

ECONOMIC AND SOCIAL COUNCIL

**Twentieth United Nations Regional Cartographic
Conference for Asia and the Pacific
Jeju, 6 - 9 October 2015
Item 5 of the provisional agenda
Report of the Regional Committee of United Nations
Global Geospatial Information Management for Asia and the Pacific**

**Report of the Working Group 1
Geodetic Reference Framework for Sustainable Development ***

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Report of Working Group 1

Geodetic Reference Framework for Sustainable Development

Activity Report

for

The 20th UNRCC-AP Meeting

Jeju Island, Republic of Korea

6-9 October 2015

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1. Resolutions Adopted at the 19th UNRCC-AP (2012)

At the Nineteenth United Nations Regional Cartographic Conference for Asia and the Pacific, Bangkok, 29 October-1 November 2012, the following Resolution was made. It is directly relevant to the activities of WG1 and is provided here for completeness.

Geodetic framework

The Conference,

Recognizing that geodetic infrastructure, products and services underpin satellite positioning technology, provide the framework for all geospatial activity and is a key enabler of spatial data interoperability, disaster mitigation and sustainable development,

Also recognizing that this is an important issue for the Committee of Experts on Global Geospatial Information Management to consider in consultation with Member States,

Further recognizing the need for the sustainability and improvement of the global network of geodetic infrastructure and International Association of Geodesy/Global Geodetic Observing System services and products, including the International Terrestrial Reference Frame,

Also recognizing the need to assist Member States in developing mandates and support for the provision of geodetic data, products and services,

Further recognizing the problems associated with the lack of coordination between Member States and the need to develop institutional arrangements and coordination frameworks, including those between regions,

Noting the progress made by the Permanent Committee on Geographical Information System (GIS) Infrastructure for Asia and the Pacific and its Working Group on Geodetic Technologies and Applications in improving arrangements for data-sharing and international cooperation,

Also noting the expertise of national geospatial information authorities and the International Association of Geodesy and the potential benefits of improving the communication between Governments and the Association,

Considering the potential security and commercial sensitivities of data sharing,

Realizing the need to improve the sustainability and capability of the Global Geodetic Observing System,

and the need to encourage and support the adoption of the International Terrestrial Reference Frame as the foundation reference frame,

Further realizing the challenges of building technical capacity in developing countries,

Recommends that Member States:

- (a) Urge the Committee of Experts on Global Geospatial Information Management to consult with Member States to adopt and sustain a global geodetic reference frame and provide a road map for its implementation;
- (b) Participate in and make commitments to the Global Geodetic Observing System to ensure its long-term sustainability;
- (c) Support the adoption of the International Terrestrial Reference Frame by participating in regional geodetic programmes such as the Asia-Pacific Regional Reference Frame;
- (d) Work towards the connecting and sharing of data on national height datums;
- (e) Share foundation observation datasets, including Global Navigation Satellite System, geodetic levelling, terrestrial gravity and tide gauge data in open formats;
- (f) Support geodetic experts from Member States to attend appropriate regional forums, such as the meetings of the Working Group on Geodetic Technologies and Applications.

2. Actions Taken since the 19th UNRCC-AP (2012)

Working Group 1 (WG1) - Geodetic Reference Framework for Sustainable Development has continued to focus its efforts on improving access to the global geodetic reference frame while also supporting regional geodetic cooperation within the Asia Pacific region. WG1 has continued its efforts to build capacity in the region with technical workshops and inter-agency collaborations concentrated on geodesy. Highlight activities have included:

