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# Economic and Social Council

12 June 2013

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## Committee of Experts on Global Geospatial Information Management

### Third session

Cambridge, United Kingdom of Great Britain and Northern Ireland

24-26 July 2013

Item 4 of the provisional agenda\*

### Global geodetic reference frame

## Global geodetic reference frame

### Note by the Secretariat

#### Summary

The present paper contains the report of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific, and the International Association of Geodesy (IAG), for consideration on the global geodetic reference frame. At its second session, held in August 2012, the Committee of Experts on Global Geospatial Information Management recognized the importance of a global geodetic reference frame and the need to maintain national positioning infrastructure, and requested the Secretariat to consult with global experts and report back progress on the topic. The report describes the outcomes of consultations with the Member States, including: an informal consultation convened on the margins of the United Nations Regional Cartographic Conference for Asia and the Pacific, held in Bangkok in October 2012; a special session on the global geodetic reference frame convened during the Second High Level Forum in Doha, Qatar, in February 2013; and a questionnaire distributed to Member States and regional organizations on the present status and role of Governments in adopting and maintaining a globally connected geodetic reference frame. The report provides an analysis and summary of the questionnaire responses from more than 95 countries, and considers a roadmap for future action for strengthening the global geodetic infrastructure including identifying pathways for improved infrastructure development and geodetic data sharing. The Committee of Experts is invited to take note of the report and to express its views on the way forward for the international community, under the coordination of the United Nations, to work with all stakeholders to improve intergovernmental coordination for a sustained operational global geodetic reference frame and infrastructure.

## **I. Introduction**

1. At its second session, held in August 2012, the United Nations Committee of Experts on Global Geospatial Information Management considered a report by the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) Working Group on Geodesy that described the growing demand for a global geodetic reference system that underpins all geospatial information, the importance of a stable and accurate global geodetic reference frame, and the need to maintain national positioning infrastructure (E/C.20/2012/9/Add.1). The Committee recognized the importance of a global geodetic reference frame, the need to maintain national positioning infrastructure, and the need for Member States to make data available to contribute to regional and global positioning frames. However, the Committee considered that further global consultation was required on the topic in order to gather consistent tangible evidence from Member States.

2. In adopting Decision 2/107 (see E/2012/46, page 6) the Committee requested the Secretariat to: organize an informal consultation on the margin of the United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) in October 2012 to discuss technical issues on the global geodetic reference frame, inviting expert organizations, including the International Association of Geodesy (IAG), other relevant international entities and regional bodies; send a questionnaire to Member States and regional organizations on the present status and role of government in adopting and maintaining a globally connected geodetic reference frame; organize a special session on the global geodetic reference system during the High Level Forum on GGIM in Qatar in February 2013, inviting major donor agencies, and to request each regional body to report on their roadmap and share it with other regional bodies; and consult with global experts and include the topic in the agenda of the third session of the Committee of Experts and to report on progress on the roadmap.

3. The Geodetic Reference Framework for Sustainable Development Working Group of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP, formerly PCGIAP) provided valuable technical expertise in the consultation process and development of the questionnaire. The present report describes the outcomes of consultations with Member States, and provides an analysis and summary of the questionnaire responses from more than 95 countries and regional organizations, and considers a roadmap for future action for strengthening the global geodetic infrastructure including identifying pathways for improved infrastructure development and geodetic data sharing. The Committee of Experts is invited to take note of the report and to express its views on the way forward for the international community, under the coordination of the United Nations, to work with all stakeholders to improve intergovernmental coordination for a sustained operational global geodetic reference frame and infrastructure. Points for discussion and decision are provided in paragraph 20.

## **II. Background**

4. Today, precise positioning sees its application in virtually every aspect of the management of geospatial information. In addition to the traditional survey, mapping and navigation (including military) fields, location-based positioning applications are expanding to civil engineering, agriculture, construction, mining, recreation, financial transactions, transportation (including intelligent systems), disaster response and emergency management, environmental studies and scientific research. With the rapid uptake of smart phones and mobile technologies, people

have more opportunities to use location-based services. Easy-to-use and convenient application programs are increasingly being developed and distributed for free or very cheaply. Location-based services are among the most popular services on phones and are used in business, games, travelling and social networking. Modern economic development, expressed in terms of location-based services, now relies heavily, and mostly without redundancy, on the guaranteed availability of and ubiquitous access to unique, homogeneous, high-quality geodetic reference systems and frames. Although vitally important to society, national governments and the consumer community generally have no real understanding of the network and associated infrastructure requirements that enable these precise positioning services to be continuously available.

