ATTACHMENT 1

United Nations Committee of Experts on Global Geospatial Information Management #

Road Map for the Global Geodetic Reference Frame for Sustainable Development Implementation Plan

Photo: Bjørn-Owe Holmberg

Developed by the

UN-GGIM Subcommittee on Geodesy

July 2018

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Introduction

This Document contains the Implementation Plan for the Road Map for the Global Geodetic Reference Frame for Sustainable Development. Governance is not dealt with as an independent topic in this Implementation Plan, but is thoroughly discussed in the Governance Position Paper[1] which should be considered in conjunction with this plan.

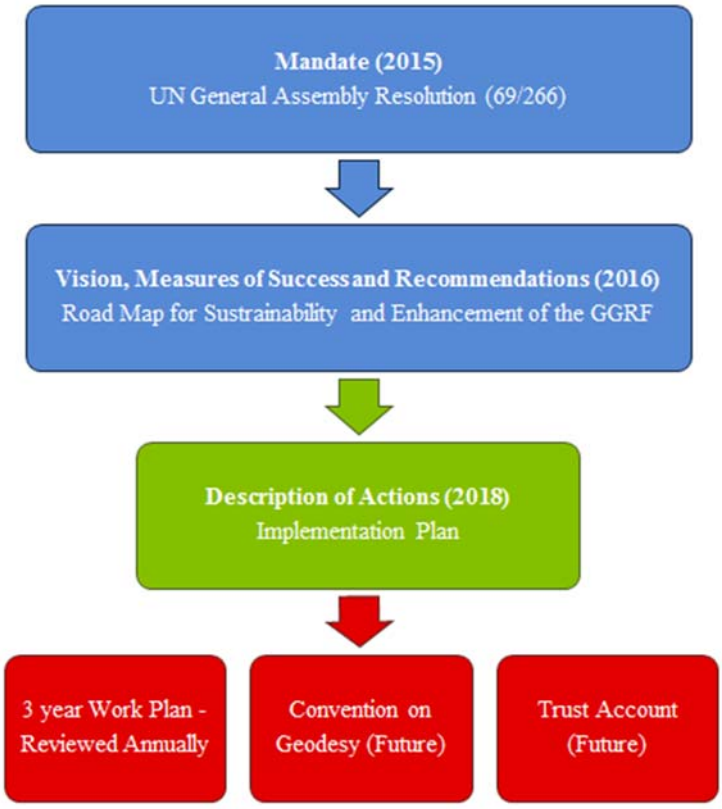

Figure 1. The strategic progression of activities through time towards a sustainable and enhanced global geodetic reference frame

The Road Map was endorsed by the UN-GGIM Committee of Experts at its 6th Session in August 2016. It addresses each of the key areas of action described in the operational paragraphs of UN General Assembly Resolution A/RES/69/266. It also suggests qualitative measures of success that would indicate if an enhanced and sustainable GGRF was achieved, and makes recommendations to assist in achieving these measures.

[1] Governance Position Paper

In developing the Road Map the Working Group recognised that five key focus areas were required as diagrammatically represented in Figure 2. Geodetic Infrastructure; Policies, Standards and Conventions; and Education, Training and Capacity Building can all be considered as infrastructure, physical, administrative and human infrastructure respectively, that can be enhanced independently of each other to some degree. Underpinning these are Governance, and Outreach and Communication, which impact directly the success achievable in the top three focus areas. Many of the actions described in the infrastructure focus areas can only be implemented if appropriate governance mechanisms are put in place, supported by effective Outreach and Communication.

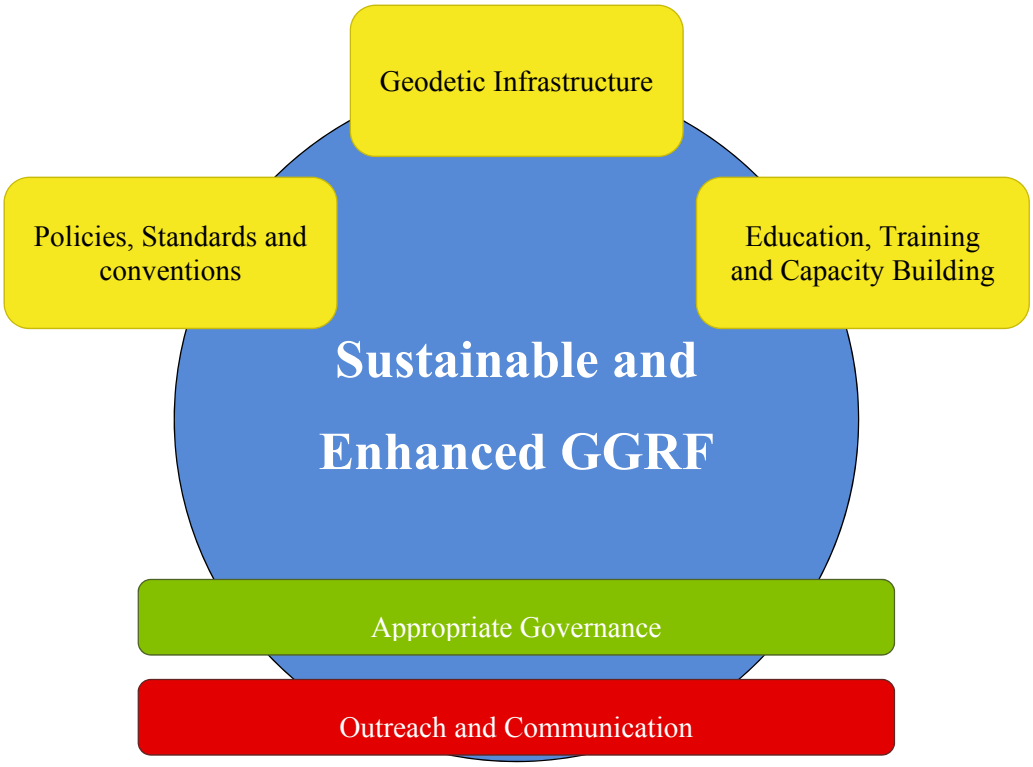

Figure 2. The five focus areas developed in the Road Map and this Implementation plan

This Implementation plan is the third step in the UN-GGIM process of improving the sustainability, and enhancing the quality, of the Global Geodetic Reference Frame as described in Figure 1 above. This process was initiated by the UN-GGIM Committee of Experts and conducted by the Working Group on the Global Geodetic Reference Frame (GGRF), which in 2017 became the UN-GGIM Sub-Committee on Geodesy.

In developing actions for this Implementation Plan the focus groups have referenced the measures of success and recommendations that were detailed in the Road Map. The actions are diverse in nature, with some being address to the Members States, others to the Subcommittee on Geodesy itself, and some to our participating organisations like the International Association of Geodesy (IAG) and the International Federation of Surveyors (FIG).

Many of the actions are reliant on effective governance arrangements to facilitate coordination and cooperation. Accordingly, this Implementation Plan should be read in conjunction with the position paper on governance, which is also tabled at the eighth session of the UN-GGIM as part of the GGRF report. Some of the actions also rely on appropriate resourcing. While no explicit commitment to resourcing is sought in this plan, the position paper on governance does discuss the merits of creating a framework and mechanism, i.e UN Trust Account, in which financial donors could potentially support some of the actions.

The real success of this Implementation Plan will be gauged by the growth in participation of member states in the Subcommittee on Geodesy and the development of its work plan over the coming year. Every step in this process to date, from General Assembly Resolution to Implementation Plan has recognised that no one country can achieve this alone. Through greater participation we start to see sustainability emerge as a sharing of responsibility. This coupled with appropriate partnerships with the International Association of Geodesy, and the International Federation of Surveyors, will begin to achieve the measures of success detailed in the Road Map and re-iterated here.

The chapters that follow have been developed by independent focus groups as detailed in the header of each chapter. The broader membership of the Subcommittee on Geodesy has also participated in steering the discussion and achieving homogeneity across focus groups.

Chapter 1: Geodetic Infrastructure

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Background

The Road Map recognised that the global distribution of geodetic infrastructure is far from optimum with a significant imbalance between the Northern and Southern hemispheres, and other large gaps in the distribution of infrastructure as demonstrated by Figure 3 below. While the DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) network is reasonable well balanced globally, and the GNSS network is also sufficient at the global scale, the same cannot be said for the Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR) networks. Nor is the Global Navigation Satellite System (GNSS) network sufficiently dense in some places to provide effective access to the Reference Frame.

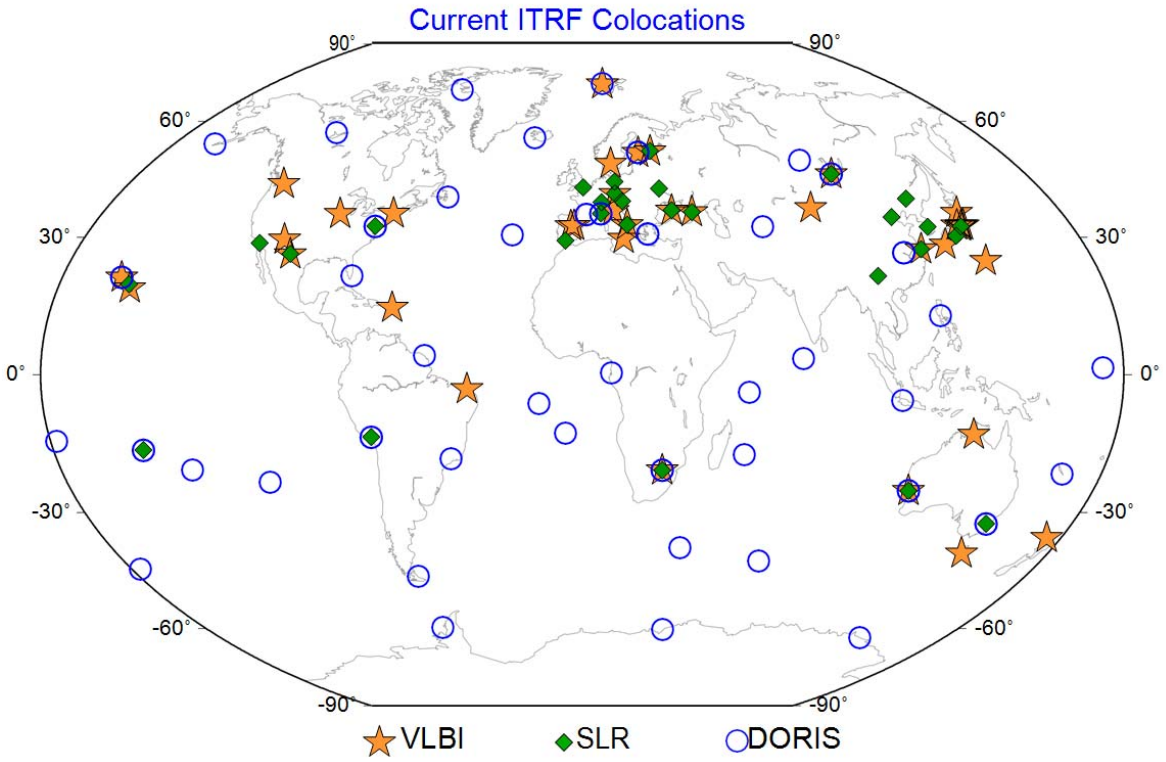

Figure 3: Global Distribution of Fundamental Geodetic Observatories which are colocated with GNSS.

