Appendix to item xx

Report to the 41th General Assembly
FIG Congress 2018, Istanbul, Turkey

FIG Commission 5 – Positioning and Measurement

Report of Activities 2017-18 (15-18)

1. General

The Commission 5 2015-18 work plan consists of realising tangible outcomes for our already well-known FIVE missions, which are -

- FOCUS on modern technologies, technical developments and applications.
- FACILITATE and follow technical developments through collaborations with other FIG Commissions and like organisations.
- FOSTER and support research and development and stimulate new ideas in the fields of expertise represented within the commission.
- FORMULATE and formalise collaboration with manufacturers on the improvement of instrumentation and associated software.
- FIG EVENTS - present and promote the work of the Commission and its working groups through technical events and necessary media.

In year 2017, Commission 5 has been focused on the technical activities for the FIG operational surveyor. Our activities have been associated with the technical programme for the FIG 2017 Working Week on 29 May -2 June 2017 in Hesinki, Finland. On 20 April 2017, the *FIG/SSUGT Cost Effectove Positioning and Geo Data Seminar* was held within the frame of "Interexpo GEO-Siberia 2017" in Novosibirsk, Russia. The *FIG/IAG/ UN-GGIM-AP/ICG/GSI/JFS Technical Seminar on Reference Frame in Practice* was held on 29-30 July 2017 in Kobe, Japan. The next Technical Seminar on Reference Frame in Practice will be held on 04-05 May 2018 in Istanbul,Turkey. One special session FIG Commission "Trends in GNSS" was orgnized by Commsion 5 within the Intergeo conference in Berlin on 26-28 September 2017, members of Commission 5 have made their presenatations in this session. One seminar "Digital Geodesy for Smart Cities-Reference Frames, Positioning, Surveying and BIM" will be organised by Commission 5,6, and 10 within the international symposium GeoPreVi 2018 in Bucharest, Romania on 25-26 October 2018.

We have also continued our effective collaboration with our international sister organisations to promote and fulfil the FIG objectives and the FIVE missions of our work plan.

A summary of the working group activities in 2017 is as follows.

2. Working Groups

2.1 WG 5.1 – Standards, Quality Assurance and Calibration

Chaired by David Martin

Standards play an important role in surveying. This is particularly true with modern instrumentation that produces measurements and results from black box solutions not fully understood by the average practicing surveyor. So even if surveyors are not directly implicated, they are implicitly very reliant upon standards underpinning the correct functioning of their instruments.

Working Group 5.1 actively participates in technical sessions, technical seminars and presentations for FIG Working Weeks and Congresses.

Importantly Working Group 5.1 is the contact for FIG liaison to the ISO Technical Commission (TC) 211 (http://www.isotc211.org/) and Technical Committee ISO/TC 172/SC 6.

ISO TC 211 is concerned with standardization in the field of digital geographic information. This commission aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. The work links to appropriate standards for information technology and data where possible, and provides a framework for the development of sector-specific applications using geographic data. At present, Nic Donnelly, from Land Information New Zealand, is the FIG liaison to TC211.

ISO/TC 172/SC 6 deals more closely with the hands on details related to using classical surveying instruments. These standards deal with field procedures for testing geodetic and surveying instruments such as theodolite, total stations levels and GNSS in real-time kinematic (RTK).

A principal aim of Working Group 5.1 remains the examination and promotion of guidelines and recommendations for standards and quality in survey measurements based on the ISO Guide to Uncertainty in Measurement (GUM) and its supplements.

2.2 WG 5.2 – 3D Reference Frames

Chaired by Nic Donnelly

The role of 3D reference frames as fundamental infrastructure for communities is increasingly recognised, most notably through the 2015 resolution of the United Nations General Assembly entitled *A global geodetic reference frame for sustainable development*. Robust, accurate and easily-accessible 3D reference frames are critical to support applications such ashazard monitoring and modelling, infrastructure development, land use planning, environmental analysis and cadastral definition. Increasingly, the 3D reference frame is used as a mechanism to conveniently access the vertical orthometric reference frame which is so critical to engineering applications.

