. Additionally, a large percentage of Core Observatories rely on aging infrastructure, especially the SLR and VLBI systems. This aging infrastructure will ultimately become unreliable and not fit-for-purpose. Poor geometric coverage, coupled with under-performing instruments elsewhere, results in inconsistency and availability issues that jeopardise the GGRF accuracy and sustainability for all Member States over time.

Each of the geodetic techniques (VLBI, SLR, GNSS, DORIS, and gravimetry) is necessary for the GGRF. Consequently, all techniques are to be maintained and their infrastructure sustained and enhanced. The individual geodetic observatories are typically funded, installed and operated by national mapping organisations, space agencies, research groups, and universities using research grants or short term funding.

The currently adopted product for the terrestrial geometric part of the GGRF is the International Terrestrial Reference Frame (ITRF)[2]. The ITRF has been developed and maintained by the International Earth Rotation and Reference Systems Service (IERS)[3], a joint service of the International Union of Geodesy and Geophysics (IUGG) and the International Astronomical Union (IAU). The ITRF is fundamental to various positioning (location-based) and Earth science applications. It is adopted and used by the IAG and other geoscience communities as the standard and most accurate global spatial referencing system available.

The International Terrestrial Reference System (ITRS) Centre, using suitable combination software, unifies the individual technique frames to form the ITRF, which is updated every 3-5 years. The implementation of the ITRF is fundamentally based on a rigorous combination and unification of geodetic products, provided by the space geodetic measurement techniques, through their co-located measuring instruments at Core Observatories. The geodetic techniques that provide measurements for the implementation of the ITRF include the GNSS, SLR, VLBI, and DORIS. These space geodetic techniques are organised as scientific services under the umbrella of the IAG: the International GNSS Service[4], the International VLBI Service for Geodesy and Astronomy[5], the International Laser Ranging Service[6] and the International DORIS Service[7].

[1] www.ggos.org
[2] ITRF: http://itrf.ign.fr/
[3] IERS: http://www.iers.org
[4] IGS – http://igs.org/
[5] IVS – http://ivscc.gsfc.nasa.gov
[6] ILRS – http://ilrs.gsfc.nasa.gov

GNSS is the critical technique for connecting the other space geodetic techniques together because of its relatively low infrastructure cost. Accordingly, all space geodetic observatories need to be equipped with GNSS instrumentation. Where possible, GNSS infrastructure should also be collocated with Absolute Gravity stations to allow for connection between the geometric and gravimetric products.

The currently adopted product for the celestial part of the GGRF is the International Celestial Reference Frame (ICRF), developed and maintained by the International Astronomical Union (IAU) and the IERS. Its implementation is based on Very Long Baseline Interferometry (VLBI) data, in the form of equatorial coordinates of primary extragalactic radio-sources. It is connected to the ITRF, via Earth Orientation Parameters (EOPs) series determined by the IERS.

The products for the physical part (gravity data, geopotential models, and height systems) of the GGRF are coordinated by the International Gravity Field Service (IGFS) of the IAG. The IGFS was established to coordinate the collection, validation, archiving, and dissemination of gravity field related data. Geometry and gravity infrastructure networks are maintained mostly independently, although several Core Observatories include continuous gravity or repeated gravity observations. Not all countries have established modern national gravity reference networks based on precise absolute gravity measurements, which provide the frame for spatially densely distributed gravity data for geoid, regional, and national height system determinations. In addition to the terrestrial observation networks, there is a dependency on the continuity of dedicated satellite missions in order to monitor gravity and sea level. Thus, there are only very few co-locations for connecting geometry and gravity.

Responsible agencies collect the geodetic observations and make them openly available through data centres to research groups and analysis centres. The latter, using sophisticated physical and mathematical models coded in highly precise software packages, generate geodetic products per technique, such as satellite orbits, station positions, Earth orientation parameters, and geopotential models.

Geodetic infrastructure maintenance and operation of data and analysis centres are undertaken by the infrastructure custodians in accordance with agency funding and program priorities, often using research grants and generally without any legally binding international agreements. While this is generally done in accordance with the specifications agreed within the technique services, there is no binding commitment for adherence to specifications or service continuity.