5. The Global Geodetic Reference Frame (GGRF) underpins all satellite positioning technology which is a key enabler of spatial data interoperability and increasingly a requirement for sustainable development. The importance of the GGRF, and more broadly the Global Geodetic Observing System (GGOS), is growing as new geospatial applications in intelligent transport, precision agriculture and industrial automation emerge globally. The GGRF also supports a range of scientific endeavors that improves the understanding of the Earth system and informs government policy by providing a capability for:

- (a) Monitoring of the solid Earth for displacement, subsidence or deformation of the ground and structures, due to tectonic, earthquake, volcanic and other natural phenomena, as well as human activity;
- (b) Monitoring of variations in sea level (coupled with climate change and global warming), the major ice sheets and global mass transport;
- (c) Monitoring variations in the Earth's rotation such as polar motion and the length of the day;
- (d) Monitoring the atmosphere with satellite geodetic techniques including the composition and physical state of the ionosphere and troposphere;
- (e) Monitoring the temporal variations in the gravity field of the Earth;
- (f) Determining satellite orbits, including earth observation and navigation satellites; and
- (g) Determining positions, and their changes with time, of points on or above the surface of the Earth with the utmost accuracy.

6. The GGRF is underpinned by an infrastructure that consists of globally distributed observatories and satellite tracking stations. It includes Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Global Navigation Satellite System (GNSS), and Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS) observatories. This infrastructure is operated by national governments through their national mapping or space agencies, but a significant proportion of this infrastructure relies on research organizations and universities which contribute on a volunteered and best-effort basis. Key elements of this global infrastructure are old and require upgrading.

7. This infrastructure is complemented by an internationally organized effort of data centers and analysis teams within governments and the scientific community that, on an ongoing basis, often in real-time, provide products, corrections and models that enable the establishment of, or access to, the GGRF. The products and services of the International Association of Geodesy (IAG), which includes the International Terrestrial Reference Frame (ITRF), are the most widely used.

### III. Global geodetic questionnaire

8. The global geodetic questionnaire, requested by the Committee of Experts, was initially drafted by the Geodetic Reference Framework for Sustainable Development Working Group of UN-GGIM-AP, and further developed at a technical workshop on the margins of the UNRCC-AP held in Bangkok, October 2012. The workshop, led jointly by Japan and Australia, was attended by government geodetic experts from Australia, Azerbaijan, Bangladesh, Chile, Fiji, Indonesia, Japan, Republic of Korea, Malaysia, New Zealand, Pakistan, Singapore, South Africa and Thailand; the International Association of Geodesy (IAG) and the International Federation of Surveyors (FIG); regional representatives of the Asia-Pacific Reference Frame (APREF), the African Reference Frame (AFREF), and the *Sistema de Referencia Geocéntrico para las Américas* (Reference frame for Latin America and the Caribbean or SIRGAS); and the leading geospatial companies Trimble Navigation and Esri. This geodetic consultation examined options for the questionnaire format, its content and its overall objectives. It was determined that a global questionnaire would:

- (a) Provide a global ‘snap-shot’ of the use of geodetic data and datums;
- (b) Measure the reliance on global geodetic infrastructure, products and services;
- (c) Measure current and anticipated future participation in the global geodetic community; and
- (d) Identify the legal, administrative, commercial and resourcing impediments that currently limit data sharing and global participation.

9. The questionnaire was distributed globally in December 2012 by the Secretariat of UN-GGIM to the national mapping agencies of the Member States. As of 16 May 2013, there were 99 questionnaire responses from 95 countries (multiple organizations from the same country completed individual surveys). These include responses (percentages are calculated from the global total of countries, not by countries the questionnaire was originally sent to) from Asia: 16 (52%), Africa: 15 (27%), Caribbean: 5 (23%), Europe: 38 (79%), Middle East: 10 (48%), North America: 3 (75%), Pacific: 4 (20%), and South America: 4 (31%).

10. The distribution of countries that responded to the questionnaire shows that the majority of the respondents are those that are socio-economically defined as ‘well developed’. The results are only representative of those countries that responded to the questionnaire (~50% response rate, [95/197]) and it could be assumed that those countries who replied are aware of the importance of the GGRF. There are 88 countries listed by the United Nations as ‘Least Developed’ and ‘Small Island Developing’. Of these 88 countries, only 18 responded to the questionnaire [~20%], which suggests that developing countries may not appreciate the importance of geodetic infrastructure for sustainable development, or that the questionnaire was not initially sent to the correct agencies. Text responses submitted by the least developed/small island developing countries highlighted that there was an understanding of the importance of geodetic infrastructure (mainly GNSS ground reference stations), but that the expense of installing and maintaining the infrastructure was the biggest restriction.

