

13th South East Survey Congress

“Expanding the Geospatial Future”

FIG Commission 5 Workshop



Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

Introduction

The technical seminar on Vertical Reference Frames in Practice as part of the FIG Commission 5 (Positioning and Measurement) Workshop on the 27th and 28th July 2015 at the Marina Bay Sands Convention Centre in Singapore in conjunction with the 13th South East Asian Survey Congress.

The technical seminar focussed on the theory and practice of vertical reference frames. The topics covered in the seminar included; Introduction to Vertical Reference Frames, Time Dependence and Transformations, Airborne Gravity Data Collection and Analysis, International GNSS Service, Vertical Deformation, GNSS Heighting with the Case Studies from Australia, Hong Kong, Japan, New Zealand and Singapore.

Seminar's proceedings with presentations of the Technical Seminar are now available at the ICG Information Portal at <http://www.unoosa.org/oosa/en/ourwork/icg/activities.html> or directly at the FIG 5 Commission webpage at: <http://fig.net/organisation/comm/5/index.asp> or http://fig.net/resources/proceedings/2015/2015_07_vertical_references_frame_practice.asp

Organisers

The workshop was organised by International Federation of Surveyors (FIG) Commission 5, in conjunction with the International Association of Geodesy (IAG), International Committee on GNSS (ICG), the United Nations Initiative for Global Geospatial Information Management for Asia-Pacific (UN-GGIM-AP) and the Singapore Land Authority (SLA); Local organisational support was provided by Victor Khoo and Richard Loo of the Singapore Land Authority.



The financial assistance from the International Committee on GNSS (ICG) is highly acknowledged to participate in the technical seminar on Vertical Reference Frames in Practice as part of the FIG Commission 5.

I wish to acknowledge that through the excellent support from John Dawson, Volker Schwieger, Li Zhang and Sharafat Gadimova made my participation in this technical seminar, a major success for me as an individual and for my organisation to build capacity on the vertical reference frames, the way forward for my organisation to support the small island states in the Pacific Islands to understand and improve the vertical reference. This technical seminar gave me the opportunity to meet the technical experts in the world who are part of the FIG Commission 5 and are part of the developed nations where the geodetic survey infrastructure is of high quality and well quantified.

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

Contributors

The workshop was financially supported by Leica Geosystems and Trimble; their presence was duly noted and acknowledged during the Technical Seminar.



Synopsis

Secretariat of the Pacific Community (SPC) is the Pacific Island region's principal technical and scientific organisation. It delivers technical, scientific, research, policy and training support to Pacific Island countries and territories in fisheries, agriculture, forestry, water resources, geoscience, transport, energy, disaster risk management, public health, statistics, education, human rights, gender, youth and culture. SPC was established in 1947 and employs over 700 staff. Its headquarters are in Noumea, New Caledonia, with other offices in Fiji, Federated States of Micronesia and Solomon Islands. SPC has 26 member countries and territories including its founding members, Australia, France, New Zealand and the United States of America, which contribute a large proportion of its funding. Other major development partners are the European Union; Global Fund to Fight AIDS, Tuberculosis and Malaria; United Nations agencies; Asian Development Bank; World Bank and Global Environment Facility.

SPC's vision for the region is a secure and prosperous Pacific Community, whose people are educated and healthy and manage their resources in an economically, environmentally and socially sustainable way.

SPC's mission is to help Pacific Island people position themselves to respond effectively to the challenges they face and make informed decisions about their future and the future they will leave for the generations that follow.

The small islands and atolls in the Pacific are widely spread out and SPC have been providing technical support with respect to accurate definition as per location of these islands and atolls. Most of the islands and atolls in the Pacific are low lying (some are 2 to 3 metres above mean sea level), therefore it is very important to have a vertical reference system established, so that the Pacific islanders are able to accurately know how high or above are their islands above sea level, whether it is chart datum or mean sea level datum. Since these islands are fairly remote and the tides are different in each location, it is very important to have an accurate vertical reference system recognised regionally and globally and above all it is quite a challenging task. One good example is the Hydrographic Project in the islands of Vanuatu funded by the Government of New Zealand and

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

Vanuatu where by geodetic and bathymetry surveys were carried out to map the good anchorage points for the cruise vessels (nearly 250 cruise ships enter into the islands of Vanuatu)

Attending the seminar, further knowledge was developed and better understanding on the Vertical Reference System Framework with respect Global Geodetic Reference Framework (GGRF). At the same time develop our professional capacity in terms of vertical reference framework in line of professional duty. This was a good opportunity to participate and meet the distinguished speakers; who are internationally renowned and other participants who has been doing the similar nature of work so that regional capacity is up to par to international standards and specifications.