- Assisting with the adoption of the United Nations General Assembly Resolution titled *A Global Geodetic Reference Frame (GGRF) for Sustainable Development*.
- The ongoing coordination of Asia Pacific Reference Frame (APREF) which is now incorporating GNSS data from a CORS network of approximately 620 stations, contributed by 28 countries in the Asia Pacific. Data are routinely processed by four Analysis Centres and made available publicly. Since November 2014, the fourth local analysis centre (LAC) from the Institute of Geodesy and Geophysics, Chinese Academy of Sciences, has contributed routine analysis solutions of a component of the APREF CORS network.
- The ongoing coordination of a regional GNSS campaign – Asia Pacific Regional Geodetic Project (APRGP). Three annual GNSS APRGP campaigns were conducted and analysis reports have been delivered to the member countries.
- The ongoing coordination of the Asia Pacific Regional Height System Unification (APRHSU) Project. Activity is continuing and a draft method for regional height unification has been developed.
- The Asia-Pacific Geodetic Capacity Building (APGCB) Project has continued. Specific activity has included:
 - A joint UN-GGIM-AP, International Federation of Surveyors (FIG), International Association of Geodesy (IAG) and United Nations International Committee for GNSS (UN-ICG) Session, Reference Frames in Practice - The Future, was conducted at the FIG International Congress 2014 on 19th June 2014 in Kuala Lumpur, Malaysia.
 - A joint UN-GGIM-AP, FIG and Secretariat of the Pacific Community (SPC) meeting of Pacific geodetic surveyors that led to the establishment of the Pacific Geospatial and Surveying Council (PGSC).
 - A joint UN-GGIM-AP, FIG, IAG and ICG technical seminar on vertical reference frame in practice held on 27-28 July 2015 in Marina Bay Sands, Singapore in conjunction with the South East Asia Survey Congress (SEASC).

3. Working Group 1 - Work Plan

The WG1 work plan for the period 2012-2015 was as follows:

No.	Project	Description	Status 2012-2015
1	Asia-Pacific Reference Frame (APREF)	The purpose of the Asia-Pacific Reference Frame (APREF) project is to create and maintain a densely realised and accurate geodetic framework, based on continuous observation and analysis of Global Navigation and Satellite System (GNSS) data.	Completed
2	Asia-Pacific Regional Geodetic Project (APRGP)	The purpose of the Asia-Pacific Regional Geodetic Project (APRGP) project is to provide access to the International Terrestrial Reference Frame (ITRF) for developing countries in the Asia and Pacific region based on an annual week long campaign of Global Navigation and Satellite System (GNSS) data.	Completed
3	Asia-Pacific Regional Height System Unification (APRHSU)	The purpose of the Asia-Pacific Regional Height System Unification (APRHSU) Project is to encourage data sharing and facilitate technical exchange towards height system development. Data to be shared will include tide-gauge observations, GNSS observations at tide-gauges, geodetic levelling and terrestrial gravity observations. Technical exchange will focus on geoid determination and height system definition.	Completed
4	Asia-Pacific Geodetic Capacity Building (APGCB)	Participants will endeavour to support an annual regional geodetic workshop for governmental geodetic experts in the Asia Pacific.	Completed

4. The Asia Pacific Reference Frame (APREF) Project

The objectives of APREF project are to:

- Create and maintain an accurate and densely realized geodetic framework, based on continuous observation and analysis of GNSS data
- Encourage the sharing of GNSS data from Continuously Operated Reference Stations (CORS) in the region
- Share experiences and encourage regional consultation in regards to CORS GNSS networks
- Develop the APREF Permanent Network, in close cooperation with IGS for the maintenance of the Asia-Pacific Reference Frame, as a contribution to the ITRF and as infrastructure to support other relevant projects
- Provide an authoritative source of coordinates and their respective time-series for geodetic stations in the Asia-Pacific region in near real-time with high quality connection to ITRF
- Establish a dense velocity field model in Asia and the Pacific for scientific applications and the long-term maintenance of the Asia-Pacific reference frame

Table 1 summarizes the current commitments of Member States. APREF products presently consist of a weekly combined regional solution, in SINEX format and a cumulative solution which includes velocity estimates. In addition to those stations contributed by participating agencies, the APREF analysis also incorporates data from the International GNSS Tracking Network including stations in the Russian Federation (16), China (10), India (3), French Polynesia (2), Kazakhstan (1), Thailand (1), South Korea (3), Uzbekistan (1), New Caledonia (1), Marshall Islands (1), Philippines (1), Fiji (1), and Mongolia (1).

