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Global geodetic reference frame

Global geodetic reference frame

Note by the Secretariat

Summary

The present paper contains the report prepared by the Subcommittee on Geodesy on the global geodetic reference frame for consideration by the Committee of Experts on Global Geospatial Information Management.

At its tenth session, held virtually on 26 and 27 August and 4 September 2020, the Committee of Experts adopted decision 10/104, in which it welcomed the significant progress made by the Subcommittee during the intersessional period, as reflected in the comprehensive review of activities and updates from its working groups. The Committee commended the efforts of the Subcommittee in the preparation of the draft position paper on sustaining the global geodetic reference frame and the draft concept paper on establishing a global geodetic centre of excellence. The Committee also welcomed and supported the offer by Germany to establish and host a centre of excellence at the United Nations campus in Bonn, as the first centre of an envisioned federated approach to enhance global cooperation and coordination among Member States and relevant geodetic stakeholders. The Committee also noted that the centre of excellence would be of vital importance in helping to ensure the development and sustainability of the global geodetic reference frame, welcomed the offers of support from Member States, and recognized the essential role of the geodetic services provided by the International Association of Geodesy, the International Federation of Surveyors, the Committee's regional committees and other key geodetic stakeholders.

In this present report, the Subcommittee provides information on its activities, including its efforts to continue to implement General Assembly resolution 69/266, on a global geodetic reference frame for sustainable development, and to establish a global geodetic centre of excellence. It also discusses its progress towards the long-term sustainability and quality of the global geodetic reference frame in the following five focus areas: governance, including collaboration and coordination; policies and standards; geodetic infrastructure; education training and capacity development; and outreach and communication. In addition, the Subcommittee provides an update on its efforts to raise awareness of the importance of sustaining the global geodetic reference frame, including the need to address the imbalance in the distribution of geodetic infrastructure globally, in particular in developing countries. It also indicates that it hosted a global geodesy forum to celebrate Earth Day, on 22 April 2021, and highlights the crucial role of geodesy in the well-being of society, the environment and the economy. It states that participants at the forum addressed the fact that geodesy, like electricity, is so fundamental to everyone's lives that it is often ignored and underappreciated, which results in its also being underresourced. The Subcommittee explains that the global geodesy forum was followed by a regional geodesy forum at which participants stressed the need to work together to sustain the geodesy value chain, which is at considerable risk of degradation.

* E/C.20/2021/1

I. Introduction

1. Positioning, navigation and geospatial data are part of everyday life. In addition to the traditional survey, mapping and navigation fields, location-based positioning applications are increasingly critical for civil engineering, industrial automation, agriculture, construction, mining, recreation, financial transactions, intelligent transport systems, disaster response and emergency management, environmental studies and scientific research.

2. The Global Geodetic Reference Frame (GGRF) enables accurate and robust alignment of spatial datasets – a key requirement for sustainable development in fields such as land use planning and administration, construction and hazard assessment. The GGRF is also an essential foundation for national height systems, which enable sustainable water management and monitoring of climate change and its impacts, such as sea-level rise, droughts, glacial retreat and ice-sheet melting. The coordinates used in these applications are ideally referred to a mathematically well-defined geodetic reference frame.

3. The GGRF is an authoritative, reliable, highly accurate, and global, spatial referencing infrastructure. The GGRF includes the celestial and terrestrial reference frame products, the infrastructure used to create it, and the data, analysis and product generation systems. The GGRF also includes gravimetric observations, products and height systems, which underpin measurements of elevation.

4. The GGRF is fundamental to supporting the collection, integration and utilization of all other geospatial data. It is relied upon for social, environmental and economic initiatives, Earth science, the measuring and monitoring of progress of the 2030 Agenda for Sustainable Development, the Paris Agreement, the Sendai Framework for Disaster Risk Reduction, the Small Island Developing States Accelerated Modalities of Action (SAMOA) Pathway, and other global, regional and national development agenda and initiatives.

5. As the foundation for accurate and reliable geospatial data collection and integration for decision making, the GGRF has a significant impact on many activities within the scope of work of the Committee of Experts. The GGRF is one of 14 Global Fundamental Geospatial Data Themes and underpins the quality and usefulness of the other 13. The GGRF is not a data theme per se, but instead is a prerequisite for the accurate collection, integration and use of all other geospatial data. Analysis of the Global Indicator Framework for SDGs with a "geographic-location" lens showed that the geospatial information has a direct or significant contribution to SDGs Indicators.

6. Recognizing the growing demand for an accurate and stable GGRF and the importance of international cooperation, the UN General Assembly adopted Resolution 69/266 in February 2015, entitled 'A Global Geodetic Reference Frame for Sustainable Development'1. Resolution 69/266 reflects that the GGRF is the foundation required for the collection, integration, and utilisation of all geospatial information. Furthermore, it supports precise positioning from Global Navigation Satellite Systems (GNSS), which is becoming an important tool for informed decision making, supporting the three pillars of sustainable development – the economy, society, and environment.