This infrastructure distribution issue is further compounded by non-homogeneity of instruments within each of the technique networks, caused by varying designs and age of infrastructure, different operations models, and different observational priorities. This is particularly significant when techniques introduce new observation types or schedules that are not supported by the older instruments. Furthermore older instruments, or those that are not maintained sufficiently, are also more prone to failure and the associated loss of data.

The Road Map went on to describe some Measures of Success and Recommendations to achieve them. The following sections expand on these to articulate Actions aimed at fulfilling the recommendations and achieving the Measures of Success.

Measures of Success

- 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.
- Geodetic observatories, and in particular VLBI and SLR instruments, are upgraded to next generation technologies.
- GNSS infrastructure is upgraded to multi-GNSS equipment with optimal coverage at the national and regional level, providing both contribution and access to the GGRF.
- 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.
- The stations of the global height system and absolute gravity reference network are linked to VLBI, SLR, GNSS, or DORIS infrastructure at geodetic observatories.
- 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.
- There is compatibility between national GNSS stations and the standards of the International GNSS Service (IGS).
- There are additional tide gauge stations collocated with GNSS stations.

- There are gravity observations at a subset of, if not all, GNSS stations.
- Regional GNSS stations can be integrated into the global IGS GNSS network.
- Analysis procedures support multi-technique combinations and provide long-term products as well as short-term and (near-) real-time products.
- A priority list of actions and investments is made available.

Recommendations

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.

Actions

1) Member States are encouraged to ensure appropriate GNSS infrastructure is developed within their country to allow public access to the Reference Frame.
2) Suitable Vertical Reference Frame control including relative / absolute gravity networks are established in each country.
3) SCoG, with IAG and FIG, define what constitutes suitable / sufficient infrastructure and provide education resources so that members can determine that for themselves.
4) Using Outreach and Communications activities, including the publication of case studies, newsletters, promotion material and business cases as appropriate, encourage member nations to develop modern national datums (reference systems) that are aligned to the GGRF.

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.

Actions

1) Develop a global investment plan for geodetic infrastructure which recognises regional differences in requirements, by:
    i. Auditing current investments and gaps,

ii. Recognising political / social / regulatory impediments to adoption,
iii. Documenting capability / capacity analysis including fiscal analysis of secondary benefits of hosting large infrastructure.

2) Develop an Operations Plan including capacity building guidelines for co-funding arrangements between nations that allows commencement prior to full capacity development occurring.

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.

Actions

1) Encourage IAG / GGOS to develop such a science plan, which also details the need for long term continuity of instruments for Reference Frame determination and accessibility.
2) encourage Member States to undertake national coordination and cooperation to ensure this commitment is factored into national and regional planning.
3) SCoG, as part of its Outreach and Communication activity needs to develop counterfactual information that illustrates the negative impact of no action.
4) Ask the IAG services for guidelines to help nations when implementing geodetic infrastructure for science and societal applications (e.g. IGS site guidelines).

d) Member States make efforts to upgrade the current observing systems at the geodetic observatories, especially VLBI and SLR instruments, to next generation technologies.

Actions

1) Develop a sample economic case for a core site including capital costs, staffing requirements, communications / power costs and requirements, operating budget. (Action for GGOS BNC and SCoG)
2) Encourage the respective IAG technique services (IGS, ILRS, IVS, IDS, IGFS etc.) to develop and share modernisation plans for their

observing systems. Ask IAG to develop templates for technique modernisation plans for the services to use.

3) Encourage station operators to develop site management plans including the management of time series discontinuities.
4) Member States to commit, through the Convention[2], to adopting these plans (from 2 and 3).

e) Member States support the IAG's continued efforts to quantify, through simulation, the global distribution and specification requirements for Core Observatories.

Actions

1) Same action as d) above

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.

Actions

1) Inform the Member States of the importance of core / co-located observatories. (Action to O&C, with input from IAG)
2) Provide a description of benefits of investing in specific observatories to the relevant Member States, in order to assist them to build the economic case within their own government.
3) Develop framework (mechanism) and document template for international / inter-agency agreements which articulates the site requirements in an agreement form.
4) Examine the possibility of (3) being reformulated in the context of a Convention[3] and Trust account.

[2] Governance Position Paper, Arguments chapter, section: Formulate and negotiate a GGRF-convention

[3] Governance Position Paper, Arguments chapter, section: Formulate and negotiate a GGRF-convention and section: Establish UN-GGIM trust fund

Chapter 2: Policies, Standards and Conventions

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Background

Appropriate policies, standards and conventions are fundamental to all data sharing, the production of the GGRF products and Member State access to these products. The UN General Assembly Resolution (A/RES/69/266) urges Member States to implement open sharing of geodetic data, standards and conventions to contribute to the global reference frame. The Road Map reveals that geodetic data sharing is inconsistent across Member States and the UN-GGIM regions. It also recommends Member States to adopt common standards to ensure interoperability of positioning techniques.

Introduction

In developing actions to address the Recommendations detailed in the Road Map it is important to understand the current situation. For the purpose of achieving as much clarity as possible we separate Data Sharing and Policies from Standards and Conventions in this report. Annex A has a detailed analysis of the current situation for both, followed by a list of Case Studies in Data Sharing, and a detailed overview of existing IAG Standards and Conventions.

It is important to note when referring to Standards that we take a broad definition of the term standard. While some of the material we refer to is recognised under a formal Standards Body, like the International Standards Organisation (ISO), other material is more appropriately described as industry agreed standards. Both play an important role in guiding how geodetic instrumentation, data, analysis and products are developed, transferred, exchanged and applied.

Measures of Success

The SCoG has identified the following Measures of Success (qualitative indicators) on Data Sharing, Policy, Standards and Conventions to assist with implementation of the GGRF 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.

In addition, with regard to infrastructure implementation:

e) There is compatibility between national GNSS stations and the standards of the International GNSS Service (IGS).

Recommendations

The Road Map recommendations for Policies, Standards and Conventions are:

- 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.

The SCoG recommends the following actions to implement the Road Map recommendations:

a) Member States more openly share their data, standard operating procedures, expertise, and technology by committing to adopting policies, where feasible, that maximise access to and use of open, free and unrestrictive geodetic data and products to support future realisations of the GGRF.

Actions

1) The Subcommittee on Geodesy (SCoG), together with the IAG services and GGOS, to develop data portals and associated meta-data catalogues that are interoperable with each other (e.g., GEO and GGOS portals) and make data and products more discoverable.
2) Member States encouraged to share their geodetic data by contributing to existing international data portals, including the IAG services, or by providing open access to their own data portals.
3) Member States with their own data portals encouraged to use international metadata standards in the operation of their portals and ensure their metadata catalogues are populated.
4) Member States utilise existing regional organisations such as the IAG regional sub-commissions and UN-GGIM regional committees, or form new ones, to cooperate on issues relating to data sharing.
5) Member States support workshops with a focus on data sharing by assisting with their organisation, providing speakers and sending delegates.

b) 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.

Actions

1) Member States document concerns and barriers to data sharing.
2) Member States document and share case studies on methods of data sharing, the benefits that have arisen and strategies for overcoming barriers, including addressing national security concerns.
3) Member States with limited or no existing geodetic observing networks to seek out financial and technical support or establish collaborative arrangements with other Member States to install or expand geodetic observing networks in their territories as recommended by the SCoG for improving the GGRF. Other Member States are encouraged to provide any support possible.

4) SCoG develop data sharing policy templates for Member States to use in preparing their national data sharing policies to ensure data sharing principles are uniformly implemented across all regions while acknowledging legal and policy challenges remain at the national level.
5) SCoG constitute a Data Sharing Advisory Group, consisting of data sharing experts from Member States such as legal, licensing and policy experts in addition to geodetic data experts, to provide advice to other Member States on how they can share their data for mutual benefit.

c) Member States support the efforts already undertaken by IAG and standards organisations such as ISO towards common geodetic standards, conventions and standard operation procedures, and make these openly available.

Actions

1) Member States commit to adherence to such standards to facilitate the effective and efficient creation, sharing, exchange and use of geodetic data and the operation of geodetic observing networks in support of the GGRF.
2) SCoG request GGOS and the IAG services to establish and make fully available standard operating procedures for geodetic observing networks and products developed under a global governance model that does not restrict innovation yet maintains the highest consistency between the ICRF, ITRF and EOPs to support future realisations of the GGRF.
3) SCoG to compile an inventory of standards, conventions and standard operating procedures used by UN-GGIM Member States to reveal inhomogeneities and inconsistencies among their data, products and formats and to provide recommendations on resolving these inconsistencies to satisfy the needs of the GGRF.
4) Member States apply processing standards and models as a fundamental basis for the generation of consistent geodetic products such as the GGRF. The numerical standards, including time and tide systems, used for such products must be clearly documented for all geodetic products.
5) Member States are encouraged to continue to work in cooperation with the international standards bodies, including participation, as appropriate, in the work programs of ISO/TC 211, the Open Geospatial Consortium (OGC) and the International Hydrographic Organization (IHO).

6) SCoG request standards organisations to consider mechanisms to facilitate wider training programs and to ensure access to standards on reasonable terms, especially for developing countries.
7) Member States publish their 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.