GNSS data from a CORS network of approximately 600 stations, contributed by 28 countries is now available and routinely processed by four Analysis Centres (ACs): Geoscience Australia, the Curtin University, the Department of Sustainability and Environment in Victoria, Australia, and the Institute of Geodesy and Geophysics, Chinese Academy of Sciences. The fourth LAC, the Institute of Geodesy and Geophysics, Chinese Academy of Sciences, has contributed solutions for the part of the APREF network since November 2014. The APREF project websites was updated as

<http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/asia-pacific-reference-frame> .

The weekly ITRF coordinate estimates in SINEX format, coordinates time series and velocity solutions for the APREF stations are published on the APREF website. The published coordinates are linked to the ITRF2008 via 132 core IGS stations around the world. The distributions of the APREF stations are plotted in the Figure 1. The number of the stations of APREF is plotted as the function of the year as shown in Figure 2.

Table 1: APREF Participants. Participating agencies have indicated whether they would undertake analysis, provide data archive and product distribution or supply data from GNSS stations (as of August 2015).

Country/Locality	Responding Agency	Proposed Contribution		
		Analysis	Archive	Stations
Afghanistan	National Geospatial-Intelligence Agency, USA			2
Alaska, USA	National Geodetic Survey (USA)			90
American Samoa	National Geodetic Survey (USA)			1
Australia	Geoscience Australia	x	x	132
Australia	Curtin University of Technology	x		1
Australia	University of New South Wales	x		1
Australia	Department of Environment and Resource Management, Queensland			8
Australia	Department of Sustainability and Environment, Victoria	x		96
Australia	Department of Lands and Planning, Northern Territory			5
Australia	Department of Primary Industries, Parks, Water & Environment, Tasmania			2
Australia	Radio and Space Weather Services, Bureau of Meteorology			3
Australia	Land and Property Management Authority, New South Wales			128
Brunei	Survey Department, Negara Brunei Darussalam			1
Cook Islands	Geoscience Australia			1
Cook Islands	Geospatial Information Authority of Japan			1
Ethiopia	Ethiopian Mapping Agency			3
Federated States of Micronesia	Geoscience Australia			1
Fiji	Geoscience Australia			1
French Polynesia	Geospatial Information Authority of Japan			1
Guam, USA	National Geodetic Survey (USA)			1
Hawaii, USA	National Geodetic Survey (USA)			19
Hong Kong, China	Survey and Mapping Office			7
Indonesia	Bakosurtanal			4

Iran	National Cartographic Center, Iran			6
Iraq	Iraqi Ministry of Water Resource General Directorate for Survey			6
Japan	Geospatial Information Authority of Japan	x	x	10
Kazakhstan	Kazakhstan Gharysh Sapary			2
Kiribati	Geoscience Australia			1
Kiribati	Geospatial Information Authority of Japan			2
Macau, China	Macao Cartography and Cadastre Bureau			3
Malaysia	Department of Survey and Mapping Malaysia (JUPEM)			7
Manus Island	Geoscience Australia			1
Marshall Islands	Geoscience Australia			1
Micronesia	Geoscience Australia			1
Mongolia	Administration of Land Affairs, Construction, Geodesy and Cartography (ALACGaC)			8
Nauru	Geoscience Australia			1
New Zealand	Land Information New Zealand	x	x	38
Northern Mariana Islands	National Geodetic Survey (USA)			1
Papua New Guinea	National Mapping Bureau, Papua New Guinea, and Geoscience Australia			2
Philippines	Department of Environment and Natural Resources, National Mapping and Resource Information Authority	x	x	4
Samoa	Geoscience Australia			1
Solomon Islands	Geoscience Australia			1
Tonga	Geoscience Australia			1
Tuvalu	Geoscience Australia			1
Vanuatu	Geoscience Australia			1