The GNSS technique contributes significantly to the derivation of the GGRF. GNSS is also the most effective technology for accessing the GGRF. In the absence of appropriate GNSS infrastructure in many developing countries, the GGRF is weakened and is difficult to access, resulting in underutilisation. As a consequence, interoperability of geospatial data is not easy to achieve in those countries, which in turn results in loss of competitiveness and societal disadvantage. This is further demonstrated in developing Member States that are at risk of natural disasters such as inundation due to sea level rise, tsunamis, and earthquakes. Addressing GNSS infrastructure gaps is required to help quantify and better manage these natural hazards and facilitate mitigation strategies.

[7] IDS – http://ids.cls.fr

Regional and national GNSS permanent networks are developed and operated by many countries, through investments of national mapping agencies, space agencies, universities, and research groups. The main purpose of these permanent networks is the establishment of modern regional and national reference frames, connected to, and compatible with, a globally consistent reference frame, e.g. ITRF. These reference frames may also be utilised for geophysical and other scientific investigations. Many countries and regions are challenged by the dynamics of the Earth and the lack of accurate access to the GGRF, due to the sparsity of geodetic GNSS infrastructures and limited technical capabilities, resulting in their national reference systems becoming inconsistent with the GGRF. Gaps in the distribution of GNSS infrastructure are evident in parts of Africa, Latin America and the Caribbean, and Asia Pacific. Skill shortages also restrict utilisation of these infrastructures where they do occur.

GNSS-based national, regional and global reference frames (including the World Geodetic System - WGS84-GPS-based realisations) now align to the ITRF. At the regional level, some IAG components (AFREF-Africa, APREF-Asia-Pacific, EUREF-Europe, NAREF-North America, SIRGAS-Latin America and the Caribbean, and SCAR-Antarctica) are organised specifically to establish regional reference frames that are connected to, and compatible with, an agreed global standard.

For example, the African Geodetic Reference Frame (AFREF) was conceived as a unified geodetic reference frame that provides a fundamental basis for national and regional reference networks fully consistent and homogeneous with the International Terrestrial Reference Frame (ITRF). To achieve this, GNSS Continuously Operating Reference Stations (CORS) were established.

In order to optimally achieve AFREF's main objective of realising a unified and modern geodetic reference frame for Africa, there is a need for participation by all African countries, which are currently at different stages of implementation of AFREF. UN GGIM: Africa, AFREF Working Group is currently being chaired by Kenya. There are developed and documented guidelines for the requirements and installation of AFREF permanent stations, which are based mainly on the International GNSS Service (IGS) guidelines. To date, there are at least seventy (70) permanent stations in Africa that submit real time data to the AFREF operational data centre, located in the Chief Directorate of National Geospatial Information, Republic of South Africa. Information sharing on AFREF is usually done through the AFREF newsletter, which is accessible on the web site of the AFREF data centre.[8]

Other permanent GNSS networks that are established by space agencies, universities, research institutions, or observing programs for specific scientific applications in areas such as sea level rise and tsunamis also exist. One such GNSS network supports the Global Sea Level Observing System (GLOSS) program. The GLOSS network is relatively good in developed countries, but faces ongoing challenges in many parts of the world, primarily because of the lack of co-located GNSS instruments. Consequently, mitigation of sea level change impacts is difficult.

The GGRF relies on an international community that operates infrastructure, data collection, and analysis. The workforce of the GGRF is supported by national mapping and space

[8] www.rcmrd.org/index.php/afref-data-centre.

agencies, as well as researchers from universities. A large proportion of the workforce contributing to the GGRF does so with scientific motivation, and therefore their contribution is often research project based, and without long-term funding.

Geodetic data analysis methods and procedures have steadily improved, but they need to be further developed if enhancement of the GGRF is to be achieved. There is also an emerging requirement for (near) real time products, which are not adequately served by some of the current infrastructure, data collection systems and analysis activities.

