

FIG Commission 5

Annual Report of Activities 2019

1. General

The Commission 5 2019-2022 work plan covers the development, use and integration of technologies for positioning and measurement and the associated standardisation, best practice and fundamental reference frame issues. Many of the issues are global in nature and FIG Commission 5 along with many other International Associations is well suited to tackle the technological challenges we face. There is an ongoing cooperation with United Nations Agencies to address global problems such as sustainable development and humanitarian needs. The disciplines covered by Commission 5 will deliver solutions for the spatial aspects of these important global problems. Specific activities aimed at developing countries include examination of Low Cost Surveying Technologies, assistance with implementation of modern Geodetic and Vertical Reference Frames and associated infrastructure and contribution to appropriate Continuing Professional Development programs.

Specifically, to work closely with the International Association of Geodesy (IAG) and the United Nations Global Geospatial Information Management (UN GGIM) on the development of new models, standards and tools for implementing a Global Geodetic Reference Frame (GGRF) that includes aspects of the International Terrestrial reference Frame (ITRF) and the International Height Reference Frame (IHRF). The GGRF will serve as a global standard for all Nations to implement their respective national datums. As such, this directly impacts FIG Members who must implement these new datums and the requirements to access them.

In addition to the specific activities above, the Commission will support and contribute to FIG Task Forces, the Standards Network, and regional Capacity Development Networks (e.g., AP CDN). The Commission will also respond to the FIG Council to address new issues as they emerge.

The year 2019 for Commission 5 has been primarily focused on the technical activities for the FIG operational surveyor. Our activities have been associated with the technical programme for the FIG 2019 Working Week in Hanoi. The *Technical Seminar on Reference Frame in Practice* was held prior to and in conjunction with the FIG Working Week 2019 on 20-21 April 2019 in Hanoi. The next Technical Seminar on Reference Frame in Practice will be held in conjunction with the SIRGAS meeting in Bolivia (South America).

We have also continued our effective collaboration with our international sister organisations to promote and fulfil the FIG objectives. The International Association of Geodesy continues to lead in the development of newer reference frames, such as ITRF 2014. This model is being evaluated and implemented for positioning and measurement in countries around the world. In particular, the IAG International GNSS Service (IGS) and FIG Commission 5 have exchanged liaisons to better ensure cohesiveness in GNSS activities.

A summary of the working group activities in 2019 is as follows:

2. Working Groups

WG 5.1 – Standards, Quality Assurance and Calibration

Chaired by David Martin

Standards play an important role in surveying and particularly with modern instrumentation that give black box solutions and measurements that are not necessarily understood by the average practicing surveyor. Although surveyors are not directly implicated in standards and standardisation, 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. Working Group 5.1 is also very closely linked to the FIG Standards Network. Importantly Working Group 5.1 is the contact for FIG liaison to the ISO Technical Commission (TC) 211 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. Nic Donnelly, from Land Information New Zealand, is the FIG liaison to TC211. One item of interest to Commission 5 is the start of a new standard for Discrete Global Grid Systems (DGGS), ISO19170. This work is undertaken jointly with OGC, which has already published a standard on DGGS. DGGS are designed to support big-data processing at global scales, providing a scalable means of assigning location to data at any desired resolution.

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). Ingo Neumann from the Geodätisches Institut Leibniz Universität Hannover is the FIG representative to ISO/TC 172/SC 6. One key standard where work is presently concentrated is ISO/DIS 17123-9 - Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments -- Part 9: Terrestrial laser scanners. Another is the republication of ISO 17123-5:2018 Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments -- Part 5: Total stations with updated formulas and an improvement in the layout. Finally, the new Standard ISO 9849 is published – Optics and optical instruments - - Geodetic and surveying instruments – Vocabulary. This standard is very important for FIG because it summarizes vocabulary used in the field of geodetic and surveying sensors and instruments. It has been extended to include terms in the area of multi-sensor-systems of the future.

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.

WG 5.2 – 3D Reference Frames

Chaired by Nic Donnelly

The working group has continued its strong focus on accounting for geodynamics within 3D reference frames. This has involved close collaboration with our counterparts in the International Association of Geodesy 's deformation modelling working group led by Richard Stanaway. Of particular note is work undertaken on two potential formats for deformation models in which working group members have been involved. One is based on GeoTIFF and the other is based on the HDF5 format. Work is now underway to implement the GeoTIFF format into the PROJ open-source software stack. This will provide an implementation that other software vendors may also be able to leverage. Having an internationally agreed format for deformation models is becoming more urgent as many nations actively pursue datum modernisation programmes.

In terms of outreach, the main focus was the Reference Frames in Practice workshop held in conjunction with the 2019 Working Week in Hanoi. This featured two days of presentations and seminars and included good engagement from the local Vietnamese geodetic community. Further workshops are planned for later in 2020 (in conjunction with the SIRGAS meeting) and for the 2021 Working Week.