11. Responses demonstrate that the national mapping agencies targeted by the initial distribution of the questionnaire are commonly responsible for the national datum, vertical coordinate system, the national GNSS reference station network, and the terrestrial gravity data. It is less common for the same agency to be

responsible for tide gauge data and other geodetic observatories (including SLR, VLBI, DORIS, and superconducting gravity meter facilities). Of the 10 categories tested in the questionnaire, mapping, cadastral, and administrative boundaries rated highest as applications of geodetic data and datums, with over 60% of respondents rating them as of critical importance. These were followed by construction, transportation and land use planning, which received ratings of high importance from over 50% of respondents.

#### IV. Importance of the GGRF by application

12. Questionnaire respondents assessed the importance of the GGRF by application in the following manner:

- (a) **Mapping: 99%** [68% critical + 31% high] of respondents considered geodetic data and datums to be of high-critical importance for mapping;
- (b) **Remote Sensing: 88%** [43% critical + 45% high] of respondents considered geodetic data and datums to be of high-critical importance for remote sensing. Aerial photography and satellite imagery are the main sources of remotely sensed data. Correctly geo-referencing the imagery relies on knowledge of datums and having geodetic infrastructure either installed (as part of the data collection instrumentation) or co-located in the imagery footprint for this to occur;
- (c) **Construction: 81%** [30% critical + 51% high] of respondents considered geodetic data and datums to be of high-critical importance for construction;
- (d) **Transportation: 71%** [16% critical + 55% high] of respondents considered geodetic data and datums to be of high-critical importance for transportation. Geodetic data and infrastructure such as GNSS reference stations provide a mechanism, not only for navigation, but also for remotely controlled vehicles, which are becoming more popular in high risk areas such as mining sites;
- (e) **Agriculture: 52%** [10% critical + 42% high] of respondents considered geodetic data and datums to be of high-critical importance for agriculture. 36% respondents considered geodetic data and datums to be of low importance for agriculture;
- (f) **Hazard Mitigation: 70%** [21% critical + 47% high] of respondents considered geodetic data and datums to be of high-critical importance for hazard mitigation. Examples include: volcanic hazard assessment and eruption warning; tsunami and earthquake hazard assessment, post-earthquake recovery; flooding, local subsidence convoluted with sea level rise; fires; landslides; water budgets and resources;
- (g) **Asset Management: 34%** of respondents rated the importance of geodetic data and datums as low for Asset Management and 25% of respondents were not sure about the importance of geodetic data and datums for Asset Management. This suggests that there is a lack of understanding about datums and spatial data, which could be correlated to the minimal use of GIS for spatial data management of infrastructural assets such as: building locations, pipelines, and power lines in that country;
- (h) **Land Use Planning: 82%** [23% critical + 59% high] of respondents considered geodetic data and datums to be of high-critical importance for land use planning;

- (i) **Cadastral: 90%** [62% critical + 28% high] of respondents considered geodetic data and datums to be of high-critical importance for cadastres. The response to this question provides an indication of the uptake of using GNSS for local control surveys, which inherently provides 3D coordinates in a well-defined reference frame;
- (j) **Administrative Boundaries: 94%** [55% critical + 39% high] of respondents considered geodetic data and datums to be of high-critical importance for administrative boundaries. The responses to this question closely resemble the responses to the use of geodetic data and datums in Mapping.

## V. Contribution to and the importance of working together

13. A significant number of questionnaire respondents (81%) were from Member State agencies that currently contribute to the global geodetic community. Evidence is provided that the majority of the responding countries are currently active in the geodetic community and support the use of International GNSS Service (IGS) products as well as the use of the International Terrestrial Reference Frame (ITRF). Over 80% of questionnaire respondents considered that the geodetic data, products and services of the International Association of Geodesy (IAG) and the Global Geodetic Observing System (GGOS), such as the ITRF, IGS tracking data and IGS tracking products were of high-critical importance in their country.