This seminar was of significant interest to us and our organisation as we carry out the hydrographic surveys, geodetic surveys and topographic surveys using different survey technologies such as echo sounders (R2 sonic multi beam system), tide gauges (Valeport), satellite (GNSS), digital (EDM Height Traversing) and conventional (levels).

The Geoscience for Development Programme has been actively involved in the regional projects such as the Pacific Sea Level Monitoring Project and Regional Maritime Boundaries project funded by the Government of Australia.

The Pacific Sea Level Monitoring Project (<http://www.bom.gov.au/pacific/projects/pslm/index.shtml>) is a longstanding regional project and we have been closely working with the Geodesy Division of Geoscience Australia. The project has established a network of Continuous Global Positioning System [CGPS] stations and Tide Gauge [SEAFRAME] Stations in the following participating countries: Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Niue, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu and Samoa. As part of the project, we have been carrying out the monitoring surveys (precision levelling monitoring surveys) in these countries.

The Regional Maritime Boundaries Project (<http://gsd.spc.int/regionalmaritimeboundaries>) includes Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Niue, Papua New Guinea, Palau, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. As for the definition of the maritime boundaries, with good horizontal locational information, vertical location information is also very important as due to sea level implications, the tides are shifting the low water mark and thus it affects the defined territorial seas baseline; that is the reference for establishment of exclusive economic zone.

In December 2014, the Pacific Geospatial & Surveying Council (<http://gsd.spc.int/pgsc>) was established for the region, specialist in the field of surveying from Australia, New Zealand, Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Niue, Papua New Guinea, Palau, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu attended and a desk was formalised at the Geoscience Division of SPC. Please find attached the council charter for your information. On behalf of the council, this seminar will be a platform for the development of the vertical reference frame for the region and will lead the way forward to develop 'one' vertical system. Expert advice and their consultation from Australia and New Zealand are highly acknowledged.

Secretariat of Pacific Community is a non-profitable organisation and it has been providing its services through funding from its member countries and international agencies such as Australian Aid, European Union, New Zealand Aid, World Bank and etc. The financial assistance from the International Committee on GNSS (ICG) and very kind support from the Secretariat of the FIG Commission 5 is highly acknowledged and appreciated. Vinaka Vaka Levu (Thank you very much) FIG and ICG with this exclusive funding and training opportunity.

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

Technical Seminar

The technical seminar on the vertical reference frame has been very instrumental to develop capacity and derive the pathway to the requirements on the establishment of the vertical reference frame in the Pacific island countries in my line of professional duty and now that most of these countries have signed up for the UN Resolution on the Global Geodetic Reference Framework through UN ECOSOC policy.

I highly acknowledge and thank all the presenters in this seminar and I look forward to more participation in these specific seminars in future as we are very limited to funds and I personally thank the sponsors once again.

The innovation of Geodesy from traditional and classical/ physical to this modern geodesy was well presented in this seminar through the world experts.

The evolution of the two-dimensional to three dimensional worlds is emerging and the vertical reference is as important as the horizontal reference.

Therefore in summary all these data sets are important to develop into "Pacific Islands Geodetic Database" that includes:-

- Pacific Islands Survey History
- Gravity Data (including air borne)
- Satellite Altimetry Data
- Geodetic Survey Data
- Global Positioning Systems/ Global Navigational Satellite Survey Data
- Sea level (Tide Gauge Data)
- Bathymetry Survey Data
- Land Topography Data

Therefore from this workshop, the Pacific islands need to develop a vertical reference frame either at local level or national level since the islands and atolls are fairly separated to each other and they are dynamic in nature and the effects of climate change changes the geographical status. As I would see that datum unification in the Pacific island countries will be the way to move forward.

Most of the countries in the Pacific need to develop their datum from local system to international reference such as ITRF and that there is no local geoid model in place except to utilise the global geoid model such as EGM2008 in this region.

With the modern techniques available, the Pacific island countries would need financial assistance from aid agencies and expertise from the organisations such as UN-GGIM, FIG, IAG and ICG not only to develop their geodetic survey infrastructure (CORS Network) but also establish their vertical and horizontal reference frame in terms of international standards and specifications. One very good example is the ongoing Australian Government funded Pacific Sea Level Monitoring Project in the region.