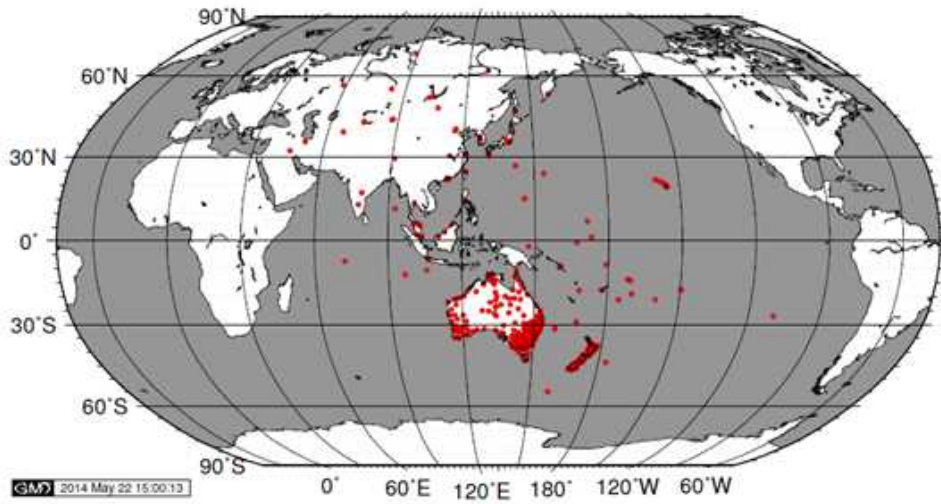


Figure 1: The distribution of APREF CORS network. Each circle represents a GNSS CORS site.

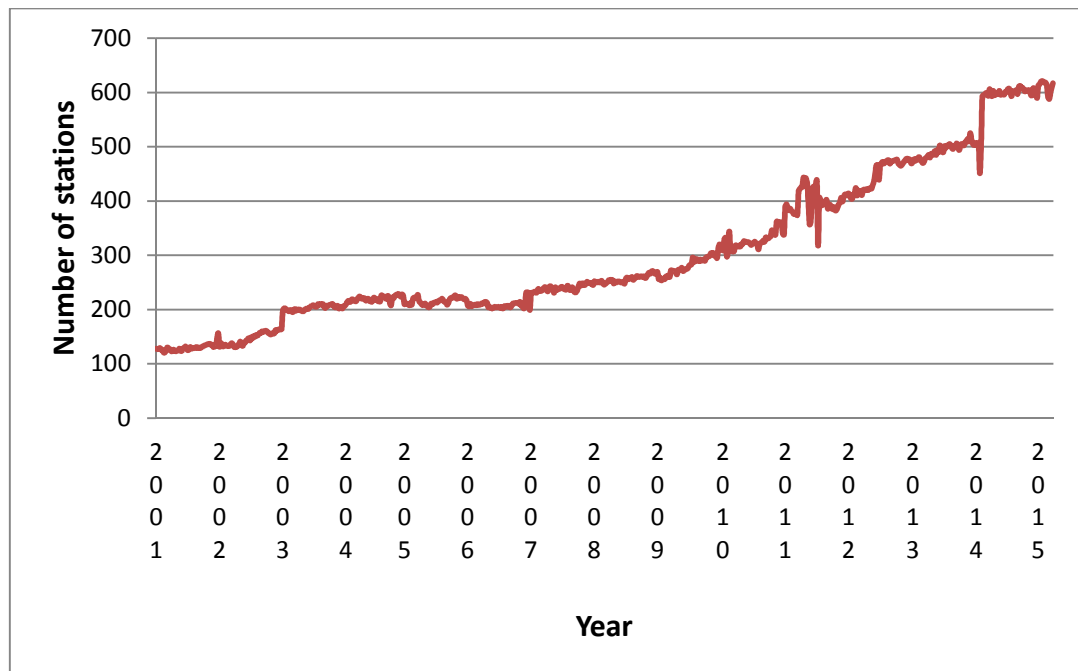


Figure 2: Number of the APREF CORS sites versus time, including 132 IGS core stations.