Measures of Success

The Working Group identifies the following measures of success (qualitative indicators) to assist with implementation of the road map recommendations:

a) A priority list of actions and investments is made available.
b) Ongoing investments are made in the existing geodetic observatories to ensure continued provision of the multiple geodetic products that are essential for science and society.
c) Geodetic observatories, and in particular VLBI and SLR instruments, are upgraded to next generation technologies.
d) GNSS (GPS) infrastructure is upgraded to multi-GNSS equipment with optimal coverage at the national and regional level, providing both contribution and access to the GGRF.
e) The GGRF is geographically distributed and of sufficient density and quality. In coordination, Member States fill gaps where Core Observatories are needed in order to ensure an optimal geometry and global coverage.
f) The stations of the global height system and absolute gravity reference network are linked to VLBI, SLR, GNSS, or DORIS infrastructure at geodetic observatories.
g) The regional entities, AFREF- Africa, APREF-Asia-Pacific, EUREF-Europe, NAREF-North America, SIRGAS-Latin America and the Caribbean and the Scientific Committee on Antarctic Research (SCAR) are organised to provide focal points for geodetic activities.
h) There is compatibility between national GNSS stations and the standards of the International GNSS Service (IGS).
i) There are additional tide gauge stations collocated with GNSS stations.
j) There are gravity observations at a subset of, if not all, GNSS stations.
k) Regional GNSS stations can be integrated into the global IGS GNSS network.
l) Analysis procedures support multi-technique combinations and provide long-term products as well as short-term and (near-) real-time products.

Recommendations

The Working Group recommends that:

a) Member States establish sufficient geodetic infrastructure to allow efficient and accurate access to the GGRF. Member States who have the capacity to assist those countries with

less capacity do so through bi-lateral and multi-lateral agreements or other arrangements.

b) Member states with insufficient capacity to build and develop sufficient geodetic infrastructure will be assisted by those Member States possessing the capacity to do so. This ensures efficient and accurate access to the GGRF.
c) Member States, working within a coordinated science plan developed by the IAG, commit to maintaining current investments in the existing geodetic observatories, as well as data, analysis, and product centres, in order to ensure sustainable provision of services.
d) Member States make efforts to upgrade the current observing systems at the geodetic observatories, especially VLBI and SLR instruments, to next generation technologies.
e) Member States support the IAG's continued efforts to quantify, through simulation, the global distribution and specification requirements for Core Observatories.
f) Member States commit to fill the gaps where Core Observatories are needed, in order to ensure an optimal geometry and coverage wherever they may exist. Efforts should be made to establish additional Core Observatories in developing regions such as Africa, South-East Asia, Latin America and the Caribbean, and in other areas where gaps exist.

Data sharing, Policy, Standards and Conventions

Current Situation

Geodetic data sharing is inconsistent across Member States and the UN-GGIM regions at this time.

Data sharing within UN-GGIM Americas exists in North American, Latin American, and the Caribbean Member States. However, in small island developing states, there is an absence of data sharing which is usually attributed to the lack of resources or a lack of regional initiatives that would require all the islands to work together and exchange data.

Some recent progress has been made through the UN-GGIM for Asia and the Pacific (UN-GGIM-AP) on GNSS data sharing, particularly through the Asia Pacific Reference Frame (APREF) project. Of the 56 Member States in the UN-GGIM-AP, 33 individual Member States are currently contributing to APREF, indicating some success but also highlighting an area for improvement in the future. In the Asia Pacific, data sharing is largely inhibited by the sparseness of geodetic infrastructure and corresponding lack of data, lack of technical expertise, and a weak culture of inter-country collaboration. In many countries, GNSS data sharing is also challenged by the lack of reliable internet access, conflicting commercial arrangements, security concerns, and other associated legal impediments. The Pacific Island Member States are particularly challenged by their geographic isolation, sparse island archipelagos, and limited resources that inhibit the development of data sharing and other collaborative frameworks. In addition to GNSS, terrestrial gravity and sea-level tide gauge data are also only sporadically shared throughout the Asia and the Pacific, an activity which if further impeded by the lack of well-developed coordinated data collection.

The UN-GGIM Arab States committee was formally established during its first meeting held in Riyadh in February 2015. The work program and the establishment of four working groups were formally initiated during the second meeting of the committee held in Algiers in June 2015. A working group on Geodetic Reference Frame (GRF) was established with the

main task of establishing a common project called ARABREF using GNSS. An initial work plan was further developed at the third committee meeting, held in Abu Dhabi in February 2016. The GRF work plan includes, in particular, GNSS data sharing among the Arab member states. An agreement document was formulated and distributed for signature by the Arab member states. For some Arab member states, data sharing is largely inhibited by the sparseness of geodetic infrastructure and corresponding lack of data, lack of technical expertise, and a weak culture of inter-country collaboration. In some Arab member states, data sharing is also challenged by the lack of reliable internet access, security concerns, and other associated legal impediments.