7. In August 2016, the Committee of Experts adopted decision 6/102, which noted the need for an appropriate governance structure to effectively implement the road map for the Global Geodetic Reference Frame. At its seventh session in 2017, UN-GGIM adopted decision 7/103, in which it endorsed the formal establishment and composition of the Subcommittee on Geodesy (the Subcommittee), agreed with proposed terms of reference, and also expressed support for the development of appropriate governance arrangements for the GGRF. At its

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

eighth session in 2018, UN-GGIM noted the Subcommittee's initial work towards improving the sustainability and enhancing the quality of the GGRF.

8. At the ninth session of the Committee of Experts, held in New York from 7 to 9 August 2019, the Subcommittee provided a background document on the governance arrangements required to help sustain the GGRF2. In adopting decision 9/104, the Committee of Experts requested that the Subcommittee explore a number of modalities to balance the longer-term vision, stability and operational requirements of the GGRF, including the establishment of a global geodetic centre of excellence in cooperation with the Committee. The Committee requested the Subcommittee to continue to ensure broad consultation on the progression and modalities of the position paper on governance, to establish global cooperation and to acquire a better understanding of how the practical and operational requirements of the GGRF could be implemented.

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

10. At the tenth session of the Committee of Experts, held virtually on 26 and 27 August and 4 September 2020, the Subcommittee provided two strategic papers as background documents to its report; a draft Position Paper on Sustaining the Global Geospatial Reference Frame[3] and a draft Concept Paper on Establishing a Global Geodetic Centre of Excellence[4]. The draft Position Paper provides a strategy and action plan to help achieve the long-term sustainability, accessibility and quality of the GGRF by delivering improvement in five focus areas: Governance; Geodetic Infrastructure; Policies, Standards and Conventions; Education, Training and Capacity Building; and Communication and Outreach. The draft Concept Paper includes a strategic plan providing a broad direction for the Centre and addresses many of the critical gaps in capacity and capability across the five focus areas described in the draft Position Paper.

11. In adopting decision 10/104 at its tenth session, the Committee of Experts commended the efforts of the Subcommittee for the preparation of the draft Position Paper and draft Concept Paper. Further, the Committee welcomed and supported the offer from the Federal Republic of Germany to establish and host a global geodetic centre of excellence at the United Nations campus in Bonn, Germany, as the first Centre of an envisioned federated approach to enhance global cooperation and coordination across Member States and relevant geodetic stakeholders.

12. In this report, the Subcommittee informs the Committee of Experts of the broad consultation process on the draft Position Paper and draft Concept Paper, and now provides the final draft Position Paper on Sustaining the Global Geodetic Reference Frame and the final draft Concept Paper on Establishing a Global Geodetic Centre of Excellence as background documents to this present report for consideration and adoption by the Committee of Experts.

13. This present report also provides information and updates to the Committee of Experts on the Subcommittee's activities, efforts and progress during this intersessional period, and of its planned next steps. In addition, this report gives a status on the establishment of the geodetic centre of excellence in Bonn.

2 GGRF_Position_Paper2019_24July_web.pdf (un.org)
3 DRAFT-Position-Paper-on-Sustaining-the-GGRF-20200806.pdf (un.org)
4 DRAFT-Concept-Paper-on-GGCE-20200806.pdf (un.org)

14. The Committee of Experts is invited to take note of the report and to express its views on the activities and next steps of the Subcommittee and way forward. Points for discussion and decision are provided in paragraph 73.

II. Activities during the intersessional period

15. This section provides a summary of the work conducted by the Subcommittee's five working groups: Governance; Geodetic Infrastructure; Policies Standards and Conventions; Education Training and Capacity Building, and Communication and Outreach during the intersessional period.

16. The Subcommittee on Geodesy has not convened a formal (in-person) plenary meeting since November 2018. During this intersessional period, the Subcommittee held two online meetings, on 8 December 2020, and 1 July 2021 to cover the most pressing issues with support provided by the UN-GGIM Secretariat. Additionally, the bureau of the Subcommittee met online on five occasions - 17 November 2020, 28 January 2021, 25 February 2021, 25 March 2021 and 27 May 2021.

17. In March 2021, His Excellency Ambassador Peter Thomson accepted the invitation to become the Subcommittee on Geodesy's Global Geodesy Ambassador. It was through his leadership and personal ownership as Fiji's permanent representative to the United Nations which saw the realisation and adoption of the United Nations General Assembly resolution 69/266, entitled 'A global geodetic reference frame for sustainable development'. His acceptance of this role will have global impact for our technical and scientific community and for the development of a more sustainable global geodetic reference frame.