5. Asia Pacific Regional Geodetic Project (APRGP) Annual GNSS Campaigns

The annual APRGP GNSS campaign was conducted in parallel to APREF so that countries without Continuously Operating Reference Stations (CORS) can connect their national geodetic infrastructure to the regional/global network (i.e. the International Terrestrial Reference Frame ITRF).

The APRGP 2012 GNSS campaign (APRGP2012) was carried out from 9 to 15 September 2012 through the coordination by Geoscience Australia (GA). The data were contributed from eleven countries and regions, i.e. Brunei, Cambodia, Hong Kong, Japan, Korea, Laos, Malaysia, Nepal, Philippines, Singapore and Vietnam. The analysis report for this campaign has been distributed through the participant member countries and reported in the Second Plenary Meeting of UN-GGIM-AP, in Iran, 28-30 October 2013.

The APRGP 2013 GNSS campaign (APRGP2013) was undertaken from 8 to 14 September 2013 through the coordination by Geoscience Australia (GA). The data were contributed from twelve countries and regions, including Bangladesh, Brunei, Cambodia, Hong Kong, Indonesia, Japan, Laos, Malaysia, Nepal, Philippines, Singapore and Vietnam. The analysis report for this campaign has been distributed through the participant member countries and reported in the third UN-GGIM-AP Meeting, in Indonesia, 10-12 November 2014.

The APRGP 2014 GNSS campaign (APRGP2014) took place from Sunday 7 September to Saturday 13 September 2014, inclusive. Data were contributed from nine countries and regions, i.e., Bangladesh, Bhutan, Hong Kong, Indonesia, Japan, Laos, Philippines, Singapore and Sri Lanka. The analysis report for this campaign has been distributed through the participant member countries and reported in the UN-GGIM-AP Executive Board Meeting in Mongolia, 10-11 June 2015.

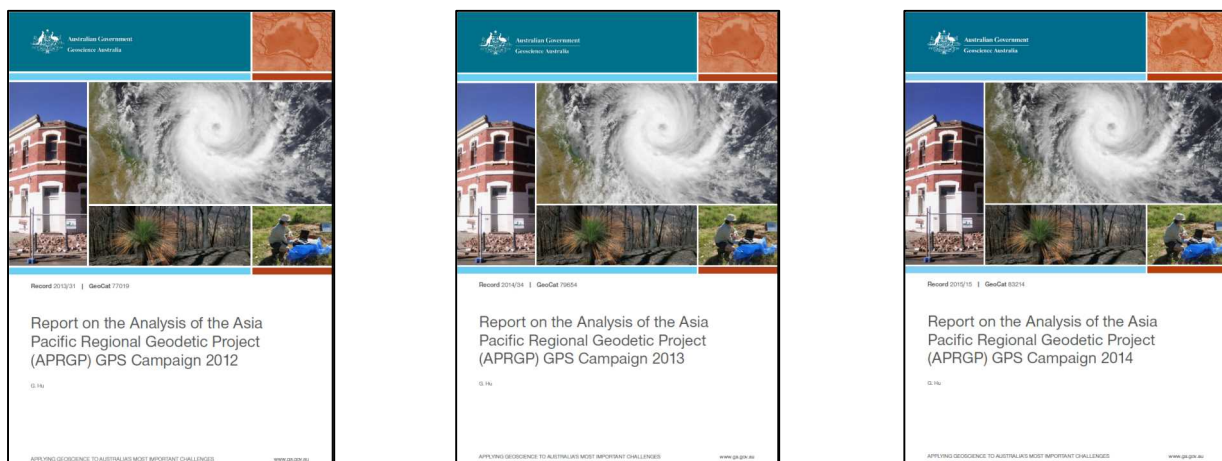


Figure 3: APRGP analysis reports for the 2012, 2013 and 2014 campaigns (available for download from www.ga.gov.au).