Development of geodetic survey capacity is a need in the region, where survey professionals are aware of what and how to develop their local reference into international reference frame with the aid of modern survey technology.

It was very interesting from the seminar presentations from the developed countries that international reference frame can be developed in the region and these techniques can be adopted but Pacific islands still have far way to go; therefore assistance is a prerequisite.

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

Programme

Monday 27th July 2015

08:30 – 09:00 **Welcome and Opening Remarks -**

Mr. **Nic Donnelly**, New Zealand

Prof. **Chris Rizos**, Australia

Mr. **Victor Khoo**, Singapore

Ms **Sharafat Gadimova**, Austria

09:00 – 10:30 **Session 1: Introduction and Definitions**

Prof. **Chris Rizos**, Australia
[**Presentation**]



Need for, benefits and applications of a height system, Height systems: Geometric height systems, Physical height systems, Physical reference surfaces (geoid, quasi-geoid), Geopotential numbers, Physical heights (dynamic, orthometric, normal, MSL), Measuring potential differences (levelling+gravity), Datum definition concepts.

10:30 – 11:00 Morning Tea

11:00 – 12:30 **Session 2: Time Dependence and Transformations**

Prof. **Chris Rizos**, Australia
[**Presentation**]

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015



Time-dependent heights: Earth tides, Glacial Isostatic Adjustment (GIA), Subsidence, Episodic vertical displacements (e.g. earthquakes, volcanos, landslides); Transformations.

12:30 – 13:30

Lunch

13:30 – 15:30

Session 3: Case Studies I

Mr **Basara Miyahara**, Japan

Case study of Japan

[**Presentation**]



Current vertical datum of Japan, Maintenance of datum utilizing COR (monitoring of displacements by CORS, revision of heights in case of earthquakes), Orthometric height determination with a hybrid geoid model.

Mr. **Simon CW Kwok**, Hong Kong

Modernization of Height System in Hong Kong

[**Presentation**]

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

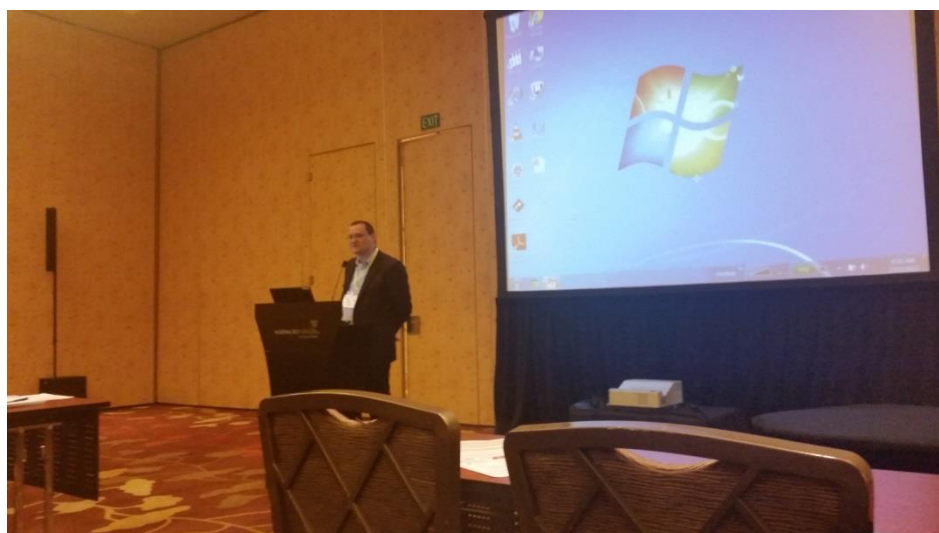


Hong Kong vertical reference system, Hong Kong Principal Datum (HKPD), Modernizing the vertical height system by (1) a comprehensive re-levelling of the bench mark network, (2) re-adjustment of the levelling measurement with reference to the HKPD, (3) densify a network of points covering the whole territory of Hong Kong with levelling, GNSS and gravity observations, and (4) creation of a Geoid Model for GNSS heighting in Hong Kong.