18. In March 2021 the co-Chair of the Subcommittee, from the Russian Federation, expressed his intention to step down from his leadership role, effective from 12 April 2021, due to national commitments and structural changes within his national organization. The Subcommittee expressed its appreciation to the outgoing co-Chair for his valuable leadership and contributions over the past several years. This has resulted in the Subcommittee having only one co-Chair, from Australia, at this time.

Governance.

19. During the intersessional period, the working group on Governance has been engaged in the consultation of the draft Position Paper and the draft Concept Paper. The working group members have worked with the UN-GGIM regional committees to promote the understanding by Member States and relevant geodetic stakeholders of the complex issues facing the global geodetic community and to ensure alignment with the practical and operational proposed by the Subcommittee.

20. The working group, cognizant of its impending and changing role, has commenced internal discussions regarding the future modalities of GGRF governance vis-à-vis the work packages of the Position Paper and an operational GGCE. The Working Group was requested to consider aspects of governance relevant for strengthening national geodetic arrangements and activities, and for bilateral activities that may involve technical and financial assistance to strengthen existing geodetic infrastructures. The working group could develop short, medium, and long-term goals and actions to enhance regional and global cooperation and communication across all the five work packages.

Geodetic Infrastructure

21. The GGRF Roadmap[5] defines the geodetic infrastructure to include Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Global Navigation Satellite Systems (GNSS), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), gravimetric, and other geodetic instrumentation which underpin the GGRF. It includes sea-level tide gauges and dense networks of GNSS stations that support positioning services. It also includes the systems and human resources required to undertake geodetic analysis and the provision of services.

22. During the intersessional period, the Geodetic Infrastructure working group concentrated its activities on consulting with the Executive Committee members and the 12 Services of the International Association of Geodesy (IAG), on the draft Position Paper and draft Concept Paper. Several responses were received and forwarded to the Subcommittee Bureau and writing team with the aim that the IAG feedback will be taken into account in the revised versions of the two papers.

23. At a number of IAG events, such as the European Regional Reference Frame (EUREF) Symposium and the IAG Scientific Assembly 2021 held virtually in Beijing, China, the Chair of the Geodetic Infrastructure working group, who is also the current IAG President, underlined the importance of UN-GGIM activities, and in particular the work of the Subcommittee on Geodesy, emphasising that the maintaining the GGRF is a unique opportunity to sustain IAG science, via sustaining the geodetic infrastructure that is the basis of all what we do in geodetic science. IAG members and components were invited to further support the Subcommittee activities as well as the establishment of the Global Geodetic Centre of Excellence in Bonn, Germany.

24. The working group has also contributed to the Global Geodesy Forum held on Earth Day, April 22, 2021, as well as to the European regional forum, held on June 23rd, entitled: 'Towards a Sustainable Global Geodetic Reference Frame: European Contribution'.

Policies, Standards and Conventions

25. The working group on Policies, Standards and Conventions has the objective to encourage Member States to continue to make their data Findable, Accessible, Interoperable and Reusable (FAIR). Over the intersessional period, working group members have been actively involved with international standards related activities that aim to make data access easier, more useful, more accurate and more efficient for users. This includes work within organizations such as: the Bureau of Products and Standards of the IAG's Global Geodetic Observing System (GGOS), the International Standards Organization (ISO) Technical Committee 211, and the Open Geospatial Consortium (OGC).

26. Notable activities from working group members include:

(a) Further development of the ISO Geodetic Registry (ISOGR), an online database of reference frames and transformations which is used to uniquely identify reference systems and transformations. As opposed to other geodetic registries, the ISO Geodetic Register is the only authoritative source for reference frames and transformations where data is entered and/or validated by the agencies that define and maintain the frames and transformations. During the past year, fifteen new coordinate reference systems and their associated transformations have been added to the ISOGR and another nine are currently in the progress. In addition, much work has been done to review and update existing information in the Registry. Work has

5 http://ggim.un.org/meetings/GGIM-committee/documents/GGIM6/E-C20-2016-4%20Global%20Geodetic%20Reference%20Frame%20Report.pdf, Annex 1, Glossary of Terms

also commenced on migrating the existing ISOGR to a new, more modern platform, updated to the latest versions of ISO standards and enabling more reliable and efficient operation in a cloud environment. ISO, OGC and the International Association of Oil and Gas Producers (IOGP), owners of the European Petroleum Survey Group Geodesy (EPSG) registry, are collaborating on the preparation of a guide on geodetic registries that clarifies the roles of the different registries currently available. ISO and IOGP have also been collaborating on ways of more efficiently linking the content of both the ISOGR and EPSG registries. The ISOGR can be found at https://geodetic.isotc211.org.