Working Group 5.2 is focussed on the 3D reference frame as represented by either geocentric (X, Y, Z) or geographic (latititude, longitude, ellipsoidal height) coordinates. It complements and closely aligns with WG 5.3 – Vertical Reference Frames, which focusses on non-ellipsoidal height systems. Members of this working group are focussed on education and guidance on the practical aspects of implementing and using 3D reference frames. Areas of research and operational interest include deformation modelling, reference frame transformations, GNSS utilization, time-dependent coordinates and reference frame standardization.

As in previous years, working group members have focussed on organising and presenting at technical sessions and seminars. The highlight of 2017 was the Technical Seminar on Reference Frames in Practice held in Kobe on 29-30 July 2017, organised in conjunction with IAG and other partners. Work is well underway on preparations for the two-day reference frames seminar to be held immediately prior to the 2018 FIG Congress in Istanbul.

2.3 WG 5.3 – Vertical Reference Frames

Chaired by Kevin M. Kelly and Dan Roman

Established at the 2014 FIG Congress in Kuala Lumpur, WG5.3 – Vertical Reference Frames (VRF) addresses issues involving heights and height which impact environmental phenomena such as sea level rise, climate change and other geodynamic processes. Practical geodetic issues related to WG5.3 include: relationships and links between land-based vertical datums and ocean tidal datums, gravimetric geoid based national vertical reference systems (or datums), regional and global height system unification, ongoing deterioration of classical vertical control networks, usefulness of existing leveling data, and of course, GNSS heighting. Our aim is to provide tools so that geomatics practitioners can effectively understand and use VRF's in their day to day work or implement VRF's in their national jurisdictions.

Our focus over this past year has been education, with two workshops addressing, among other things, vertical and 3D geometric-kinematic reference frames (in conjuction with WG5.2). A Technical Seminar on Reference Frames in Practice was held in Kobe on 29-30 July 2017 in conjunction with the International Association of Geodesy (IAG) Scientific Assembly. Key topics covered included geometric and vertical reference frame theory, crustal deformation theory, vertical reference frames and GIS, national reference frame case studies and capacity development of the FIG Asia Pacific Capacity Development Network. The seminar attracted 68 delegates from 19 different countries. Another Technical Seminar on Reference Frames in Practice will be held at the FIG Congress in Istanbul on 4-5 May 2018. The seminar aims at surveyors, spatial professionals, students and operational geodesists interested in learning more about practical aspects of reference frames. The two-day seminar will address reference frame fundamentals with emphasis on crustal deformation datum unification.

2.4 WG 5.4 – GNSS

Chaired by Suelynn Choy

The GNSS working group continues to support international R&D activities in GNSS through participation in the ION Pacific PNT and GNSS+ Meetings, Multi-GNSS Asia Conference, International Symposium on GNSS, INTERGEO and etc. Focus areas are in multi-constellation multi-frequency GNSS precise positioning and efficient delivery of high precision GNSS positioning which includes satellite based augmentation services.

The WG 5.4 also continues to represent FIG at the UN International Committee on GNSS (UN ICG) and contribute towards the activities and recommendations of the UN ICG Working Group D. In addition, the WG is working with IAG contributing towards their effort in enhancing integer ambiguity resolution for multi-GNSS PPP and PPP-RTK.

In 2017, Suelynn Choy was elected as a steering committee member of Multi-GNSS Asia. The key objective of Multi-GNSS Asia is to encourage and promote utilisation and applications of satellite positioning, navigation and timing services in the Asia and Oceania region. This region is a unique place that will see the earliest and highest level of coverage from the new and mondernised GNSS satellites. The WG is actively supporting Multi-GNSS Asia for the upcoming Multi-GNSS Asia Conference to be held in Melbourne, Australia, from 23-25 October 2018. WG 5.4 will participate in the upcoming RTCM SC-104 Meeting in Sydney, Australia, from 5-6 February 2018.

In January 2018, Suelynn Choy presented a lecture on GNSS Precise Point Positioning at a training programme on GNSS organised by the Asian Institute of Technology, Thailand; UN ICG; S4D/CSIS, and The University of Tokyo. The training course was designed for those who would like to learn about GNSS.

2.5 WG 5.5 – Multi-Sensor-Systems

Chaired by Allison Kealy and Günther Retscher (IAG)

WG5.5 is a joint working group between FIG and IAG. In 2017 activity centered around multi-sensor systems for GNSS difficult environments. Two specific areas were indoor positioning and autonomous vehicles in urban environments.