Chapter 3: Education, Training and Capacity Building

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Background

As a component of the UN GGIM Subcommittee on Geodesy, the Education Training and Capacity Building (ETCB) Focus Group seeks to assess the current availability of education, training, and capacity building resources, identify gaps in capacity or other areas of need, and propose short-, mid-, and long-term solutions to realise the full scientific and social benefit of the Global Geodetic Reference Frame. Wherever possible, elements of this plan that are in support of the United Nations Sustainable Development Goals (SDGs) or Sendai Framework for Disaster Risk Reduction will be identified and tracked.

Introduction

In the course of preliminary plan development, it became evident that while basic ETCB needs are global, a regional focus strategy is essential to Road Map implementation. The nature, size, and variety of challenges differ across regions and may include linguistic, technological, economic, and cultural impediments. It is also clear that access to highly skilled personnel varies widely among Member States, thus necessitating the need to ensure that knowledge and competence is readily and openly shared. Furthermore, identifying and making existing educational and capacity building resources available and easily discoverable is key to optimising the efficiency of the group's objectives as well as conservation of limited financial, infrastructural, and human resources. As a first step to understand the challenges, the group has prepared and sent out a questionnaire asking UN Member States to identify their level of competence and capacity as well as short and long-term needs of ETCB. A report summarising the results of this questionnaire will be presented towards the end of 2018.

The ETCB Focus Group relates the benefits of its work to the global audience through identifying geodetic contributions to the UN Sustainable Development Goals (SDGs). The

potential for geodesy to support the global indicator framework of the SDGs is vast and diverse, and its value may be seen at international, regional, and Member State levels. Geodesy offers unique technological solutions to discover, access, process, and analyse data and information needed to assess progress within the global indicator framework for the SDGs and targets for the 2030 Agenda for Sustainable Development.

Measures of Success

- All Member States have, or have access to, appropriate geodetic capacity to underpin the realisation of the sustainable development goals.
- Geodetic education, skills, and capabilities are continuously developed and available to all Member States sufficient to underpin both GGRF and Member State sustainability and development.
- A global geodetic technical assistance program exists.
- 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.
- 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.
- Capability transfer occurs between existing experts and those emerging in this area.
- Sufficient resources are allocated to research programs promoting and underpinning GGRF development.

Recommendations

The recommendations are divided in the following five areas:

- Development organisations investment in national and regional geodetic capacity building to ensure efficient access to, and utilisation of the GGRF in developing Member States.
- Member States, in cooperation with the IAG, FIG and other appropriate organisations, establish a global geodetic technical assistance program.

- 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.
- 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.
- Member States openly share all geodetic skills.

Discussion of each recommendation includes recommendation-specific actions, consultations, timelines and constraints. The details regarding this discussion can be found in Annex B. It has been identified by the ETCB Focus Group that the current main constraints are of a financial and linguistic nature. Establishing a Trust Fund to provide stable and reliable funding for the recommended ETCB actions (below) could ensure long-term and sustainable support of this component[4]. The linguistic sensitivities inherent to education and training should not be underestimated. Most higher-level international courses are held in English, but to be successful we need to ensure that right courses are given at the right time with the right content, and in a language that is most conducive to student success.

a) Development organisations investment in national and regional geodetic capacity building to ensure efficient access to, and utilisation of the GGRF in developing Member States.

- Develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN-GGIM Subcommittee on Geodesy, especially from developing or historically under-represented Member States; and by working with the UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) to determine training needs at regional levels.
- Conduct Reference Frame Competency and Educational Needs Assessments using GGRF-wide and subcommittee-approved metrics. This will assess the geodesy training needs of Member States, as well as capacities of member States to assist and

[4] Governance Position Paper, Arguments chapter, section Establish UN-GGIM trust fund

contribute to capacity building efforts, particularly focusing on providing resources to developing Member States.

- Establish a priority list of short, mid and longer-term training needs, their objectives, and required resources for fulfilling these needs.

b) Member States, in cooperation with the IAG, FIG and other appropriate organisations, establish a global geodetic technical assistance program.

- Prepare and implement an annual openly available, SCoG-endorsed, training program that includes workshops and the provision of technical material. Compile and promote this training program with upcoming training opportunities, spanning from one-day courses to university certification or diploma programs. Align this program to a centralised list of relevant technical workshops and training activities, along with any available funding, research stipends, sponsored secondments, or other means of supporting participants from developing member states.
- Develop a standing scientific organising committee to ensure content of these workshops is relevant, optimised, and delivered by the appropriate geodetic community members. This committee should also establish training agreements with key stakeholders.
- Ensure training material from workshops is made readily and openly available to the wider geodesy community. Since the official working language of the Subcommittee is English, materials will first be available in English, then the other UN languages, and in additional languages, if translation services are available.
- Implement a policy of open-availability for all materials and recordings from training programs/classes endorsed by the UN GGIM Subcommittee on Geodesy.
- **NGO Collaboration:** Work with the International Association of Geodesy (IAG) and International Federation of Surveyors (FIG) and other relevant organisations, such as the Group on Earth Observations (GEO) to establish and run technical workshops in, and with a focus on, developing Member States.

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.

- Prepare and implement an annual openly available training program that includes workshops and the provision of technical material.

- Compile and promote an annual training program with upcoming training opportunities, spanning from one-day courses to university certification or diploma programs.
- Ensure training material from workshops is made readily and openly available to the wider geodesy community.
- Implement a policy of open-availability for all materials and recordings from training programs/classes endorsed by the (future) UN GGIM Subcommittee on Geodesy.

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.

- Provide a mechanism to develop and disseminate technical material by implementing an ETCB web page as a sub-page of the GGIM Subcommittee on Geodesy.
- Work with the GGRF WG Outreach and Communications Focus Group to ensure optimal development and delivery of educational and advocacy materials, and to ensure that the web site is regularly updated with information on workshops, and provides ready access to openly available training materials.
- **University, Research Institute, and other Academic Collaboration**: Work with geodesy technical and research institutes to develop and enhance geodesy training. Establish minimum training needs for a set of standardised tasks, spanning infrastructure, academic, and long-term sustainability. Established training resources and centres of expertise to support standardised task training and access to advanced education resources.

e) Member States openly share all geodetic skills.

- Encourage stakeholder and member state participation in capacity building by promoting the capacity building program through geodesy conferences and meetings, and the UN-GGIM web site, and incentivising (using non-monetary means) stakeholder participation and sponsorship.
- Geodetic Organisational Support, and Advocacy: Maintain close contact with national and international agencies and organisations, including IAG, IAG Services (such as the International GNSS Service), and FIG, who may provide funding, advocacy, or

other technical support for training and capacity building. Work with stakeholders to ensure cooperation and benefits for the ETCB strategy.

- Establish centres of training expertise and capability, work with established educational institutions to establish training courses and workshops.
- Work with national agencies as well as international organisations to develop internationally-recognised certification programs for those completing key levels of education or training.

Chapter 4: Outreach and Communication

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Introduction

There is a need to raise the general awareness around the value proposition of the Global Geodetic Reference Frame (GGRF) to support adoption and implementation.

The GGRF Road Map for sustainable development clearly identifies the requirement for good communication.[5]

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.

The growth of communications channels and choices in today's digital society makes outreach an important priority and challenge. In addition, geodesy is inherently a complex field of science, and communicating the complex nuances to a diverse audience is a difficult task best done with the support of technical communications specialists.

Solid communication and outreach work is necessary to realise the purpose and intention of the United Nations GGRF resolution[6] and Road Map.

Considerable communication and outreach efforts were critical to the adoption of the GGRF resolution at the United Nations General Assembly[7]. Member States dedicated substantial communication resources to this work and secured the fast and successful adoption of the GGRF resolution. Since then, communication contributions from Member States have been reduced.

The vision guiding this work is "an accurate, sustainable and accessible Global Geodetic Reference Frame to support science and society." This chapter outlines on

[5] E/C.20/2016/4/

[6] United Nations General Assembly, «A global geodetic reference frame for sustainable development», A/69/L.53; 18 February 2015

[7] UN Press release/ A/69/L.53

how the Member States can contribute to the realisation of this vision and the Road Map's recommendations, by engaging in four basic communication actions:

1) Build a geospatial communications network;
2) Establish a geospatial communications coordinator;
3) Develop a geospatial collaboration space;
4) Establish a UN Subcommittee on Geodesy working group for outreach and communication.

The objective is to encourage 80 percent of the Member States to participate in the activities outlined in the GGRF Road Map implementation plan and position paper by 2023. The SCoG will encourage this participation by advocating that GGRF is the foundational framework for all spatial data and positioning activities.

Communication Actions

Action 1: Build a geospatial communications network

Many highly-skilled geodetic experts lack familiarity and experience in communicating their science outside their specialised audiences. Due to the inherent complexity of geodetic sciences, strategic communication to policy makers is an ongoing challenge. [8]

The GGRF Road Map highlights that Member State cooperation on geodesy-centric communications is vital for GGRF.

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) seeks to play a leading role in setting the agenda for the development of global geospatial information while promoting its use to address key global challenges.[9] The SCoG operates within this scope, aiming for an accurate and sustainable GGRF. This one geospatial network will be beneficial for all.

[8] E/C.20/2016/4

[9] UN-GGIM Aims and Objectives

At the UN-GGIM 7th session, the Committee of Experts expressed support to build a web of communication experts[10] to enable close cooperation between geodetic and communication experts.

During development of the GGRF Road Map Implementation Plan, it became evident that the GGRF will benefit by expanding this communication network to include communication professionals from the whole geospatial community.

The SCoG therefore recommends that Member States participate in this communications network.

The goals of the network are to:

- Encourage connection between communications experts/advisors and technical geospatial experts within each Member State.
- Develop a communications community that captures experiences and shares case studies, news stories, social media posts, promotional materials and other communications resources and tools so the benefit of geospatial data, such as a sustainable and enhanced GGRF, become more widely and easily understood.
- Strengthen the whole UN-GGIM communication and outreach capability.