(b) Members of working group are involved in leading a global initiative to identify and meet user requirements for FAIR geodetic data. This initiative is paying particular attention to ensuring the new and emerging user base of positioning information (e.g. location based services and intelligent transport services) have FAIR geodetic data. Some of the major research projects and work packages are:

i) Identify and address critical gaps in international standards identified in which could inhibit the uptake of precise positioning products.

ii) Through a process of user consultation and engagement we will provide users with fit-for-purpose metadata profiles which meet their current and future requirements.

iii) Generate an awareness and interest amongst the international positioning community on the use of modern and well supported protocols, such as Message Queuing Telemetry Transport (MQTT), for the dissemination of real-time GNSS data and correction streams.

iv) Demonstrate the feasibility of using protocols, such as MQTT, the dissemination of real-time GNSS data and product streams.

(c) Further revision and refinement of the Geodesy Markup Language (GeodesyML) to ensure the provided precise positioning data is FAIR.

(d) Initial discussions with the Open Geospatial Consortium (OCG) on collaboration on an Innovation Program.

(e) A new OGC Domain Working Group on a Gridded Geodetic data eXchange Format (GGXF) has been created to develop a common, standardized format for grids of different types of geodetic data. This includes grids for geoids, transformations, velocity models and general deformation models. Such a standardized grid format will enable GIS developers to implement such grids in an easier and more timely manner and, thus, greatly facilitate interoperability of geodetic products. Significant progress has been made in the past year and an initial draft of the standard is nearly complete. More information about the GGXF working group can be found at https://github.com/opengeospatial/CRS-Gridded-Geodetic-data-eXchange-Format.

(f) Another new OGC Domain Working Group on a Deformation Model Functional Model (DFM) has been created in a joint effort with the International Associate of Geodesy Working Group 1.3.1 on Time-Dependent Transformations Between Reference Frames in Deforming Regions. The aim of this joint working group is to develop a standardized way of representing the many different kinds of deformation models used in geodesy. This working group is closely linked with the GGXF working group, where the GGXF grid format is expected to be the primary method of delivering deformation models. In the last year, much work has been done on identifying the different kinds of deformation models and their time functions, and an initial draft is nearly complete. More information about the DFM working group, can be found at https://github.com/opengeospatial/CRS-Deformation-Models.

27. Based on discussions in international forums, the working group have found that data sharing is inconsistent or absent across UN-GGIM regions. The barriers to data sharing include: legislative limitations; institutional and conflicting commercial concerns; lack of financial and technical resources; lack of regional collaboration and initiatives (often due to geographic isolation or cultural behaviour); sparseness of geodetic infrastructure and lack of data; and security concerns. The working group will continue to encourage Member States to more openly share their geodetic data by contributing to existing international data portals or provide access to their own portal, use international metadata standards and metadata catalogues for their own portals, and continue to assist in data sharing workshops.

Education, Training and Capacity Building

28. The final outcomes of a worldwide geodetic educational needs assessment to establish a priority list of short and long-term training needs, developed and launched in 2018, have been documented and published by the International Federation of Surveyors (FIG) as a FIG Article of the Month in January 2021. The outcomes of this analysis determined that strong institutional support from national geodetic organizations and international professional organizations, such as the International Association of Geodesy (IAG) and International Federation of Surveyors (FIG), as well as structure mechanisms for resourcing, will be required to realize the GGRF.

29. Based on the needs assessment from the questionnaire, the Education, Training and Capacity Building working group has continued to actively engage with international technical bodies and representatives of small island developing states to support the modernisation of geodetic infrastructure and systems through capacity building and skills development workshops. Essential to these engagements is the integration of geodetic capacity building within the broader scope of geospatial information management to contribute to the Sustainable Development Goals (SDGs) and Sendai Framework for Disaster Risk Reduction (Sendai Framework) within the standardized vocabulary and templates of the Integrated Geospatial Information Framework (IGIF).

30. Building upon the valuable information collected in the 2018 assessment, the working group has prepared and launched a follow-on Global Survey on Geodetic Reference Frame Competency. The results from this follow-on global survey will allow the Subcommittee to better understand and raise awareness on gaps and future investment needs in geodetic education, training, and capacity development to sustain national, regional, and global geodetic reference frame for sustainable development.

31. The working group actively organised and participated in the Global Geodesy Forum on 22 April 2021, as well as the regional geodesy forums. Geodetic capacity and capability are crucial to ensure a sustainable geodetic reference frame and therefore these questions are in the core of the communication to the participants of these forums. It can be noted that members of the working group organised, moderated, and presented at the Geodesy Forum for UN-GGIM: Americas held on 14 May, as well as at the Asia and the Pacific Regional Geodesy Forum held on 8 June 2021. Members of the working group also organised and presented at the European Geodesy Forum held on 23 June.