A major activity undertaken by members of the joint IAG Working Group WG 4.1.1 and FIG WG 5.5 was field experiments at the Ohio State University In October 2017. These revolved around the concept of collaborative navigation, and partially indoor navigation. Collaborative positioning is an integrated positioning solution which employs multiple location sensors with different accuracy on different platforms for sharing of their absolute and relative localizations. Typical application scenarios are dismounted soldiers, swarms of UAV's, team of robots, emergency crews and first responders. The stakeholders of the solution (i.e., mobile sensors, users, fixed stations and external databases) are involved in an iterative algorithm to estimate or improve the accuracy of each node's position based on statistical models. For this purpose different sensor platforms have been fitted with similar type of sensors, such as geodetic and low-cost high-sensitivity GNSS receivers, tactical grade IMU's, MEMS-based IMU's, miscellaneous sensors, including magnetometers, barometric pressure and step sensors, as well as image sensors, such as digital cameras and Flash LiDAR, and ultra-wide band (UWB) receivers.

A novel approach for positioning with Wi-Fi was initiated and developed at TU Wien (Vienna University of Technology) under the lead of Guenther Retscher. This approach for localization and tracking of mobile smartphone users is termed Differential Wi-Fi (DWi-Fi) by analogy with DGPS. From reference stations deployed in the area of interest differential measurement corrections are derived and applied at the mobile user side. Hence, range or coordinate corrections can be estimated from a network of reference station observations as it is done in common CORS GNSS networks. A low-cost realization with Raspberry Pi units

has been realized for these reference stations. These units serve at the same time as Access Points (APs) broadcasting Wi-Fi signals as well as reference stations scanning the receivable Wi-Fi signals of the surrounding APs. As the RSS measurements are carried out continuously at the reference stations dynamically changing maps of RSS distributions, so-called radio maps, can be derived. The DWi-Fi concept was evaluated in several field campaigns conducted at TU Wien, RMIT University and The University of Melbourne as well as at the Ohio State University.

The working group also maintained a strong and active presence at the following international events through participation in coordinating workshops, scientific and organizing committees, delivering short courses and tutorial, publishing papers and presentations, session chairing, etc.

- ION ITM, California, USA, Jan 30-Feb 2, 2017
- ION Pacific PNT 2017, Honolulu, Hawaii, May 1-4, 2017
- FIG Working Week, Helsinki, Finland, May 29-June 2, 2017
- ION GNSS, Portland, Oregon, USA, Sep. 25-29, 2017
- Mobile Mapping Symposium, Cairo, Egypt, May 6-8, 2017
- IAG-IASPEI, Kobe, Japan, July 30-Aug. 4, 2017

Upcoming work will consist the continuation of the research in the field of ubiquitious localization of smartphone users as well as other sensor platforms in combined out/indoor environments. The evaluation and analyses of the collected measurement data at the conducted field campaigns is well under way and will be continued. Results will be presented at the FIG General Assembly in Istanbul, Turkey and upcoming ION PLANS and GNSS+ as well as IPIN conferences.

2.6 WG 5.6 – Cost Effective Positioning

Chaired by Leonid A. Lipatnikov

For the WG 5.6 the most important accomplishment of the year 2017 was organizing the Cost Effective Positioning and Geo Data Seminar which took place in Novosibirsk, Russia on 20 April. The primary objective of the Seminar was to shape a vision for the future of cost-effective positioning technologies. The seminar was aimed at bringing developers of precise low-cost solutions, surveyors, and other potential users together. The agenda of the seminar covered both hardware and software solutions. Access to the Seminar was open to all participants of Interexpo Geo-Siberia. The total number of attendees at the Seminar was more than 60 including participants from Russia, Germany, and Belgium. Handouts and photos of the Seminar can be found at http://www.fig.net/news/news_2017/04_comm5_novosibirsk.asp

An online lecture “Precise Point Positioning: Principles, Applications, Prospects” was given by Leonid Lipatnikov on March 1, 2017 in the frame of webinar series organized by Alexander Ustinov. Especial attention was payed to cost-efficiency aspects of PPP, including free software, free online processing services, free data sources, and prospects of free real-time access to correction data via satellite based augmentation systems. The lecture attracted 86 attendees online, gained more than 1,100 watches over 11 months. Available in Russian language at https://www.youtube.com/watch?v=hNUbis1H6j0

The focus of the forthcoming year is publication on cost-effective positioning techniques.