The network will also:

- Liaise with communicator networks in international organisations that share interest in geospatial, GGRF and earth observation issues, including GEO, CEOS and others, for knowledge sharing, network collaboration and mutual meeting points.
- Connect with geospatial- and GGRF-supporting UN initiatives that directly or indirectly relate to the Sustainable Development Goals (SDGs).
- Contribute to the development of a social media strategy with the objective to increase awareness and drive engagement of the @unggim and @unggrf twitter accounts in support of #GGIM and the #GGRF.
- Engage with UN SDG direct-promotion campaigns and use SDG-relevant hashtags to increase exposure across the greater Earth observation and UN community.

The network will follow the subcommittee's guidelines to:

[10] E/2017/46-E/C.20/2017/18, Decision 7/103, page 7

- Develop a communications and outreach strategy to guide the implementation of a suite of communication products.
- Implement regional initiatives and activities and share best practices and case stories.
- Providing accessible information and new, easy-to-use tools regarding the benefits of committing to, and contributing to, the GGRF.
- Translate communication resources to make them understandable nationally.

Participation is on a best-efforts basis, and all levels of participation are welcome and encouraged. The network is intended to operate electronically with no expectations of travelling to meetings.

Due to differing communications capability in nations, as well as language- and technical barriers, the network will be organised according to the level to which Member States are able to, or wish to, participate in such collaboration.

The SCoG encourages Member States to nominate a contact person, preferably with some communications and public relations experience, who can represent the Member State or organisation in the UN-GGIM communications network. This communication network will strengthen not only the GGRF, but also the whole UN-GGIM communication and outreach capability.

The successful operation of such a network is the answer to the GGRF Road Map recommendation c) section Communication and Outreach, and facilitates the realisation of recommendation a), b) and d).

Action 2: Establish a geospatial communications coordinator

A main challenge when establishing a communication network with global participation and different capabilities in nations is the coordination of this effort. The same accounts for the establishment of an agreed and coordinated global geodetic outreach program as recommended by the GGRF Road Map.[11]

The vision for the GGRF Road Map Implementation Plan will require commitment and dedicated communication efforts from Member States. Coordination of these efforts will be key to realising the measures of success and achieve results.

[11] E/C.20/2016/4

It is necessary to engage a dedicated geospatial communication coordinator to keep up the momentum of the GGRF communication efforts, realise the Road Map's Measures of Success, and support the establishment of a geospatial communicators network.

The tasks of the geospatial communications coordinator are to:

- Act as the communications secretariat and contact base for the communications network.
- Finalise the development and coordinate implementation of the GGRF communications strategy.
- Coordinate communication activities with Member States and maintain communications tools according to the subcommittee's communications strategy and guidelines.
- Coordinate the development of a communications collaboration space.
- Coordinate social media activities through a developed social media strategy.
- Provide accessible information, templates and new, easy-to-use tools regarding the benefits of committing to, and contributing to, the GGRF.

The engagement of a communications coordinator will be essential to a successful communications network. This person will provide guidance to Member States, as well as support building the UN-GGIM and GGRF communication capacity as a whole.

The successful creation of this role is the answer to the GGRF Road Map recommendation a) section Communication and Outreach, and facilitates the realisation of recommendation b), c), d) and e).

Action 3: Develop a geospatial communications collaboration space

The successful use of communications tools demands collaboration spaces where Member States can share, find, and make use of documents and tools such as newsletter templates, social media strategies, infographics, animations, photos, narratives/ case stories and collection of quotes easily - in all UN languages.

To successfully communicate about the GGRF internationally, there is a need to share documents, images and other communications materials. Enhanced cooperation and a dynamic set of communications tools customised for different audiences and channels need

be available to all members of the geospatial communications network. [12] A collaboration space that compliments the existing UN-GGIM [13]and UN GGRF [14] websites could enable sharing documents and other material that is both functional and accessible.

The SCoG therefore recommends the Member States support the development, and contribute content to, a collaboration space for the geospatial communications network.

The goals of the communications collaboration space are to:

- Provide a platform to share documents and communications materials, templates, tools, and strategies.
- Provide easy access to all Member States as the preferred UN-GGIM tool bank.

The communications coordinator will coordinate the development of this collaboration space.

The successful development of this collaboration space will contribute to the GGRF Road Map recommendation a) section Communication and Outreach, and facilitates the realisation of recommendation b), c), d) and e).

Action 4: Establish a UN Subcommittee on Geodesy's working group for outreach and communication

The UN-GGIM Subcommittee on Geodesy (SCoG) shall provide, through coordinated outreach and communications, comprehensive advocacy for global geodesy. This advocacy will serve as the basis upon which all future geospatial data and positioning activities are founded. Outreach and communication in collaboration with appropriate regional initiatives and activities is necessary to underpin these advocacy efforts. [15]

Given the significant role that communications and outreach plays in the successful and sustainable implementation of the GGRF, it is evident that much work is to be done. To ensure sustained, effective, and long-term progress in the outreach and communications component of the SCoG, it is requested to convert the existing focus group to an established subcommittee Working Group on Outreach and Communications.

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[12] E/C.20/2016/4

[13] UNGGIM-wg1

[14] unggrf

[15] ggim.un.org ScoG Objectives, 10

The goals of the SCoG's Working Group on Outreach and Communications are to:

- Set the strategic direction for communications and outreach for the GGRF.
- Follow progress in fulfillment of the actions in this chapter, and provide guidance in the establishment of the communications network, coordinator position, and collaboration space.
- Work with other focus areas within the SCoG to ensure their communications requirements are identified, prioritised, and realised.

Annex A: Policies, Standards and Conventions

Current Situation and Case Studies

Data Sharing and Policies

Geodetic data sharing is inconsistent across Member States and the UN-GGIM regions at this time. Data sharing is of particular importance to nations facing common challenges relating to their location. In many situations, it is easier to make the case for data sharing if neighbouring countries are all taking a similar approach at the same time. This increases the speed of benefits realisation and creates momentum around data sharing initiatives. The following are examples of (or lack of) regional cooperation.

Data sharing within Europe has existed for a long time. 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.

Data sharing in the Americas has been somewhat inconsistent among the different regions. Data sharing in North America and South America has existed for many years under the auspices of IAG sub-commissions NAREF (North American) and SIRGAS (South America and Latin America). It has been an integral part of these groups and both have contributed greatly to the International GNSS Service data archives and product generation. Data for nearly all publically operated continuous GNSS stations in North America has been freely available for decades. However, throughout the Caribbean region there has been an absence of data sharing which is usually attributed to the lack of resources and/or a lack of regional initiatives that would require all the islands to work together and exchange data.

Nevertheless, some recent progress on data sharing has been made in this region. UN-GGIM Americas was created in 2013 and is comprised of 38 member countries stretching from North America through to South America, including all the islands of the Caribbean region. A key objective of the regional body is to advance geospatial data infrastructure in the Americas, where required. In keeping with this objective, a project focused on strengthening the spatial data infrastructure capacity of the Caribbean region was conceptualised with data sharing being a key component. This project, referred to as "The Caribbean Project", was implemented based on the weaknesses in spatial data infrastructure within specific areas of the Caribbean region. In addition to the Caribbean Project, other geospatial data sharing initiatives have been embarked upon. One of the most successful examples is COCONet (Continuously Operating Caribbean GPS Observational Network). Spearheaded by UNAVCO Inc and funded by the U.S. National Science Foundation (NSF), the primary aim of this initiative is to develop a large-scale geodetic and atmospheric infrastructure in the Caribbean to form the backbone for a broad range of geoscience and atmospheric investigations with particular relevance to geohazards. The plan is to establish a network of at least 46 new continuous Global Positioning System (cGPS) and meteorology stations, refurbish an additional existing 21 stations, and archive data from at least 61 cGPS stations that are already or will soon be in operation. Although the project is still in its developmental stage, the data sharing initiative is clear. More information on these projects is given as case studies in Annex A.

Some recent progress has also 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 under the auspices of IAG Sub-commission 1.3. 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.

UN-GGIM Arab States was formally established during its first meeting held in Riyadh (Saudi Arabia) 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 inhibited by the same issues as discussed in the paragraph above for Asia Pacific.

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 and products, especially GNSS and gravity data. Most of the barriers to data sharing are a result of the following issues:

- legislative
- institutional & conflicting commercial concerns
- lack of resources; financial, technical (communications, expertise)
- lack of regional initiatives and collaboration
- weak culture of inter-country collaboration
- geographic isolation
- sparseness of geodetic infrastructure and corresponding lack of data
- security concerns

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

Part of problem with geodetic data sharing is that the benefits are often not well-understood by policy makers. Geodetic data may be perceived as being highly technical and scientific, and of limited interest compared to other spatial data. Decision-makers need to understand that while sharing geodetic data has benefits to the global community, there are particular and

significant benefits that accrue to the organisation or country sharing its data. For example, many countries share GNSS data with the International GNSS Service (IGS), which in turn makes it available to the global community. The benefit to the country sharing the GNSS data comes from the fact that the global models developed using this data will be more accurate over the extents of the country. This supports the use of GNSS-enabled technologies at the highest levels of precision, development of accurate national reference frames and therefore the accurate management of geospatial data.

The following table, based on Sarib and Blick (2018), identifies key benefits of sharing geodetic data:

Table 1: Benefits of Data Sharing

Global Benefit	**Data Sharer Benefits**
Improved quality of global products	Global products are improved in their primary area of interest.
Monitor global change to mitigate risks	Regional models are improved, hence natural hazards are better understood in the subject country.
Innovative applications	Innovation often arises in individuals or small groups, that do not have the resources to collect their own data.
Reuse and return on investment	Geodetic data is often collected at considerable cost. Sharing this data means that additional benefits can accrue, over and above those for which the data was originally collected.

While such benefits may be obvious to technical experts, they need to be documented for a non-technical audience. These case studies can then be used by other countries seeking to improve their data sharing.

Access to geodetic data sharing advice and expertise can be challenging, due to the limited number of experts in the field and the range of expertise that may be required to formulate a data sharing policy and implement that policy. While there are a number of existing organisations that provide access to geodetic expertise, such as FIG, there is no clear mechanism for obtaining data sharing expertise. Such experts are needed to provide advice and support for a nation or organisation to develop their own policies.

Nations wanting to improve their data sharing can benefit from the experiences of those who have already made steps towards greater sharing of their data. Developing data sharing policy is complex, with requirements to understand the technical, legal, social, political and commercial implications. A policy template would help nations to consider all the aspects relevant to their local context at an early stage and provide guidance on how each of these aspects might be addressed.