32. Since the tenth session of the Committee of Experts, the working group has contributed widely, and often remotely via videoconference, to numerous geodetic workshops, seminars, plenaries, and conferences, especially in the Asia-Pacific and Americas regions, all of which has significantly improved the geodetic stakeholder community's awareness and perception of the Committee of Experts in these regions.

33. The working group continues to emphasize the need for regionally focused strategies, as the nature and variety of challenges differ regionally and may include linguistic, technological, economic, and cultural impediments. Additional findings from the educational needs assessment indicated that access to highly skilled personnel varies widely among Member

States, thus requiring the need to ensure that knowledge and competence are shared in findable, accessible, interoperable, and reusable formats (FAIR). A key to optimizing the efficiency of the group's objectives is to identify and make existing educational and capacity building resources easily discoverable, while identifying gaps in capacity and proposing short and long-term solutions to bridge these deficiencies. The working group plans to collaborate with FIG, the IAG and its technical services, as well with stakeholder international organizations such as the UN International Committee on Global Navigation Satellite Systems (ICG), the Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS), to build a focal point for enabling information discovery and distribution around the world.

34. The working group noted with interest the diverse potential uses of the IGIF, especially the communications and capacity development benefits illustrated in its Strategic Pathways. The working group has proposed three guiding principles to support the IGIF: i) a strategic regional focus, utilizing the IGIF to bridge gaps and sensitivities in language and culture; ii) ensure that knowledge and skills are discoverable and openly shared by aligning resources to a common vocabulary and comprehensive organizational templates; and iii) utilizing the IGIF to facilitate collaboration with geodetic support and advocacy organizations. Members of the working group have published a paper titled 'A Geodesy and Positioning Thematic Layer - Identifying tools to connect the GGRF and the United Nations GGIM Integrated Geospatial Information Framework (IGIF)' which can be seen as an input and discussion paper on the need to develop a geodesy and positioning thematic layer. Members of the working group presented a summary of its recommendations at the 2021 FIG Working Week and 2021 IAG Scientific Assembly.

35. The working group plans to organize its future work in a strategic implementation plan to align with the goals in the Position Paper on Sustaining the GGRF, and supporting subsequent plans developed by the Subcommittee on Geodesy to help achieve sufficient geodetic capacity development to ensure the long-term sustainability and quality of the GGRF. This ETCB Strategic Implementation Plan will advocate, utilize, and support the recommendations, templates, and vocabulary of the IGIF whenever possible. The working group notes the value of diverse perspectives in its work and encourages members of the Subcommittee to contribute to its work.

Communications and Outreach

36. During the intersessional period, the Communications and Outreach working group continued to provide communication services to the Subcommittee on Geodesy. The working group has worked on materials to communicate the work of the Subcommittee, through social media6, established a LinkedIn profile7 for the Subcommittee and upgraded unggrf.org to a new platform.

37. The working group also provided strategic communications related to the messaging of the Global Geodesy Forum; developed a social media plan and provided publicity for the global geodesy forum and the regional geodesy forums through the Subcommittee's media channels8 in collaboration with the UN-GGIM secretariat and UN-GGIM regions, as well as using the working group member's own channels, such as the IAG Newsletter9.

38. The working group's development of the new UN-GGRF platform[10] has resulted in a full articles collection, search function, responsive design and makes it overall easier to

6 UNGGRF (@UNGGRF) / Twitter
7 (2) UN-GGIM Subcommittee on Geodesy: Oversikt | LinkedIn
8 UN-GGIM Global Geodesy Forum on Earth Day - Sustaining the Global Geodetic Reference Frame — Sustaining the Global Geodetic Reference Frame (unggrf.org)
9 Microsoft Word - IAG_Newsletter_March_2021.doc (iag-aig.org)
10 https://www.unggrf.org/

communicate upcoming news from the Subcommittee. The mission of unggrf.org is to be the news platform and landing page for the Subcommittee and to complement the Subcommittee's UN-GGIM web page[11].

39. The working group notes that communication must be integrated in all GGRF work to succeed in sustaining the global geodetic reference frame.

III. Broad global consultation on the Position Paper on Sustaining the Global Geodetic Reference Frame and Concept Paper on Establishing a Global Geodetic Centre of Excellence

40. The Committee of Experts, at its tenth session in August 2020, in adopting decision 10/104, welcomed the broad consultation during the intersessional period on the Position Paper on Sustaining the Global Geodetic Reference Frame (Position Paper) and Concept Paper on Establishing a Global Geodetic Centre of Excellence (Concept Paper). The aim of the consultation process was to promote the understanding by Member States and relevant geodetic stakeholders of the complex issues facing the global geodetic community, and to ensure alignment with the practical and operational requirements proposed by the Subcommittee as positive steps towards the realization of the centre of excellence.