In Europe, the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive 2007/2/EC of the European Parliament and of the Council with regard to interoperability of spatial data sets and services established, among other requirements, that the ETRS89 shall be used for the referencing of spatial data sets in INSPIRE. ETRS89 is maintained by the IAG sub-commission EUREF and it is accessed through the EUREF Permanent Network (EPN). More than 100 European agencies and universities are involved in EPN. ETRS89 coordinates for the reference stations and GNSS observation data, as well as related products of a network of more than 200 permanent operating GNSS observing stations distributed over the European continent, are publicly available. Databases, computation, and analysis are coordinated by EUREF through EPN, EUREF Technical working group, EUREF analysis centres and various topical projects. UN GGIM Europe was founded in 2014, followed by the GGRF Working Group for Europe in 2015, to address the strategic issues in this field.

Globally, most of the mathematical and physical models, as well as numerical standards that are necessary for data analysis of the different geodetic technique measurements, are available, agreed upon, developed, maintained, and published by different IAG components. The IAG, often in collaboration with standards organisations like the International Organisation for Standardisation (ISO), maintains and develops new standards that allow transparent and repeatable geodetic science to be undertaken. These standards also allow interoperability between technique-specific products. The IERS Conventions Centre[9] deals with the geometric techniques, and the technique-specific IAG services have analysis standards specific to their geodetic technique data. Standards and conventions related to data and product exchange formats are also developed by the technique services of IAG and inventoried by the GGOS Bureau of Products and Standards (BPS).

Extensive knowledge and experience already exists within the IAG, including subject matter areas such as standard operating procedures for infrastructure, data collection and distribution, data analysis, and product generation. This knowledge and expertise is of great value to countries wanting to develop capabilities, and more needs to be done to ensure that it is available to those in need.

GGRF products are made openly available, as are the geodetic data collected at the observing sites. Similarly, the geodetic products generated by the IAG technique services are also openly available to all users. However, many Member States are still reluctant to share their geodetic data, especially GNSS and gravity data. Data sharing needs to be undertaken

[9] http://62.161.69.131/iers/

in full consideration of licensing, quality, liability, authority, and security issues, while at the same time respecting local and national legal and policy frameworks.

Measures of Success

The Working Group identifies the following measures of success (qualitative indicators) on Policy, Standards and Conventions to assist with implementation of the road map recommendations:

a) Geodetic data is shared more openly. Member States commit to make GNSS and gravity data openly available.
b) Data sharing principles are uniformly implemented across all regions, while acknowledging legal and policy challenges at the national level.
c) The benefits from sharing geodetic data are documented by Member States, and national security concerns are addressed.
d) The establishment and use of standard operating procedures developed under a global governance model should not restrict innovation.

Recommendations

The Working Group recommends that:

a) Member States support the efforts already undertaken by IAG and standards organisations such as ISO toward geodetic standards, and make these standards openly available.
b) Member States more openly share their data, standard operating procedures, expertise, and technology.
c) Member States resolve their concerns that currently limit data sharing and establish appropriate governmental mandates where required, as a valuable contribution to the enhancement of the GGRF.

Education, Training, and Capacity Building

Current Situation

Utilisation of the GGRF helps build a foundation for a country's development and sustainability. A lack of geodetic skills blocks this utilisation. Hence, a lack of geodetic competence and capability hinders a Member States development and sustainability.

The skills required to install and operate geodetic instruments are very specific and mastered by only a small number of people worldwide. The skills required to analyse and combine geodetic observations and make practical use of this knowledge as a basis for sustainable development are even more difficult to master. Further limiting knowledge dissemination is the fact that neither of the aforementioned skillsets are generally taught in mainstream higher education programs.

Some geodetic skills and capabilities currently exist in many Member States. However, these skills are vulnerable, as they are often limited to individuals or very small teams. In addition, there has been a declining number of students attending higher geodetic educational programs in later years, reducing the total amount of geodetic experts.

Modern geodetic technical capabilities and education infrastructures are still missing in many developing Member States, preventing them from contributing to the GGRF and from achieving the benefits of accessing it.