6. Asia Pacific Regional Height System Unification (APRHSU) Project

The Asia-Pacific region is particularly vulnerable to water related natural disasters including flooding and tsunami due to the prevalence of island, riverine and low-lying geographies. Therefore, the unification of the height system to enable collaborative responses to disaster mitigation and response is important for the sustainable development of the Asia-Pacific.

The APRHSU project is led by Dr. Jayhyoun, Republic of Korea. The project distributed two questionnaires on the vertical height system to member countries. The analysis of the first questionnaire has been completed and a final report is in preparation. The analysis of the second questionnaire is underway and will be completed in June 2015. A draft document on the standardization of the vertical reference system is currently under review. The APRHSU project investigated an optimal methodology for height system unification. In the future, the APRHSU will distribute the analysis on the questionnaire, finalize the draft report on the standardization of the height system, finalize the unification method, and develop a web-based map tool to communicate findings.

To investigate the status of the height systems of Asia-Pacific region, two questionnaires were distributed from 2013. The first questionnaire focused on vertical datum, vertical positioning, network, and organization. The second questionnaire sought more detailed information such as the standardization and construction of the associated databases.

The Results of Questionnaire 1

The 1st questionnaire was divided into four sections, I) vertical datum; II) vertical positioning; III) vertical control network; and IV) organization, with the questions as follows:

- Is your organization responsible for the national vertical coordinate system (e.g., the orthometric height determination, datum and geodetic levelling)?
- Does your country have multiple local vertical datums?
- Does your country have unified vertical datum shared with other neighboring countries?
- What kind of height is being used in your country?
- What kind of measurement do you use to determine the height of a specific point?
- Do you have official recording format for the measurements?
- Do you have any instruction, rule and/or regulation for vertical positioning?
- Do you have any instruction, rule, standard, or guideline on the equipment for the vertical positioning?
- Do you have established vertical control network?
- Is the geodetic surveying for national vertical control point performed through the financial support from the government?

Total 22 countries/regions responded. Of these, 15 (Macao, Malaysia, Myanmar, Bangladesh, Vietnam, Sri Lanka, Singapore, Iran, Indonesia, Japan, China, Polynesia, Philippines, Australia and Hong Kong) use Sea-level tide gauge data to establish their height system, 2 (New Zealand and Brunei) are based on a geoid and 5 (Mongolia, Azerbaijan, Laos, Nepal and Afghanistan) are established from connections to neighboring countries.

Seventeen use only levelling, 12 countries use levelling with gravity, 15 use GNSS and 1 uses another method. In 16 countries, excluding Bangladesh, Mongolia, Japan, Nepal and Sri Lanka, they use more than 2 kinds of the height. Seventeen use orthometric height, 13 use ellipsoidal height, 6 use normal height and 2 use normal-orthometric height.

The Results of Questionnaire 2

The 2nd questionnaire was divided into three sections: I) national vertical geodetic data; II) geodetic database; and III) participation in the APRHSU project. The questions were as below.

- Is your organization responsible for the national geodetic levelling data?
- Is your organization responsible for the national terrestrial and/or airborne gravity data?
- Is your organization responsible for the national sea-level tide gauge data?
- Does your country have an official geoid model?
- Did your country carry out GNSS observations at the vertical origin(s) including auxiliary point(s) nearby and/or the national tidal bench mark (TMB) tied to the sea-level gauge?
- Does your country have GNSS observations at the vertical geodetic control points (i.e., GNSS/levelling data)?
- Which of the following height systems is being used at your country's vertical control?
- Does your country have the national standard of the vertical geodetic observations?
- Does your country have a database for management and maintenance of the vertical geodetic observations?
- Does your country have a convention to use "Newtonian Constant of Gravitation G" for geodetic computations?
- Does your country have a convention regarding "Permanent Tide System" to uniformly treat geodetic quantities (e.g., gravity and station positions)?
- In your country, do you contribute to the international geodetic community?
- Have you or your colleagues heard of the APRHSU project before this questionnaire?
- We believe that the geodetic data sharing is a key to successful implementation of the APRHSU. Which of following data does your organization contribute to the project?