41. The global consultation process commenced on 9 October 2020 and concluded on 24 June 2021. At the close of the global consultation process, 19 responses were received in writing: 13 from Member States and six from relevant stakeholders including the services of the International Association of Geodesy. Numerous other responses were also received verbally in the regional geodesy forums (see paragraphs 46-50).

42. As part of the global consultation effort, on Earth Day, April 22, 2021, the Subcommittee hosted a Global Geodesy Forum titled 'The Power of Where: The Value of Geodesy to Society'. The virtual Forum was open to all to attend and focused on the significance of geodesy for the wellbeing and betterment of society, environment and economy. The expert panel of speakers highlighted to policy and decision makers, chief executives, director-generals and senior executives from Member States and relevant stakeholders the benefits enabled by an accurate and reliable GGRF. They discussed how the GGRF helps to provide safer and more resilient communities and myriad societal benefits. Furthermore, the speakers demonstrated the significant economic value of investment in geodesy and the role geodesy plays in assisting developing countries with efficient and effective land and environmental management.

43. The United Nations Secretary-General's Special Envoy for the Ocean, His Excellency Ambassador Peter Thomson, provided a stimulating opening address for the Forum as the Subcommittee's Global Geodesy Ambassador.

44. Following the Global Geodesy Forum, regional consultation followed through regional geodesy forums in the Americas, Asia and the Pacific, Arab States and European regions during May and June 2021. These regional geodesy forums were jointly organized by the Subcommittee, UN-GGIM Regional Committees, and the secretariats of the UN-GGIM Regional Committees. They were open to Member States and relevant stakeholders, and encouraged discussion on the needs, and priorities, of the regions. A significant amount of verbal feedback on both the Position Paper and Concept Paper was provided during these regional meetings and was ultimately used to improve the two papers.

45. The UN-GGIM: Americas forum was convened on 14 May 2021 with more than 120 participants. The event was entitled 'Geodesy Forum for UN-GGIM Americas – Geodesy for

[11] http://ggim.un.org/UNGGIM-wg1/

Sustainable Americas'[12]. Five country cases (Chile, Costa Rica, Dominican Republic, Panamá, and United States of America) were presented by their respective representatives and illustrated the support to the documents in consultation and the expectations about the Centre. The event was organized by the executive secretary of UN-GGIM: Americas.

46. The UN-GGIM Asia and the Pacific forum was convened on World Ocean Day, 8 June 2021[13]. The Forum attracted over 80 participants from Member States, the private sector, and geodetic expert groups such as IAG. The two papers were introduced and the participants from countries were invited to discuss their needs, priorities, issues and challenges to access and sustain the GGRF. Forum participants expressed their appreciation to the Subcommittee, and in particular Germany, for the extensive efforts to establish the Centre this past year and expressed optimism and support for future development of geodetic infrastructure.

47. The UN-GGIM: Arab States consultation and meeting was convened on 16 June 2021. The two papers and the regions geodetic issues were discussed. There was also a lot of discussion (and useful ideas) on how the Centre could support the Arab States. Main points of interest were modernisation of reference frames, and education, training and capacity building. The Arab States supported the two papers and gave a very well prepared and consolidated regional feedback to the Subcommittee.

48. The UN-GGIM: Europe forum was convened on 23 June 2021. The forum was titled "Towards a Sustainable Global Geodetic Reference Frame: European Contribution"[14], and attracted more than 50 participants. The focus of the European forum was to seek feedback from European Member States on the two papers. During the event a poll revealed that the forum participants consider international commitment regarding funding and increased national resources to international geodetic work to be the most important priorities for Europe to secure development and long-term sustainability of the GGRF. All the participants indicated their support to the two papers, with no substantial suggestions for changes.

49. All comments and suggestions were consolidated into a single document to support the subsequent review and refinement process. Many of the responses acknowledged the efforts by the Subcommittee to formulate and develop the Position Paper and Concept Paper, recognized the importance of the GGRF and the importance of having dedicated resources in the form of the Global Geodetic Centre of Excellence.

50. The review and refinement process of the Position Paper and Concept Paper was carried out respectfully, with each individual contribution considered and addressed accordingly. The process sought to be respectful to the rich and valued contributions from Member States and relevant stakeholders. This involved a writing team made up of three members of the Subcommittee and review of the final draft documents by members of the Bureau to ensure consensus.

51. All submissions on the Position Paper and Concept Paper were supportive and provided encouragement to the Subcommittee to continue their efforts with respect to both the Position Paper and Concept Paper. There was strong support from many submissions for a federated Global Geodetic Centre of Excellence, with a range of ideas on the modalities of how this could function. All options are reasonable, and the final determination of the modality is likely to depend on the resourcing, and conditions of resourcing, made available by Member States.