IAG organise occasional training and specialised geodetic schools, but their number and frequency is not enough to allow for easy and regular access to modern geodetic capabilities.

There also exist circumstances where geodetic capability exists, generally in a small number of specialists, but the capacity to make sustainable contributions to the GGRF is not evident.

Appropriate geodetic skills and educational programs are needed for the development and sustainability of the Global Geodetic Reference Frame.

Measures of Success

The Working Group has identified the following measures of success (qualitative indicators) on Education, Training, and Capacity Building:

a) All Member States have sufficient geodetic capacity to underpin the realisation of the sustainable development goals.
b) Geodetic education, skills, and capabilities are continuously developed and available to all Member States in a magnitude underpinning both GGRF and Member State sustainability and development.
c) A global geodetic technical assistance program exists.
d) Those Member States wishing to contribute to the GGRF are supported through the provision of technical assistance, educational programs, and coaching. Targeted capability development may be required to allow for continuity of skills through time.
e) Continuous improvement of geodetic expertise in developing and developed Member States, through participation in, and open sharing of, geodetic skills through conferences, meetings, and educational programs.
f) Capability transfer occurs between existing experts and those joining the field.
g) Sufficient resources are allocated to research programs promoting and underpinning GGRF development.

Recommendations

The Working Group recommends that:

a) Development organisations consider investments in national and regional geodetic capacity building to ensure efficient access to, and utilisation of, the GGRF in developing countries.
b) Member States, in cooperation with the IAG, establish a global geodetic technical assistance program.

c) Member States, which have the capacity, assist Member States with less capacity to build sufficient geodetic capacity to efficiently and accurately access and utilise the GGRF in order to realise the sustainable development goals.
d) Member States take actions to ensure educational and research institutions recognise the importance of geodetic science, and increase the availability of geodetic-focused degrees and programs of study, as well as increase the number and availability of geodetic courses in other associated degrees.
e) Member States openly share all geodetic skills.

Communication and Outreach

Current Situation

It is evident that general awareness around the value proposition of the GGRF is necessary for its sustainability. If decision makers do not understand the value of an investment in the GGRF, then they are unlikely to prioritise GGRF investments above other initiatives.

There is a requirement for good communication to improve the sustainability of the GGRF. An ability to communicate tailored messages to specific target groups is important, as is the use of professional communication resources and tools. Currently, geodetic science, and the underpinning GGRF, is not well understood by decision makers, particularly at the political level.

The growth of communications channels and choices in today's multimedia makes outreach an important priority and challenge. In addition, geodesy is inherently a complex field of science, and communicating the complex nuances of geodetic science to a diverse audience is not an easy task.

To increase awareness and drive engagement around the UN-resolution and the importance of the GGRF, the Working Group has developed several communication tools for broad distribution: a communication strategy, an animated movie titled "Geodesy - a global science on a restless planet", multiple newsletters and fact sheets, a power point template, and a social media strategy including the twitter campaign @unggrf. A parallel objective of the twitter campaign has also been to draw followers to both UNGGRF and UN-GGIM. In addition, social media directs followers to the GGRF web page[10] for more information.

Many geodetic experts lack experience in communicating their science outside their specialised audiences. Due to the inherent complexity of geodetic science, strategic communication from national mapping agencies and geospatial organisations to policy makers continues to be a challenge. This limits Member States from being proactive in outreach and making use of the communication tools in their own countries.

Further compounding this challenge, currently available communication tools are available only in English. This limits the tools' range of impact because in order to ensure the development and sustainability of the GGRF, the UN-GGIM delegates, decision makers, and

[10] www.unggrf.org.

geodetic opinion leaders must understand how important it is to communicate global geodesy and the GGRF road map in their own regions.

It is imperative to develop communication and outreach programmes that make the global geodetic reference frame more visible and understandable to society.

Measures of Success

The Working Group identifies the following measures of success (qualitative indicators) on communication and outreach:

a) Member States cooperate to communicate the importance of the GGRF through an agreed and coordinated communications program. The framework provided by the program includes all communication efforts with actions and tools customised for different audiences and channels, with these actions and tools to be revised as the process moves forward.
b) All communication tools are available in all official UN languages. Furthermore, tools are translated to the language of the target audience in regionally focused communication campaigns.
c) Member States have established close cooperation between communications experts and scientific/geospatial experts.
d) Increased numbers of students are attending higher level geodetic educational programs.
e) The communication work is evaluated and results are used to expand the strategy and secure success on the way forward towards a sustainable GGRF.