A number of workshops have been organised by the UN-GGIM and its partners to explore issues relating to data sharing. These workshops generally try to focus on topics relevant to the region in which they are held, providing practical suggestions on different approaches to data sharing. For example, in April 2018, such a workshop was held in Tonga, which included representatives of many Pacific Island nations. While the content of these workshops is valuable, perhaps more important is the forum they provide for participants to share experiences, form common goals and develop action plans to share their data more widely.

The ongoing success of these workshops is contingent on the support of UN Member States, both through the provision of experts and the participation of representatives of as many nations as possible, irrespective of how far down the data sharing path they may be.

Standards and Conventions

The IAG maintains and develops new standards that allow transparent and repeatable geodetic science to be undertaken. These standards also allow interoperability between technique-specific products.

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 IERS Conventions Centre (http://62.161.69.131/iers/) 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). The key task of the BPS is to keep track of adopted geodetic standards and conventions across all IAG components and to evaluate products of IAG with respect to their adequate use. The BPS has compiled an inventory of standards and

conventions used for the generation of IAG products (Angermann et al., 2016). This inventory summarises the current status of standards and conventions that are relevant for geodesy. It also identifies gaps and inconsistencies, and provides recommendations for improvements. A more detailed overview of the standards and conventions that are in use within the IAG is given in Annex A.

In addition to these fundamental physical constants, a set of suitable fundamental parameters is needed as a basis for the definition and realisation of reference systems as well as for the generation of geodetic products. The formulations of the basic theories of physics and their applications are based on fundamental physical constants. A complete list of all fundamental physical constants is given by the National Institute of Standards and Technology. More information on the fundamental physical constants in given in Annex A.

Many standards related to geographic information, including geodetic reference systems, have and are being developed by ISO Technical Committee 211 (Geographic information/Geomatics). More specifically, ISO/TC 211 aims to establish a set of standards information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. These standards are linked to other appropriate ISO standards for information technology and data where possible, and provide a framework for the development of specific applications using geographic data.

ISO standards related to geodetic reference systems include:

- ISO 6709: Standard representation of geographic point location by coordinates
  Defines the representation of coordinates to be used in data interchange, including latitude, longitude, height, depth and other coordinate types. Representation includes units of measure and coordinate order. Latest standard at https://www.iso.org/standard/75147.html.
- ISO 19111: Geographic information – Referencing by coordinates
  Defines the conceptual schema for the description of spatial referencing by coordinates, including spatio-temporal referencing. It describes the minimum data required to define one-, two- and three-dimensional spatial coordinate reference

systems and spatial-temporal reference systems. It also describes the information required to change coordinates from one coordinate reference system to another. Latest standards at https://www.iso.org/standard/74039.html.

- ISO 19115-1: Geographic information – Metadata – Part 1 Fundamentals
  Defines a metadata schema for describing geographic information and services and includes information about temporal and spatial parameters, data quality, among others. Latest standard at https://www.iso.org/standard/53798.html.
- ISO 19127: Geodetic Register
  Defines rules for the population and maintenance of registers of geodetic parameters, including geodetic reference systems and transformations, and identifies the data elements, in compliance with ISO 19135 and ISO 19111, required within these registers. Latest standard at https://www.iso.org/standard/41784.html.
- ISO 19135-1: Geographic information -- Procedures for item registration -- Part 1: Fundamentals
  Defines procedures to be followed in establishing, maintaining, and publishing registers of unique, unambiguous, and permanent identifiers and meanings that are assigned to items of geographic information. In order to accomplish this purpose, ISO 19135-1 specifies elements that are necessary to manage the registration of these items. Latest standard at https://www.iso.org/standard/54721.html.
- ISO 19161-1: Geographic information – The International Terrestrial Reference System (ITRS): definition, realisations and dissemination.
  Defines the basic information and definitions related to the International Terrestrial Reference System (ITRS), its realisations and how to access these realisations consistent with the conventions adopted by the International Union of Geodesy and Geophysics (IUGG), specifically its International Association of Geodesy (IAG), and the International Astronomical Union (IAU). Under development.

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.

The geodetic community is frequently called upon to provide data, products and services to support a broad spectrum of government, industry, science and societal applications. Coupled

with this is the ubiquitous uptake across society of accurate and reliable Positioning, Navigation and Timing (PNT) information. In order to service these user demands in a robust way, geodetic data and the associated metadata need to be standardised, discoverable and interoperable. The continual increase in the volume and complexity of data means we also need to generate, transfer and use data and metadata via a machine-readable form. In order to achieve these stated goals it is clear that the time has come to develop a XML-based standard for geodesy.

Metadata have thus far been under the purview of the data centres supporting the IAG services (such as IGS, ILRS, IVS, and IDS). Metadata enables their underlying data and derived products to be organised and catalogued which ultimately aids users in the search and discovery process. Furthermore, properly organised metadata can aid in interoperability between data systems thus promoting data sharing.

Although GGOS has not officially adopted a metadata standard, interoperability with existing standards is important and a logical way forward in developing the GGOS portal. A key goal of the portal is to seamlessly provide access to IAG service data and products to a global user community; this goal requires that the GGOS and service portals are interoperable. In addition, these portals must be interoperable with external portals, such as GEO. As recommended at previous GGOS Unified Analysis Workshops, the IAG services should develop web portals that are interoperable with each other and with the GGOS portal.

It is therefore important that these portals adopt recognised international standards. Several standards exist in the community that are relevant to metadata for the GGRF:

- ISO 19115-1: Geographic information – Metadata – Part 1 Fundamentals
  Defines a metadata schema for describing geographic information and services and includes information about temporal and spatial parameters, data quality, among others. Latest standard at https://www.iso.org/standard/53798.html.
- ISO 19136: Geographic information – Geography Markup Language (GML)
  Specification for expressing geographical features enabling interchange of geographic information among systems. GML was defined by OGC and is also an ISO standard. Latest standard at https://www.iso.org/standard/32554.html.
- GeodesyML
  The Geodesy Markup Language (GeodesyML) provides a standard for describing and sharing geodetic data and metadata. It provides a common language for describing

important geodetic concepts and is fully compatible with ISO standards 19115 and 19136. For more information see http://geodesyml.org/.

Initial work within the GGOS Bureau of Networks and Observations Data and Information Standing Committee involves the CDDIS and its implementation of metadata describing its data and derived products. The CDDIS, an Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centre (DAAC), uses the EOSDIS Common Metadata Repository (CMR) for management of its collection-level (and granule-level) metadata. The CDDIS is currently re-writing and re-loading all collection-level metadata records; many have been loaded into the CMR. Users, including GGOS, can access these records from the EarthData Search Client (https://search.earthdata.nasa.gov/search). The CMR is compatible with ISO 19115.

Knowledge of the multitude of existing geodetic reference systems and their inter-relationships is a fundamental requirement for data sharing. Metadata for these reference systems is essential to enable conversions between them in an accurate manner. There are a number of existing sources of such information, referred to as “registers”. One of the most popular is the EPSG Register operated by the Association of Oil and Gas Producers. However, that register is not publically administered nor always vetted by the authoritative sources of such reference systems. The ISO Geodetic Registry is a new international register of geodetic reference systems and transformations under the auspices of ISO/TC 211. All information in the register must be approved by its authoritative sources. A Control Body for the register approves all its content and is chaired by a representative of the IAG. Control Body members are nominated by the member nations in ISO and liaisons with other organisations. To enable interoperability of data and products, UN-GGIM Member States are encouraged to contribute their geodetic reference systems and transformations to the ISO Geodetic Registry.

Case Studies in Data Sharing

A.1: The Caribbean Project: A Data Sharing Initiative

UN–GGIM Americas was created in 2013. It is comprised of 38 member countries stretching from North America through to South America. It also includes all the islands of the Caribbean region. The objective of the regional body includes determining the regional issues for geospatial information management and taking the necessary action on these to maximise

economic, social and environmental benefits. The committee seeks also to foster exchange of knowledge, experience and technology among member states. The advancement of geospatial data infrastructure in the Americas, where required, is also a key objective.

In keeping with its objective, a project focused on strengthening the spatial data infrastructure capacity of the Caribbean region with data sharing being a key component was conceptualised for implementation. The project referred to as "The Caribbean Project" was implemented based on the weaknesses noted in the Caribbean region in specific areas. The exercise was broken down into three (3) areas:

a) Diagnosis
b) Capacity building
c) Infrastructure acquisition/improvement

The diagnosis phase focused on utilising select instruments such as questionnaires to assess the geospatial status within different Caribbean states. The information gained was used to inform the kind of capacity building to engage in and the type geospatial infrastructure development to focus on for the region.

Under the capacity building phase a number of workshops and training courses were conducted in which knowledge was shared in the following areas of the geospatial field with participants from across the region:

1) Geographic Information Systems (GIS) Course
2) Geospatial standards
3) Geospatial data infrastructure
4) Use of geodetic equipment
5) Land use classification
6) Software tools for building geoportals

The workshops and training sessions served the purpose of bridging the technical information gap which was identified in the diagnosis phased and aimed at ensuring that a standard understanding of certain geospatial principles and practices was in place throughout the different Caribbean territories.

The final component of the initiative focused primarily on establishing a Caribbean-wide geodetic network. This was deemed to be necessary based on the absence of an integrated region-wide setup (even though some islands had local networks) and the imbalance in the

ability of some territories to implement local reference stations by themselves. It was noted that the prolonged absence of a continuously operating regional reference system would impact the ability of the Caribbean countries to contribute to a Global Geodetic Reference Frame (in keeping with the ultimate objective of UN-GGRF). As such taking the step to assist with establishing a regional system to which each of the Caribbean territories would contribute and benefit from reference data was a relevant move.

Under the geospatial infrastructure development phase of the project 14 geodetics stations were procured and distributed for setup in select islands across the Caribbean. In March 2015, the Chairman of UN-GGIM America (Rolando Ocampo) signed a Memorandum of Understanding (MOU) with the University of the West Indies (UWI). Under this MOU it was agreed that the UWI Campus in Trinidad would host the data centre for the Caribbean Geodetic Network. It is to this data centre that all the reference data generated by the stations set up across the region would be transmitted and stored. The agreed protocol with respect to the data generated processed and stored at the data centre is to make it freely available to all the islands within the region. Further refinement of the protocol is expected as best practices are explored.