Eighteen countries responded to the second questionnaire. Seven of them have a geoid model, 8 have sea-level tide gauge data, 9 have terrestrial and/or airborne gravity data, and 17 have geodetic levelling data. All of the countries/regions answered that they have geodetic levelling data, exclude Polynesia.

Seven countries (Malaysia, Mongolia, Iran, Japan, China, New Zealand, Polynesia) answered that they have a geoid model.

The type of height system used at the vertical origin varied. Three countries (Macao, Cook Island and Philippines) use levelled height without taking account of non-parallelism of equipotential surface, other 3 countries (New Zealand, Mongolia, Fiji) use normal-orthometric height, 11 countries/regions (Nepal, Malaysia, Bangladesh, Bhutan, Sri Lanka, Singapore, Afghanistan, Iran, Japan, Polynesia and Fiji) use orthometric height and only Iran used a geopotential number.

Six (Macao, Malaysia, Bangladesh, Afghanistan, Fiji, Philippines) of them have sea-level tide gauge data, 5 countries (Macao, Malaysia, Bhutan, China, Philippines) have terrestrial and/or airborne gravity data, 13 countries (Nepal, New Zealand, Macao, Malaysia, Mongolia, Bangladesh, Bhutan, Sri Lanka, Singapore, Fiji, Philippines) have geodetic levelling data and the 8 countries (New Zealand, Macao, Malaysia, Mongolia, Bangladesh, Bhutan, China, Fiji) have GNSS/levelling data.

Seven (New Zealand, Malaysia, Bangladesh, Iran, Japan, Fiji, Philippines) answered that they can provide sea-level tidal gauge data, 6 countries (New Zealand, Bhutan, Japan, China, Polynesia, Philippines) would provide terrestrial gravity data, 10 countries (New Zealand, Mongolia, Bangladesh, Bhutan, Sri Lanka, Japan, China, Polynesia, Fiji, Philippines) would provide geodetic levelling data and 12 countries/regions (New Zealand, Malaysia, Mongolia, Bangladesh, Bhutan, Sri Lanka, Singapore, Iran, Japan, China, Polynesia, Fiji) would provide GNSS/levelling data.

7. Asia-Pacific Geodetic Capacity Building (APGCB) Project

WG1 has continued to be involved in regional workshops aimed at geodetic capacity building in the Asia Pacific. A joint UN-GGIM-AP, International Federation of Surveyors (FIG), International Association of Geodesy (IAG) and United Nations International Committee for GNSS (UN-ICG) Session, Reference Frames in Practice - The Future, was conducted at the FIG International Congress 2014 on 19th June 2014 in Kuala Lumpur, Malaysia.

A joint UN-GGIM-AP, FIG and Secretariat of the Pacific Community (SPC) meeting of Pacific geodetic surveyors was facilitated by the WG1 Chair in November 2014. This meeting has subsequently led to the establishment of the Pacific Geospatial and Surveying Council (PGSC).

A joint FIG /UN-GGIM-AP / IAG/ICG technical seminar on vertical reference frames was held in Marina Bay Sands, Singapore in 27-28 July 2015 in conjunction with the 13th South East Asian Survey Congress.

8. Other Activity

WG1 has been closely involved in the development of the United Nations General Assembly Resolution entitled *A Global Geodetic Reference Frame (GGRF) for Sustainable Development*. The objective of this United Nations Resolution is to ensure the sustainability and enhancement of the GGRF by:

- Encouraging enhanced global cooperation in geodesy;
- Encouraging maintenance and enhancement of geodetic infrastructure;
- Encouraging free and open geodetic data access policies and reducing data security concerns;
- Motivating Member States to improve international engagement on geodetic matters;
- Facilitating improved intergovernmental coordination of geodetic activities, standards and infrastructure development; and
- Providing recognition that the contributions by Member States to the global geodetic infrastructure are to the benefit of all.