14. The Member States indicated some preference to undertake data sharing internationally. Over 50% of agencies that responded to the questionnaire are potentially able to share the majority of their static GNSS and geodetic levelling data internationally. Terrestrial gravity data has the least potential for sharing internationally with only 33% of respondents indicating that the majority of their terrestrial data was available, and 21% of respondents indicating that none of their data was internationally accessible. Half of the respondents indicated that their real-time GNSS reference station data was hypothetically available for sharing internationally. Over 40% of the questionnaire respondents were not sure about the availability of tide gauge data for sharing internationally. This is strongly correlated to the circumstance that national mapping agencies targeted are not generally responsible for the tide gauge network and data. This data also includes countries which do not have a tide gauge network (i.e. land locked countries).

## VI. A mandate for the Global Geodetic Reference Frame

15. The increasing economic need for the global geodetic reference frame was recognized by participants at the Second High Level Forum on GGIM held in Doha in February 2013. The Forum agreed that while the science of establishing a sound geodetic reference frame is available, it was essential to have governments accept the responsibility of establishing and maintaining a sound national geodetic reference frame which could serve as the foundation for a global system. Some countries had expanded their national system on account of economic benefits through better positioning services. It was agreed that the Committee of Experts has an important role to play and that a resolution at the General Assembly of the United Nations, urging governments to support a global geodetic frame, would provide a strong mandate for further development of the frame. In this regard, the participants of the High Level Forum committed to working together as an international community, under the coordination of the United Nations, to work with all stakeholders to improve a sustained operational global geodetic reference

frame and infrastructure, to support the increasing demand for positioning and monitoring applications with associated societal and economic benefits.

16. Through the questionnaire responses, a large majority of the Member States (75%), recognizing that any economic development now needs more precise positioning at the global level, indicated that their organization would benefit from having a high level mandate in place that would provide clear responsibilities for national governments and international agencies. In summary, it was felt that such a mandate would:

- (a) Provide recognition and raise the profile of those agencies providing geodetic infrastructure to help inform government and decision makers of its importance;
- (b) Encourage additional investment by Member States in geodetic infrastructure;
- (c) Encourage free and open geodetic data access policies and reduce data security concerns;
- (d) Motivate Member States to improve international engagement on geodetic matters;
- (e) Facilitate improved intergovernmental coordination of geodetic activities, standards and infrastructure development; and
- (f) Recognize common-good contributions by Member States to the global geodetic infrastructure.

## **VII. Recommendations**

17. Many Member States now have a vision of a ‘location-enabled’ society and expectations that positioning services will be available continuously, along with other critical services such as telecommunications, power and water. However, a key weakness of this vision is the sustainability of the global geodetic reference frame and infrastructure. Not only is the global infrastructure old and requires modernization, but the global cooperation within geodesy is based on a voluntary international collaboration between national mapping agencies and international scientific agencies, relying on a ‘best efforts’ principle. With the growing demand for more precise positioning services, and clearer accountability of fiscal budgets, it is necessary to improve the global cooperation within geodesy by moving away from the best efforts principle and move towards mutual global efforts under the mandated umbrella of structures such as the Committee of Experts through the General Assembly. Improving intergovernmental coordination for a sustained operational global geodetic reference frame and infrastructure requires global recognition and a mandate.

18. Based on the responses from the geodetic questionnaire from almost 100 countries, and considerable global consultation and dialogue, the Geodesy Working Group of UN-GGIM-AP, in close collaboration with the International Association of Geodesy (IAG), recommends that the Committee of Experts establishes a Working Group to develop the draft text of a United Nations General Assembly resolution that:

- (a) Acknowledges the role and importance of the Global Geodetic Reference Frame (GGRF) and the associated efforts of the International Association of Geodesy (IAG) and the Global Geodetic Observing System (GGOS);

- (b) Encourages Member States to support the sustainability of the GGRF through new and ongoing investment by governments to ensure long-term coverage of the space-geodetic ground infrastructure in time and geographic distribution;
- (c) Encourages Member States to participate in forums that facilitate international governmental cooperation and open data sharing of geodetic data.

19. It is further recommended that the newly established Working Group continues to develop a global geodetic roadmap that addresses elements including: developing coordinated policies; new infrastructure for spatial referencing; better global geodetic positioning coverage; improved international data sharing; sustainable funding and investment; common standards, methods and approaches; and strategic partnerships (between mapping agencies, space agencies, etc.).

## **VIII. Points for discussion**

### **20. The Committee is invited to:**

**(a) Take note of the work done by the Working Group on Geodetic Reference Framework for Sustainable Development of UN-GGIM-AP;**

**(b) Establish a Working Group to develop the draft text of a United Nations General Assembly resolution to be tabled in the 2013-14 Session as described in paragraph 18;**

**(c) Provide guidance on the planned activities of the new Working Group, including a roadmap that addresses the issues in paragraph 19.**