Additional components of the infrastructure such as the server to receive, process and share the reference data has been installed and made ready to receive submissions from the fourteen stations located throughout the region. The setup for web access has also been completed. Confirmation of this was received from Dr. Bheshem Ramlal who carries oversight for the data centre in Trinidad. He has pointed out however, that when last checked only three countries have submitted IP addresses so that the necessary connection can be made to the data centre and data received from the stations to the central hub. The assumption, subject to confirmation, is that some of the countries are having technical challenges with the setup. The network is therefore not yet fully functional and as such no data has been actively shared just yet. Plans are however afoot to have the technical challenges assessed so that the necessary intervention can be made to have the technical challenges addressed. Once this is achieved full operation of the network will be in effect with reference information being shared throughout the region which is the main objective of the initiative.

A.2: Continuously Operating Caribbean GPS Observational Network Project (COCONet)

In addition to the Caribbean project outlined above, other geospatial data sharing initiatives have been embarked upon. One of the most successful initiatives is COCONet (Continuously Operating Caribbean GPS Observational Network). Spearheaded by UNAVCO Inc. and funded by the U.S. National Science Foundation (NSF), the primary aim of this initiative is to develop a large-scale geodetic and atmospheric infrastructure in the Caribbean to form the backbone for a broad range of geoscience and atmospheric investigations with particular relevance to geohazards.

As part of COCONet, the plan is to establish a network of at least 46 new continuous Global Positioning System (cGPS) and meteorology stations, refurbish an additional 21 existing stations, and archive data from at least 61 cGPS stations that are already or will soon be in operation. COCONet provides raw GPS data, GPS measures of precipitable water vapour, surface meteorology measurements, time series of daily positions, as well as a station velocity field to support a broad range of geoscience investigations. Additionally, atmospheric data products are distributed to researchers using both the Unidata Local Data Manager (LDM) and other web Internet distribution systems. Geodetic data products are available from the UNAVCO public data archive and potential regional data partners in the Caribbean. All of the participants in the project have committed to a free and open data policy. Although the project is still is still in its developmental stage, the data sharing initiative is clear.

A.3: Pacific Geospatial and Surveying Council (PGSC)

The PGSC comprises national geospatial and surveying agencies from the Pacific Islands Countries and Territories (PICTs). A key priority for the PGSC is "improving and standardising geospatial information gathering and dissemination". In their charter, endorsed by 11 Pacific island governments, the Council recognises:

"That information on geography, custodianship and ownership is foundational for decision-making, resilience and sustainability. It is therefore essential that such foundational data and information has authority, currency and is comprehensive."

In April 2018, the Council released The Pacific Geospatial and Surveying Council Strategy 2017-2027 to guide the development of geospatial and surveying activities over the next ten years. One of the goals of this strategy is that:

"Countries across the region adopt a modern Geodetic Reference Frame (GRF) and improved technology that underpins geospatial systems and applications."

The PGSC recognises that modern national reference frames are an important prerequisite to enabling the sharing of geospatial data. This does not imply that all countries need to adopt an identical frame. Rather, the national reference frames need to be aligned to an appropriate realisation of the ITRF. It is this linkage to the ITRF which will ensure data interoperability to high levels of accuracy among different nations.

In the foreword to the strategy, PGSC Chair, Faatasi Malologa, notes the importance of data sharing to achieving the desired outcomes:

"Accurate mapping, positioning, monitoring and **data availability** [emphasis added] is of primary importance to our region's economic growth as it has a direct impact on key sectors such as shipping, land tenure, engineering and coastal development, fisheries and aquaculture, forestry and agriculture, tourism and more."

IAG Standards & Conventions

Brief overview

This document gives an overview about the standards and conventions that are in use within the International Association of Geodesy (IAG). The purpose of the document is to provide a summary of the present status concerning IAG standards and conventions, including a survey of the relevant literature.

The document consists of the following sections:

- Resolutions for geodesy adopted by IAG, IUGG and IAU
- Numerical standards used in geodesy
- Standards and conventions used for the generation of IAG service products

The work of IAG's GGOS Bureau of Products and Standards (BPS) provides a basis for this document. A key task of the BPS is to keep track of adopted geodetic standards and conventions across all IAG components and to evaluate products of IAG with respect to their adequate use. The BPS has compiled an inventory of standards and conventions used for the generation of IAG products (Angermann et al., 2016). This inventory summarises the current status of standards and conventions that are relevant for geodesy. It also identifies gaps and inconsistencies, and provides recommendations for improvements.

Resolutions for geodesy adopted by IAG, IUGG and IAU

Resolutions are non-binding laws of a legislature, but more binding than recommendations. In non-legal bodies, such as the International Union of Geodesy and Geophysics (IUGG), the International Astronomical Union (IAU) and IAG, which cannot pass laws, they form the highest level of commitment. Resolutions shall be respected by all institutions and persons affiliated with the adopting body (Drewes, 2008).

Most important resolutions for geodesy are those adopted by IUGG, IAG and IAU. The IUGG and IAG resolutions are adopted at the IUGG General Assemblies and published every four years in the IAG Geodesist's Handbook (Drewes et al., 2016). They are also available in electronic form at http://www.iugg.org/resolutions. The IAU resolutions are adopted by General Assemblies held every 3 years. They are published regularly in the IERS Conventions along with detailed information for their implementation (Petit and Luzum, 2010). An electronic version can be obtained from

http://www.iau.org/administration/resolutions. The BPS inventory provides a summary of the resolutions, which are relevant with respect to standards and conventions for geodesy (Angermann et al., 2016).

Numerical standards used in geodesy

The present situation is that different numerical standards are in use within the geodetic community. The values of the Geodetic Reference System 1980 (GRS80, Moritz, 2000) are still used as official ellipsoid parameters, although it represents the scientific status of the 1970s. In the concept of GRS80, the tidal systems and relativistic theories are not considered (Ihde et al., 2017). The numerical standards of the IERS Conventions 2010 (Petit and Luzum, 2010), which are based on the best estimates of Groten (2004), are commonly used for the processing of the geometric observations and for the generation of IERS products. For data and products related to the gravity field and satellite gravity field missions, different standards and conventions are in use, e.g., EIGEN (Förste et al., 2012), GOCE (European GOCE gravity consortium 2012), standards of the Earth Gravitational Model 2008 (EGM2008, Pavlis et al., 2012). Table 1 provides a summary of the numerical standards used within IAG.

Table 1: Comparison of numerical standards used within IAG. (1)TT-compatible value; (2)value given in zero-tide system; (3)TCG-compatible value.

	Semi-major axis **a** [m]	Gravitational constant **GM** [10^{12} m^3 s^{-2}]	Dyn. form factor **J2** [10^{-6}]	Earth's rotation **ω** [rad s^{-1}]	Norm potential $\mathbf{U_0}$ or $\mathbf{W_0}$ [m^2 s^{-2}]
GRS80 (1979)	6 378 137	398.600 5	1 082.63	7.292 115	62 636 860.850
EGM2008	6378 136.3	398.600 4415 (1)	1082.635 9	7.292 115	62 636 856.0
IERS Conv. (2010)	6 378 136.6 (2)	398.600 4418 (3)	1082.635 9	7.292 115	62 636 856.0
IERS Conv. (Update 2017)	6 378 136.6 (2)	398.600 4418 (3)	1082.635 9	7.292 115	62 636 853.4
IAG Resolution No. 1 (2015)					62 636 853.4

The fact that the semi-major axis between GRS80 and IERS Conventions 2010 differs by 0.4m is critical and has to be considered correctly for users of geodetic products. Also the numerical standards of the EGM2008 (Pavlis et al., 2012) are different from the numerical standards given in the IERS Conventions. The current situation concerning numerical standards and the different use of time and tide systems is a potential source for inconsistencies, and even errors, of geodetic products. Thus, it is essential for a correct interpretation and use of geodetic results and products that the underlying numerical standards are clearly documented. Moreover, to combine geodetic results given in different time or tide systems, transformations have to be performed to get consistent results.

In cooperation between the IERS Conventions Centre and the BPS, the conventional value W0 = 62 636 853.4 m2 s-2 for the geoid's geopotential issued in the IAG (2015) Resolution No. 1 (Drewes et al., 2016; Ihde et al., 2017; Sánchez et al., 2016) has recently been updated in Chapter 1 of the IERS Conventions (Stamatakos, 2017). Thus, the former difference between the IERS Conventions 2010 value and the new IAG 2015 value of about -2.6m2 s-2 (equivalent to a level difference of about 27cm) has been resolved recently.

The Joint IAG Working Group "Establishment of the Global Geodetic Reference Frame (GGRF)" (Chair: Urs Marti, Switzerland) supports the UN-GGIM Subcommittee on Geodesy with the definition and establishment of the GGRF. This JWG works on the establishment and coordination of the geometric reference frame, the International Height Reference System (IHRS), the Global Absolute Gravity Reference System and their temporal changes (Marti, 2016). In this context a major focus is on the underlying standards and reference models to achieve consistency (e.g., advance the realisation of a conventional global reference gravity field model, study the influence of earth orientation parameters and tidal models on the realisation of a consistent global reference frame in geometry, height and gravity, study the necessity to replace (update) the global reference system GRS80).

The BPS inventory provides the following recommendations on numerical standards (Angermann et al., 2016), also endorsed as recommendations of the Unified Analysis Workshop 2017 (Gross and Herring, 2017):

- Recommendation 1: The used numerical standards including time and tide systems must be clearly documented for all geodetic products.

- Recommendation 2: The geopotential value W0 = 62 636 853.4m2 s-2 issued by the IAG resolution No.1 (2015) should be used as the conventional reference value for geodetic work.
- Recommendation 3: The development of a new Geodetic Reference System GRS20XX based on best estimates of the major parameters related to a geocentric level ellipsoid is desired.

Standards and conventions used for IAG Service products

As specified in the Road Map for the Global Geodetic Reference Frame (United Nations Document: E/C.20.2016/4/Add.1) and in the IAG position paper for the description of the GGRF (iag.dgfi.tum.de/fileadmin/IAG-docs/GGRF_description_by_the_IAG_V2.pdf), the GGRF includes products providing realisations of the celestial and terrestrial reference frames, gravimetric products and physical height systems. It also includes the IAG component technique observing systems, data centres, analysis centres, and combination and product centres.