12 UN-GGIM: Americas - Projects (un-ggim-americas.org)
13 WG1 Asia-Pacific Regional Geodesy Forum: The Power of Where - The Value of Geodesy to Society | UN-GGIM-AP
14 European Geodesy Forum - Towards a sustainable Global Geodetic Reference Frame: European Contribution | UN-GGIM Europe (un-ggim-europe.org)

52. The Subcommittee had to address two major considerations: i) include information explaining the important role of physical geodesy and height determination; ii) make it clear that there are sustainability issues with a range of geodetic infrastructure, not just Global Navigation Satellite System (GNSS) infrastructure. These considerations and multiple others were carefully considered and addressed in the provided Position Paper and Concept Paper.

53. The consultation process concluded with the development of revised versions of the two draft papers: the final draft Position Paper on Sustaining the Global Geodetic Reference Frame and the final draft Concept Paper on Establishing a Global Geodetic Centre of Excellence. Both papers are now provided as background documents to this present report for consideration and adoption by the Committee of Experts.

IV. Final draft Position Paper on Sustaining the Global Geodetic Reference Frame

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

55. Sustaining the GGRF will require effort across five focus areas: Governance; Geodetic Infrastructure; Policies, Standards and Conventions; Education, Training and Capacity Building; and Communication and Outreach.

56. The sustainability and quality of the GGRF, and its continual accessibility, have significant and cascading economic, environmental and societal implications including: a lack of formal commitments to sustain; a lack of redundancy; the need for global coordination; and low benefits realisation of education, training and capacity building.

57. To some extent, funding, capability, capacity, or a combination of the three, is required to sustain the GGRF for all Member States across five focus areas. We need: more geodetic infrastructure and newer geodetic infrastructure; adequate resourcing for organisations who operate geodetic infrastructure and produce geodetic products and services; dedicated resources to research, innovation and development; modern standards and formats for our geodetic data and products to ensure it is Findable, Accessible, Interoperable and Reusable; improved access to geodetic products and services; improved communication on the importance of geodesy; and assistance for developing countries in the form of education, training and capacity development.

58. To address challenges and the deficiencies across the five focus areas, the Subcommittee has developed a range of work packages in the Position Paper which aim to address the critical gaps in the GGRF. The work packages are designed to balance the longer-term vision for the GGRF, while ensuring its short and medium-term accuracy and stability, and hence, its quality. Importantly, the work packages to sustain the GGRF will be a collaboration between Member States, organisations such as the IAG and FIG, industry, and relevant geodetic stakeholders.

59. During the intersessional period a broader consultation process was undertaken on the 'draft Position Paper on Sustaining the Global Geodetic Reference Frame' to promote understanding by Member States and relevant geodetic stakeholders of the complex issues facing the global geodetic community and to ensure alignment with the practical and operational requirements proposed by the Subcommittee as positive steps towards the realization of the Centre of Excellence.

V. Final draft Concept Paper on Establishing a Global Geodetic Centre of Excellence

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

(a) enhance global cooperation and coordination across Member States and relevant geodetic stakeholders to maximise the benefit of ongoing geodetic efforts, ensure coherence, and avoid duplication of effort.

(b) strengthen geodetic infrastructure.

(c) assist Member States in making their geodetic data Findable, Accessible, Interoperable and Reusable in line with standards, policies and conventions.

(d) support education, training and capacity building.

(e) improve communication and raise awareness.

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

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

(a) Single Centre hosted by one Member State as the only donor, or

(b) A Federated Centre (preferred option) – multiple Member States to co-host the Centre. This could be a single Centre which is funded by a number of Member States, or a network of Centres hosted by various Member States working under a coordinated governance model.

62. During the intersessional consultation process, Member States provided strong support for a Global Geodetic Centre of Excellence; with the majority of feedback preferring a federated Global Geodetic Centre of Excellence, with a range of ideas on the modalities of how this could function. All contributions in the consultation process were carefully considered and addressed in the final draft Concept Paper on Establishing a Global Geodetic Centre of Excellence.

VI. The Global Geodetic Centre of Excellence in Bonn

63. At its tenth session, the Committee of Experts welcomed and supported a German offer to host the Centre at the UN Campus in Bonn, Germany. The work plan and priorities of the Centre will be adapted to the available workforce, with virtual secondments including from Norway and possible future extensions. Member States and organisations may contribute to the Centre in several ways including, in-kind staff contributions (in person and virtual), organizing dedicated workshops for education, training and capacity building, providing geodetic instruments and expertise, or contributions for a longer period of time to coordinate and organize specific tasks and activities of the Centre. Any contributions will need to be coordinated once the Centre becomes operational.