Recommendations

The Working Group recommends that:

a) Member States cooperate to establish an agreed and coordinated global geodetic outreach program.
b) Member States support and enhance outreach in accordance with the global geodetic outreach program.
c) Member States initiate, encourage, and promote better outreach cooperation between national communications experts and geodetic experts.
d) Member States use the developed communication strategy and tools (including newsletters, video, unggrf.org and social media @unggrf) for the purpose of raising the base level of awareness around the benefits of the GGRF to society.
e) If necessary, Member States translate communication tools into multiple languages to make them understandable on a national basis.

Governance

Current situation

There are currently a variety of governance mechanisms in place that loosely coordinate the maintenance and development of the GGRF. These governance mechanisms are not sufficient to ensure the sustainability of the GGRF. The loose and informal manner of the governance mechanisms allows for inefficient and slow development processes, and the lack

of formal commitment jeopardises sustainability and blocks progress. Some bilateral agreements exist between space agencies and national mapping organisations, but there is no comprehensive internationally binding governance for the GGRF.

Contributions to the GGRF are given by individual Member States with no guarantee of availability and continuity in the long term. These contributions are primarily given by developed Member States based on their national needs and then made available globally for the common good. The IAG services also produce global geodetic products based on these voluntary and time-varying contributions.

Presently, within the GGRF, there exists no governance mechanism that enforces and manages multilateral intergovernmental cooperation. Consequently, investments in geodetic infrastructure are not optimal and the geographical distribution of geodetic observatories globally is inconsistent, resulting in a weak global geodetic reference frame.

At the regional level, the UN-GGIM regional entities (Africa, Americas, Arab States, Europe and Asia-Pacific) and the IAG regional components (AFREF- Africa, APREF-Asia-Pacific, EUREF-Europe, NAREF-North America, SIRGAS- Latin America and the Caribbean and SCAR-Antarctica) make partially coordinated contributions. These contributions vary from region to region and are not coordinated globally in an optimal manner.

The development and sustainability of the Global Geodetic Reference Frame is reliant on an improved governance structure.

Measures of Success

The Working Group has identified the following measures of success (qualitative indicators) of beneficial Governance. An agreed governance mechanism:

a) Is in place, providing an arena where Member States can discuss and agree on GGRF issues, and identify, initiate, develop, and plan strategies, projects, and activities to enhance the GGRF.
b) Facilitates counselling, coordination, and administration of the arena, projects, and activities to enhance the GGRF and other relevant activities beneficial to the sustainability and development of the GGRF.
c) Initiates, facilitates, develops, and coordinates relevant outreach programs underpinning and promoting GGRF development and sustainability.
d) Urges Member States to commit to maintain and improve appropriate national geodetic infrastructures, including their contributions to the IAG services (data, analysis and products centres), and counsels, facilitates, and administers conventions and protocols connected to these commitments.
e) Urges, counsels, formalises, manages, and establishes multilateral cooperative networks and bi-lateral agreements concerning the development and sustainability of the GGRF.
f) Addresses the need for geodetic capability building and in cooperation with Member States and relevant organisations initiates, plans, manages, and coordinates a global geodetic technical assistance program.
g) Addresses infrastructure gaps and duplications, and works towards the establishment of global geodetic Core Observatories in remote areas or in developing countries.
h) Promotes and facilitates the development of clear policies and procedures that commit Member States to open sharing of geodetic data. This includes the counselling,

administration, and management of conventions and protocols connected to these commitments.

i) Works with international aid organisations to identify new funding mechanisms for GGRF infrastructure and capability building in developing countries.

j) Cooperates with relevant organisations to promote industry and association engagement including, but not limited to, the IAG and its component services, IAU, FIG, IUGG, CEOS, and GEO to optimise the sustainability and development of the GGRF.

Recommendations

The Working Group recommends that:

c) The Member States note the importance of effective governance to the sustainability and enhancement of the GGRF

d) The Members States collectively commence the development of an implementation plan for the recommendations in the GGRF road map.