The BPS inventory (Angermann et al., 2016) provides in chapter 4 an evaluation of standards and conventions currently adopted and used by IAG and its components for the generation of IAG products. This section summarises the present status concerning IAG standards and conventions, including relevant literature.

IAG products exist for the celestial and terrestrial reference frame as well as for the Earth Orientation Parameters (EOP) which are provided by the responsible products centres of the IERS (www.iers.org). The IERS Conventions (latest version: IERS Conventions 2010; Petit and Luzum, 2010) provide the basis for the work of the geometric services of IAG, the International GNSS Service (IGS; Dow et al., 2009), the International Laser Ranging Service (ILRS; Pearlman et al., 2002), the International VLBI Service (IVS; Schuh and Behrend, 2012) and the International DORIS Service (IDS; Willis et al., 2010), as well as for the definition and realisation of geodetic reference systems and for the generation of IERS products. In addition to the IERS Conventions, several technique-specific standards are defined by the respective services (IGS, ILRS, IVS, and IDS) for the generation and analysis of the GNSS, SLR, VLBI, and DORIS data and technique-specific products (e.g., GNSS satellite orbits).

The International Gravity Field Service (IGFS) is responsible for the coordination of the gravity-related IAG services (BGI, ISG, IGETS, ICGEM, IDEMS) and its overall goal is to coordinate the provision of gravity field related data, software and information for the scientific community (Barzaghi and Vergos, 2016). The IGFS Central Bureau has recently been established at the Aristotle University of Thessaloniki providing an updated IGFS website (www.igfs.topo.auth.gr), including a dedicated products portal for the download of data and products generated by the IGFS services (Vergos et al., 2017). As an example, about 170 models of the global gravity field of the Earth are made available to the public via the ICGEM website (icgem.gfz-potsdam.de; Barthelmes, 2016). A recommendation is that a conventional global gravity field model might be useful as a reference model to be used for the generation of official IAG products, whereas scientific users should be free to use any preferred model for their particular purposes.

Currently, a formal IAG height system product or Height Systems Service does not exist. An important step oriented to the establishment of a worldwide unified (standardised) vertical reference system was the release of the IAG resolution No.1 (2015) for the definition and realisation of an International Height Reference System (IHRS) and the adoption of the conventional value W0 = 62 636 853.4m2 s-2 for the geopotential at the geoid (Drewes et al., 2016; Ihde et al., 2017; Sánchez et al., 2016). A proposal for the IHRF reference network with about 170 stations co-located with geometric techniques, absolute gravity and tide gauges has been prepared by the GGOS Focus Area "Unified Height System and the IAG JWG 0.1.2 "Strategy for the Realization of the IHRS" (Sánchez and Sideris, 2017).

The BPS inventory provides recommendations for future improvements for each product (Angermann et al., 2016). Some general recommendations of the BPS inventory concerning IAG products are provided below:

- Recommendation 1: The processing standards and models should be consistently applied by all the analysis centres of the IAG services as a fundamental basis for the generation of consistent geodetic products such as the GGRF.
- Recommendation 2: The station networks and the spatial distribution of high quality co-location sites should be improved for the integration of the different geometric and gravimetric observation techniques contributing to the GGRF establishment.
- Recommendation 3: It is also recommended that a conventional global gravity field model might be useful as a reference model to be used for the GGRF.

- Recommendation 4: The Resolution No. 3 (2011) of the International Union of Geodesy and Geophysics (IUGG) recommends, that the highest consistency between the ICRF, the ITRF and the EOP as observed and realised by IAG and its components such as the IERS should be a primary goal in all future realisations of the ICRS.

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Fundamental Geodetic Physical Constants

This brief summary on fundamental physical constants is based on Sect. 1.2.3 of the Inventory on Standards and Conventions compiled by the GGOS Bureau of Products and Standards (Angermann et al., 2016). The formulations of the basic theories of physics and their applications are based on fundamental physical constants. A complete list of all fundamental physical constants is given by the National Institute of Standards and Technology (NIST, see https://www.nist.gov). NIST publishes regularly a list of constants, such as the fundamental physical constants internationally recommended by the Committee on Data for Science and Technology (CODATA).

CODATA is an interdisciplinary Scientific Committee of the International Council for Science (ICSU). IUGG and IAU are member unions of CODATA. The Committee works to improve the quality, reliability, management and accessibility of data. CODATA is concerned with all types of data resulting from measurements and calculations in all fields of science and technology, including physical sciences, biology, geology, astronomy, engineering, environmental science, ecology and others. The CODATA Committee (former Task Group) on Fundamental Physical Constants was established in 1969. Its objective is to periodically provide the international scientific and technological communities with an internationally accepted set of values for the fundamental physical constants. The first such CODATA set was published in 1973, and later in 1986, 1998, 2002, 2006 and 2010 (see Mohr et al., 2012). The latest version, the 2014 least-squares adjustment of the values of the

set of fundamental physical constants was released in 2015 (Mohr et al., 2016; see https://www.physics.nist.gov/cuu/Constants).

The fundamental physical constants are classified in universal, electromagnetic, atomic and nuclear, physico-chemical constants as well as adopted values. The set of values provided by CODATA do not aim at covering all scientific fields. Only a few of these fundamental constants are also relevant for geodesy. These are primarily two universal constants and two adopted values:

a) universal constants
    - Newtonian constant of gravitation (G): 6.674,08 ± 0.00031 [10-11m3kg-1s-2]
    - Speed of light in vacuum (c, c0): 299,792,458 [ms-1] (exact)

b) adopted values (as mean values at sea level)
    - Standard acceleration of gravity (gn): 9.806,65 [ms-2] (exact)
    - Standard atmosphere (atm): 101,325 [Pa] (exact)

It is obvious that the astrogeodetic community needs, in addition to these fundamental physical constants, a set of suitable fundamental parameters as a basis for the definition and realisation of reference systems as well as for the generation of geodetic products (e.g., IERS Conventions 2010, Petit and Luzum, 2010).

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Annex B: Education, Training and Capacity Building Recommendations and Actions

f) Development organisations investment in national and regional geodetic capacity building to ensure efficient access to, and utilisation of the GGRF in developing Member States.

Actions / sub actions	Develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN-GGIM Subcommittee on Geodesy, especially from developing or historically under-represented Member States; and by working with the UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) to determine training needs at regional levels. Conduct Reference Frame Competency and Educational Needs Assessments using GGRF-wide and subcommittee-approved metrics. This will assess the geodesy training needs of Member States, as well as capacities of Member States to assist and contribute to capacity building efforts, particularly focusing on providing resources to developing Member States. Establish a priority list of short, mid and longer-term training needs, their objectives, and required resources for fulfilling these needs.
Cross Reference to Measures of success	Develop a series of measurable goals and objectives aligned with steps in implementation; establish a permanent ETCB working group within the Subcommittee on Geodesy to implement and measure progress against the strategy using these metrics: Monitor the effectiveness of workshops and meeting. Identify gaps in technical training and academic programs. Suggest areas for improvement and further ETCB development. Evidence of the benefit of education, training, and capacity building to a Member State's own interests will be provided whenever possible. Firm arguments supporting the otherwise unachievable benefit of international collaboration will support these efforts. Evidence of the alignment of geodetic education, training, and capacity building to United Nations Sustainable Development Goals, as well as the Sendai Framework for Disaster Risk Reduction, will be provided.
Consultations with Member States and others	Complete initial Reference Frame Capacity Questionnaire and collate results. Implement a second Questionnaire tailored to address areas of greatest concern and any ambiguities lingering from the initial questionnaire.

Timing	The short term (by end of 2018) goal for this recommendation is to use questionnaires to determine what investments in capacity building are needed, and where. In the mid-term, after identifying areas of greatest need, work with Questionnaire responders, UN-GGIM SCoG members/participants, and others to advocate these investments to appropriate diplomatic, academic, and governmental authorities. If actions prescribed in answer to this recommendation are successful, in five years from now there will be: a higher level of geodetic technical capability, particularly among developing nations; and a developed capacity building program that focuses at the regional level and emphasises supporting efforts in developing nations.
Reliance on Governance theme	Linkages to, and reliance upon, the Governance component of SCoG work include the following: Seek assistance from SCoG Trust Fund to facilitate receipt of financial contributions/investments in the GGRF from Member States, Observers, and other stakeholder entities. Geodesy Convention for influence and accountability for those Member States and other entities making commitments to the GGRF, and to raise the awareness and profile of geospatial data in general.
Cross Reference / dependency on other themes	Collaborations with the SCoG focus groups on communications (for information and advocacy assistance) and infrastructure will be encouraged to ensure optimal mutual support and avoid redundancies.
Regional distinctions	This effort seeks to develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN-GGIM Subcommittee on Geodesy, especially from developing or historically under-represented member states. The UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) will also be regularly informed about SCoG efforts and consulted to determine training needs at regional levels. Due to the key role that both written and spoken language plays in all manners of education, training, and capacity building, it will be essential that all resources are able to be translated either professionally by UN and official translators, by volunteer translators into non-UN languages, or by machine if no human translation is readily available.

Sensitivities	The SCoG will conduct due diligence, with the assistance of UN-GGIM regional groups, to ensure that all coordination and development efforts are conducted in a way that is respectful to local and regional cultures, and in supportive collaboration with existing entities seeking to promote geodetic capacity building and education.

g) Member States, in cooperation with the IAG, FIG and other appropriate organisations, establish a global geodetic technical assistance program.