64. Contributions to the UN Trust Fund, which will fund the operation and work program of the Centre, are also welcome. Any funding provided can have specific focus, for example, multiple Member States could contribute to the establishment and maintenance of a geodetic

observatory in one country, or finance a levelling campaign in another, or sponsor a geodesy summer school in another country, as examples.

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

66. Acknowledging that the GGRF depends on the participation of countries all around the globe, and the need to take action to strengthen international cooperation, the Centre's overarching goal is to deliver a programme of work to achieve the long-term sustainability and quality of the GGRF.

VII. Next Steps

67. Following a three-year process, the Subcommittee has completed two major milestones, the completion of the Position Paper on Sustaining the Global Geodetic Reference Frame, and the completion of the Concept Paper on Establishing a Global Geodetic Centre of Excellence. Both papers have been subjected to broad global consultation, review and refinement and will anchor the work of the Subcommittee going forward. These documents are now provided for consideration and adoption by the Committee of Experts and are provided as background documents to this present report.

68. The Position Paper describes a range of work packages aimed to sustain the GGRF, and addresses the lack of funding, capacity and capability across the five focus areas in the GGRF. The work packages are designed to balance the longer-term vision for the GGRF, while ensuring its short and medium-term requirements for accuracy and stability. Work packages to sustain the GGRF is a collaboration between Member States, organisations such as the IAG and FIG, academia, industry and relevant geodetic stakeholders. The Centre (section VI) is expected to support a number of the tasks within the work packages and help maximize the success of the work packages, ensure value for money, and avoid duplication of effort. However, in many cases the contribution from the Centre will be to improve the collaboration and governance, including tracking progress and assessing success.

69. These work packages include (but are not limited to):

(a) Enhance global cooperation across Member States and relevant geodetic stakeholders, including IAG and FIG.

(b) Ensure robust data analysis and product services, and infrastructure.

(c) Assist Member States in identifying their geodetic needs and pathways to meet these needs.

(d) Undertake a user requirement study.

(e) Develop, implement and communicate a Global Geodesy Development Plan.

(f) Develop and assist with implementing a data-sharing strategy and promote making geodetic data so it can be shared globally and used to improve decision-making.

(g) Develop a capacity development program based on UN Development Program guidelines.15

(h) Develop an Education Training and Capacity Building 'resource hub'.

(i) Develop and implement a communication and outreach strategy with deliverables.

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

(j) Demonstrate through case studies how geodesy can play a key role in resolving/achieving change.

70. Implementing the work packages will depend on resources, capacity and capability. The Subcommittee invites the Committee of Experts to help develop a priority order to the work packages, guide the Subcommittee on how to proceed with the implementation of the work packages, and specifically, on how to build efficient and competent working groups with even geographical representation and a balance between developed and developing nations.

71. The Global Geodetic Centre of Excellence in Bonn, Germany, is expected to commence in late 2021. The two background documents to this present report form the foundation for the Centre's initial work. The Subcommittee stands ready and willing to support the Centre in its establishment, provide expert guidance through the Centre's International Advisory Committee, and work to ensure the Centre has the best start-up conditions possible regarding establishing strategic liaisons with relevant Member States, IAG, FIG and relevant geodetic stakeholders, and in providing updates on the GGRF history, status and other relevant background information.

72. The Subcommittee seeks to work with UN-GGIM regional committees to refresh their regional representations and thus the membership of the Subcommittee after the eleventh session. Thereafter, the Subcommittee plans to convene its third plenary (in-person) meeting in 2022 when global conditions permit. In this regard, the Subcommittee welcomes offers from interested Member States to host its third plenary meeting, which has been postponed indefinitely since April 2020.

VIII. Points for discussion

73. The Committee of Experts is invited to:

(a) Take note of the present report and the work of the Subcommittee on Geodesy during the intersessional period, including its considerable efforts to grow the critical understanding and importance of the GGRF as a vital infrastructure for the global geospatial community;

(b) Consider the Position Paper on Sustaining the Global Geodetic Reference Frame, in particular, on the work package (Section 3) items, with a view to its adoption;

(c) Consider the Concept Paper on the Establishment of the Global Geodetic Centre of Excellence, in particular, on the strategic plan, with a view to its adoption;

(d) Provide guidance on how to attract more contributions to support the establishment and operations of the Global Geodetic Centre of Excellence and encourage Member States to contribute to the operations of the Centre;

(e) Provide guidance on the planned activities of the Subcommittee *inter alia*: 1) on how to proceed with the implementation of the work packages; and 2) building efficient and competent working groups with even geographical representation and a balance between developed and developing nations; and

(f) Take note of the Subcommittee's intention to convene its third plenary meeting in 2022 when global conditions permit.