3. Cooperation

3.1 Cooperation with Other Commissions

This cooperation with other commissions primarily consisted of holding joint technical seminar, e.g. Cost Effectove Positioning and Geo Data Seminar was orgnised together with *Commission 3*. The seminar "Digital Geodesy for Smart Cities-Reference Frames, Positioning, Surveying and BIM" will be organised by together with *Commssion 6 and 10* in 2018.

3.2 Cooperation with Sister Organisations

The Cost Effectove Positioning and Geo Data Seminar was orgnised together with *Siberian State University of Geosystems and Technologies (SSUGT)*. Technical Seminar on Reference Frame in Practice in 2017 was orginised togother with *IAG, UN-GGIM-AP,ICG, Geospatial Information Authority of Japan (GSI) as well as Japan Federation of Surveyors (JFS).* Digital Geodesy for Smart Cities-Reference Frames, Positioning, Surveying and BIM Seminar will be organised together with *Romanian Surveyors Union and Romanian Association of Private Surveyors*.

3.3 Cooperation with UN

In December 2017, Suelynn Choy and FIG Vice President Mikael Lilje attended the 12th meeting of the UN ICG, in Kyoto, Japan, from 2-7 December 2017. The report can be found:
http://fig.net/news/news_2017/12_icg_12.asp

3.4 Cooperation with ISO

Nic Donnelly, Chair of Working Group 5.2 is also the FIG special liaison to ISO/TC211. As part of this role, he represents FIG on the Control Body for the ISO Geodetic Registry. This registry is being developed to provide an authoritative source of 3D and vertical reference frame data, primarily to support the geospatial community. He is also a member of the project team for ISO19161 *Geographic information -- Geodetic references -- Part 1: The international terrestrial reference system (ITRS)* and the editing committee for ISO 19111 *Geographic information -- Spatial referencing by coordinates*. These development/revision of these standards will make it easier for the geospatial community to correctly and efficiently utilise geodetic reference frames.

4. Events

FIG/IAG/ UN-GGIM-AP/ICG/GSI/JFS Technical Seminar on Reference Frame in Practice was held on 29-30 July 2017 in Kobe, Japan. The proceeding and report can be found in
http://www.fig.net/resources/proceedings/2017/2017_07_refframe_japan.asp and
http://www.fig.net/organisation/networks/capacity_development/asia_pacific/events/2017_refframe_kobe/RFIP_Kobe_FIG_UNGGIM_Report.pdf

Cost Effective Positioning and Geo Data Seminar was organised within the frame of the XIII International Exhibition and Scientific Congress "Interexpo GEO-Siberia 2017" in Novosibirsk, Russia on April 20, 2017.

The handouts and the report are available at
http://www.fig.net/news/news_2017/04_comm5_novosibirsk.asp

A *special Session "Trends in GNSS"* was orgnised by Commission 5 at the well-known international exhibition and congress "Intergeo 2017" in Berlin, Germany (26-28 September 2017). The member of comission 5, Dan Roman, Suelynn Choy and Li Zhang have made presenations ("High Precision GNSS", "Physical Heights from GNSS" and " Low-Cost GNSS for geodetic applications") in this session, the session was well attended.

2018

In 2018 Commission 5 will endeavour to send representatives to the following conferences:

- FIG/IAG/UN-ICG/HKMO Technical Seminar on Vertical Reference Frames in Practice, 04-05 May in Istanbul, Turkey
- FIG Congress 2018, 06-11 May in Istanbul, Turkey
- ION GNSS+ 2018, 24-28 September 2018, Miami, Florida, US
- IPIN 2018, 24-27 September 2018, Nates, France
- Digital Geodesy for Smart Cities-Reference Frames, Positioning, Surveying and BIM, 25-26 October 2018, Bucharest, Romania

5. Communication and publications

Commission 5 have issued numerous reports and periodic newsletters to our delegates. These information can also be found on websites

- http://www.fig.net/organisation/comm/5/index.asp

Suelynn Choy and Leonid Lipatnikov are planning to revise the publication "Cost Effective GNSS Positioning Techniques".

Aditionally it is planned to revise the Reference Frames in Practice Manual as a Web-based-version in 2018.

Volker Schwieger
Chair