Actions / sub action	Prepare and implement an annual openly available, SCoG-endorsed, training program that includes workshops and the provision of technical material. Compile and promote this training program with upcoming training opportunities, spanning from one-day courses to university certification or diploma programs. Align this program to a centralised list of relevant technical workshops and training activities, along with any available funding, research stipends, sponsored secondments, or other means of supporting participants from developing member states. Develop a standing scientific organising committee to ensure content of these workshops is relevant, optimised, and delivered by the appropriate geodetic community members. This committee should also establish training agreements with key stakeholders. Ensure training material from workshops is made readily and openly available to the wider geodesy community. Since the official working language of the SCoG is English, materials will first be available in English, then the other UN languages, and in additional languages, if translation services are available. Implement a policy of open-availability for all materials and recordings from training programs/classes endorsed by the UN-GGIM Subcommittee on Geodesy. **NGO Collaboration:** Work with the International Association of Geodesy (IAG) and International Federation of Surveyors (FIG) and other relevant organisations, such as the Group on Earth Observations (GEO) to establish and run technical workshops in, and with a focus on, developing Member States.
Cross Reference to Measures of success	Both formal academic geodetic program enhancement/development, and other vocational skill development and technology transfer (sharing) shall enhance geodesy capability across member states. Capacity building workshops, online certification course series, and other education and/or training sessions shall be coordinated regionally and supported through cooperation with regionally and globally accredited organisations and academic institutions. These capacity-building events should be held in conjunction with IAG, GGOS, IAG services, FIG workshops and conferences; as in-conference splinter sessions or pre/post conference full-day or multi-day intensive courses. Material will be made available via universities participating in massive open online courses (MOOC). Evidence of the alignment of geodetic education, training, and capacity building to United Nations Sustainable Development Goals, as well as the Sendai Framework for Disaster Risk Reduction, will be provided.

Consultations	Complete initial Reference Frame Capacity Questionnaire and collate results Implement a second Questionnaire tailored to address areas of greatest concern and any ambiguities lingering from the initial questionnaire.
Timing	Timing for this recommendation's actions is mid-to long term, as this is a secondary action after identifying gaps/needs Five years from now there should be recognised certification and achievement documentation programs, supported by regular technical training courses and material that is openly available to all nations.
Reliance on Governance theme	Funding from SCoG Trust Fund for technical assistance efforts. A formal UN Geodesy Convention for influence and accountability of those wishing to, or already committed to, participating with the guidance and assurances of established UN protocols.
Cross Reference / dependency on other themes	
Regional distinctions	This effort seeks to develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN Subcommittee on Geodesy, especially from developing or historically under-represented member states. The UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) will also be regularly informed about SCoG efforts and consulted to determine training needs at regional levels. Due to the key role that both written and spoken language plays in all manners of education, training, and capacity building, it will be essential that all resources are able to be translated either professionally by UN and official translators, by volunteer translators into non-UN languages, or by machine if no human translation is readily available.
Sensitivities	The SCoG will conduct due diligence, with the assistance of UN-GGIM regional groups, to ensure that all coordination and development efforts are conducted in a way that is respectful to local and regional cultures, and in supportive collaboration with existing entities seeking to promote geodetic capacity building and education.

h) 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.

Actions / sub action	Prepare and implement an annual openly available training program that includes workshops and the provision of technical material: • Compile and promote an annual training program with upcoming training opportunities, spanning from one-day courses to university certification or diploma programs. • Ensure training material from workshops is made readily and openly available to the wider geodesy community. • Implement a policy of open-availability for all materials and recordings from training programs/classes endorsed by the (future) UN GGIM Subcommittee on Geodesy.
Cross Reference to Measures of success	The capacity building needs of individual member states shall be assessed against a standardised set of GGRF implementation criteria, as agreed by the Subcommittee on Geodesy as a whole. Both formal academic geodetic program enhancement/development, as well as other vocational skill development and technology transfer (sharing) shall enhance geodesy capability across member states. Evidence of the alignment of geodetic education, training, and capacity building to United Nations Sustainable Development Goals, as well as the Sendai Framework for Disaster Risk Reduction, will be provided.
Consultations	Complete initial Reference Frame Capacity Questionnaire and collate results. Implement a second Questionnaire tailored to address areas of greatest concern or ambiguities.
Timing	Five years from now there will be a higher level of geodetic technical capability, particularly among developing nations. A developed capacity building program that focuses at the regional level and emphasises supporting efforts in developing nations.
Reliance on Governance theme	Funding from SCoG Trust Fund for drafting, translating, and dissemination of training materials, including video, interactive, and in print. Geodesy Convention as an instrument of influence for those wishing their high-capacity Member State to participate in assisting Member States with less capacity.
Cross Reference / dependency on other themes	

Regional distinctions	This effort seeks to develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN Subcommittee on Geodesy, especially from developing or historically under-represented member states. The UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) will also be regularly informed about SCoG efforts and consulted to determine training needs at regional levels. Due to the key role that both written and spoken language plays in all manners of education, training, and capacity building, it will be essential that all resources are able to be translated either professionally by UN and official translators, by volunteer translators into non-UN languages, or by machine if no human translation is readily available.
Sensitivities	The SCoG will conduct due diligence, with the assistance of UN-GGIM regional groups, to ensure that all coordination and development efforts are conducted in a way that is respectful to local and regional cultures, and in supportive collaboration with existing entities seeking to promote geodetic capacity building and education.

i) 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.

Actions / sub action	Provide a mechanism to develop and disseminate technical material by implementing an ETCB web page as a sub-page of the GGIM Subcommittee on Geodesy. Work with the GGRF WG Outreach and Communications Focus Group to ensure optimal development and delivery of educational and advocacy materials, and to ensure that the web site is regularly updated with information on workshops, and provides ready access to openly available training materials. **University, Research Institute, and other Academic Collaboration**: Work with geodesy technical and research institutes to develop and enhance geodesy training. Establish minimum training needs for a set of standardised tasks, spanning infrastructure, academic, and long-term sustainability. Established training resources and centres of expertise to support standardised task training and access to advanced education resources.
Cross Reference to Measures of success	The capacity building needs of individual member states shall be assessed against a standardised set of GGRF implementation criteria, as agreed upon by the Subcommittee on Geodesy as a whole. Both formal academic geodetic program enhancement/development, as well as other vocational skill development and technology transfer (sharing) shall enhance geodesy capability across member states. Capacity building workshops, online certification course series, and other education and/or training sessions shall be coordinated regionally and supported through cooperation with regionally and globally accredited organisations and academic institutions. These events may be held in conjunction with IAG, GGOS, IAG Service, FIG workshops and conferences; as in-conference splinter sessions or pre/post conference full-day or multi-day intensive courses. Global access may also be made available via universities participating in massive open online courses (MOOC). Evidence of the alignment of geodetic education, training, and capacity building to United Nations Sustainable Development Goals, as well as the Sendai Framework for Disaster Risk Reduction, will be provided.
Consultations	Complete initial Reference Frame Capacity Questionnaire and collate results. Implement a second Questionnaire tailored to address areas of greatest concern or ambiguities.

Timing	Five years from now there will be a higher level of geodetic technical capability, particularly among developing nations.
Reliance on Governance theme	Funding from SCoG Trust Fund for curriculum development and advocacy as well as funding workshops, scholarships/stipends for students and higher-education teachers. A Geodesy Convention to underpin and support the argument for geodetic-focused programs of study.
Cross Reference / dependency on other themes	Outreach and Communications Focus Group.
Regional distinctions	This effort seeks to develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN Subcommittee on Geodesy, especially from developing or historically under-represented member states. The UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) will also be regularly informed about SCoG efforts and consulted to determine training needs at regional levels. Due to the key role that both written and spoken language plays in all manners of education, training, and capacity building, it will be essential that all resources are able to be translated either professionally by UN and official translators, by volunteer translators into non-UN languages, or by machine if no human translation is readily available.
Sensitivities	The SCoG will conduct due diligence, with the assistance of UN-GGIM regional groups, to ensure that all coordination and development efforts are conducted in a way that is respectful to local and regional cultures, and in supportive collaboration with existing entities seeking to promote geodetic capacity building and education.

j) Member States openly share all geodetic skills.

Actions / sub action	Encourage stakeholder and member state participation in capacity building by promoting the capacity building program through geodesy conferences and meetings, and the UN-GGIM web site, and incentivising (using non-monetary means) stakeholder participation and sponsorship. **Geodetic Organisational Support, and Advocacy**: Maintain close contact with national and international agencies and organisations, including IAG, IAG services (such as the International GNSS Service), and FIG, who may provide funding, advocacy, or other technical support for training and capacity building. Work with stakeholders to ensure cooperation and benefits for the ETCB strategy. Establish centres of training expertise and capability, work with established educational institutions to establish training courses and workshops. Work with national agencies as well as international organisations to develop internationally-recognised certification programs for those completing key levels of education or training.
Cross Reference to Measures of success	Evidence of the benefit of education, training, and capacity building to a member state's own interests will be provided whenever possible. Firm arguments supporting the otherwise unachievable benefit of international collaboration will support these efforts. Both formal academic geodetic program enhancement/development, as well as other vocational skill development and technology transfer (sharing) shall enhance geodesy capability across member states. Capacity building workshops, online certification course series, and other education and/or training sessions shall be coordinated regionally and supported through cooperation with regionally and globally accredited organisations and academic institutions. Evidence of the alignment of geodetic education, training, and capacity building to United Nations Sustainable Development Goals, as well as the Sendai Framework for Disaster Risk Reduction, will be provided.
Consultations	Complete initial Reference Frame Capacity Questionnaire and collate results. Implement a second Questionnaire tailored to address areas of greatest concern or ambiguities.

Timing	Five years from now there should be: A higher level of geodetic technical capability, particularly among developing nations. A developed capacity building program that focuses at the regional level and emphasises supporting efforts in developing nations. Recognised certification and achievement documentation programs, supported by regular technical training courses and material that is openly available to all nations.
Reliance on Governance theme	A Geodesy Convention for influencing Member States to openly share their geodetic skills, training methods, and other educational resources.
Cross Reference / dependency on other themes	Communications (for developing skill-sharing materials, and writing advocacy newsletters/website/social media).
Regional distinctions	This effort seeks to develop a capacity building program that ensures balanced regional representation by encouraging regional participation on the UN Subcommittee on Geodesy, especially from developing or historically under-represented member states. The UN-GGIM regional groups (UN-GGIM Americas, Europe, Asia-Pacific, Arab States, and Africa) will also be regularly informed about SCoG efforts and consulted to determine training needs at regional levels. Due to the key role that both written and spoken language plays in all manners of education, training, and capacity building, it will be essential that all resources are able to be translated either professionally by UN and official translators, by volunteer translators into non-UN languages, or by machine if no human translation is readily available.
Sensitivities	The SCoG will conduct due diligence, with the assistance of UN-GGIM regional groups, to ensure that all coordination and development efforts are conducted in a way that is respectful to local and regional cultures, and in supportive collaboration with existing entities seeking to promote geodetic capacity building and education.