15:30 – 16:00 Afternoon Tea

16:00 – 17:30 **Session 4: Airborne Gravity for an improved vertical datum and ICG**

Mr **Nic Donnelly**, New Zealand
Airborne Gravity for an improved vertical datum
[**Presentation**]



Contribution of airborne gravity to the geoid/quasigeoid, planning an airborne gravity survey, flying airborne gravity, data processing, calibration lines, assessment of results, using New Zealand as an example

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

Ms **Sharafat Gadimova**, Austria
Presentation of International Committee on GNSS (ICG) at UN
[**Presentation**]

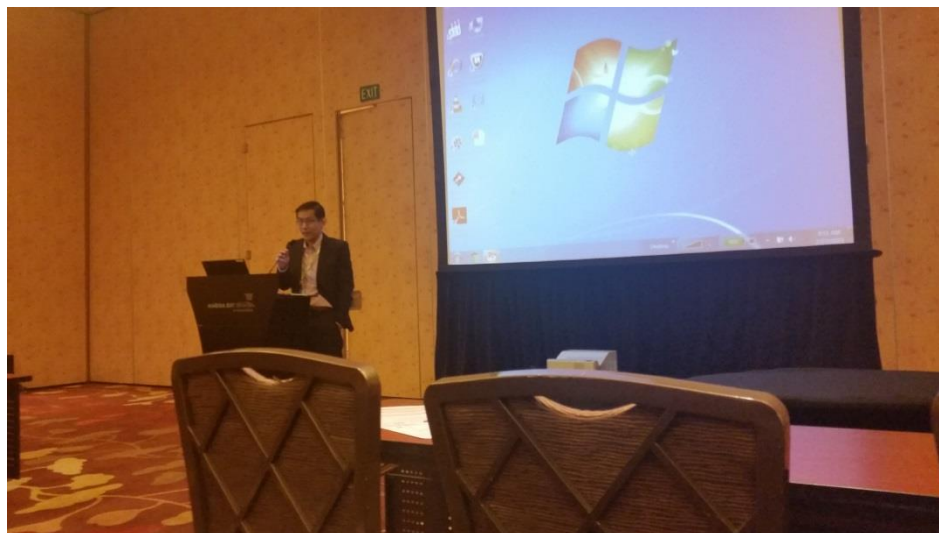
The presentation will highlight the latest developments in the ICG and the future role of ICG in a multi-constellation GNSS. The outline of the ICG's Programme on GNSS applications, focusing on capacity-building in the use of GNSS-related technologies in various rapidly growing fields of science and industry will be provided.

19:00 – 22:00 Seminar Dinner

Tuesday 28th July 2015

14:00 – 15:30 **Session 5: GNSS Heighting and Episodic Vertical Displacements**

Mr. **Richard Loo** and Mr. **Victor Khoo**, Singapore
GNSS Heighting and Application to Singapore
[**Presentation**]



The presentation will introduce the height datum used in Singapore, describe the computation of geoid model, usage of GNSS in heighting and the importance of the height datum.

Mr **Nic Donnelly**, New Zealand
Incorporation of episodic vertical displacements into vertical reference frames
[**Presentation**]

Types of vertical displacement, impact on vertical reference frames, data collection, managing the relationship between geometric and vertical reference frames, user requirements for vertical deformation modelling, incorporating a deformation model into a vertical reference frame

15:30 – 16:00 Afternoon Tea

16:00 – 17:30 **Case Studies II**

Mr **Graeme Blick**, New Zealand
Case Study New Zealand

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

[Presentation]



New Zealand's levelling datums, New Zealand Quasigeoid 2009, New Zealand Vertical Datum 2009, relationships between levelling and quasigeoid-based reference frame, the role of the vertical reference frame in earthquake recovery, user requirements for the vertical reference frame, proposed new vertical reference frame for New Zealand

Dr. **John Dawson**, Australia

Case Study Australia

[Presentation]



The Australian Height Datum (AHD). Maintenance of AHD using GNSS, a new national geodetic adjustment and refinement of AUSGeoid - Australia's combined gravimetric-geometric quasi-geoid model. The use of Interferometric Synthetic Aperture Radar (InSAR) to develop a national deformation model to support height system maintenance.

17:30

Closing Remarks – FIG Commission 5, IAG

Technical Seminar on Vertical Reference Frames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015



Source: Mr Graeme Blick, LINZ.



Technical Seminar on Vertical Reference Fames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015



Technical Seminar on Vertical Reference Fames in Practice

FIG Commission 5 (Positioning & Measurement) Workshop

Singapore 27-28 July 2015