Work has commenced on a revised edition of FIG publication No. 64, Reference Frames in Practice Manual. The aim is to have this complete towards the end of 2020. Amongst other things, the manual will be updated to include information about the latest global reference frames, the UN-GGIM Global Geodetic Reference Frame and additional national case studies.

WG 5.3 – Vertical Reference Frames

Chaired by David Avalos-Naranjo

In order 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, this working group has promoted education through participation in the international workshop Reference Frames in Practice, Hanoi, Vietnam, April 20, 2019. This participation helped increase the understanding of modern VRFs and realize the actions needed to relate vertical positioning datasets from different sources. Additionally, during the FIG Working Week 2019, WG5.3 convened a technical session where representatives from 15 countries witnessed and discussed practical aspects of constructing and using vertical reference frames, as well as reviewed the current challenges of switching to modern definitions and more accurate VRFs like the International Height Reference System (IHRM).

WG 5.4 – GNSS

Chaired by Suelynn Choy and Ryan Keenan

The GNSS working group continues to support multi-constellation GNSS activities through in the UN International Committee on GNSS (UN ICG) with collaboration from the International GNSS Services (IGS), International Association of Geodesy (IAG) and Multi-GNSS Asia (MGA).

Significant progress has been made in 2019 towards addressing “Interoperability of GNSS Precise Point Positioning (PPP) Services” by GNSS/RNSS and SBAS System Providers. WG 5.4 convened two specialized workshops on GNSS PPP services at the Applications of Global Navigation Satellite Systems Workshop, Suva, Fiji, 24-28 June 2019. More specifically these sessions provided presentations to increased awareness of the system-provided PPP services, the user benefits, and opportunities to support point navigation and timing applications in developing countries. It also encouraged standardization and interoperability of the system provided PPP services. A joint meeting took place at the 14th Meeting of the International Committee on Global Navigation Satellite Systems (ICG-14) in Bangalore, India, 9-13 December 2019, which highlighted the importance to harmonize key aspects of System Provided PPP services. This subsequently led to a recommendation to establish a Task Force within ICG to address key aspects of “Interoperability of GNSS Precise Point Positioning (PPP) Services”. The PPP Task Force will be chaired by Australia (Australian SBAS), Japan (QZSS) and the European Union (Galileo). FIG WG 5.4 is a member of the Task Force and will continue to monitor, contribute and report on the Task Force’s progress and work.

Detailed FIG Report on “Applications of Global Navigation Satellite Systems Workshop Suva - Fiji, 24-28 June 2019” can be found here:

https://www.fig.net/organisation/networks/capacity_development/asia_pacific/report/FIG_AP_CDN_and_Comm%205_Report-UN-ICG_Suva_Fiji.pdf

FIG Report on “14th Meeting of the International Committee on Global Navigation Satellite Systems (ICG-14)”: http://www.fig.net/news/news_2019/12_icg14.asp

In terms of Outreach and capacity building activities beyond those mentioned above for ICG et al, FIG WG 5.4 is actively involved in two working groups within the UN GGIM’s Subcommittee on Geodesy (SCoG). At present, these two groups - Outreach & Communication (OC), and Education, Training and Capacity Building (ETCB) - are focussed on their respective activities in raising awareness about, and adoption of, the Global Geodetic Reference Frame (GGRF) in support of current and future mass-market satellite-based positioning needs and applications as well as the UN SDGs. In particular, the WG ETCB will be presenting a paper at FIG WW 2020 on the results of a global Questionnaire around the perceived geodetic Reference Frame competency levels around the world, and subsequently the global geodetic community’s needs around ETCB. Also, all working groups on the SCoG are involved with the definition of how the proposed UN GGIM Global Geodetic Centre of Excellence (GGCE) could look like in terms of governance, mandate and objectives.

https://www.unggrf.org/UN-GGIM_Newsletter_10-2019.pdf

Additionally, FIG WG 5.4 was approached directly by ISO TC20/SC14/WG1 to assist with reviewing WD24246 - the development of a new standard for ‘GNSS positioning augmentation centers’. This review process will continue into 2020, with an expected publication near the end of 2020. With this new standard, it is expected that the dissemination of GNSS

augmentation information from solution providers will be open, unambiguous and accessible to the growing user community.

In summary, FIG WG 5.4 is actively involved with those groups responsible for helping to define the future of GNSS positioning into the next decade, and beyond.

WG 5.5 – Multi-Sensor-Systems

Chaired by Allison Kealy and Günther Retscher (IAG)

In 2019, WG efforts focused on processing techniques in three primary areas – firstly, more representative statistical error distributions for the non traditional sensors such as wifi and ultra wideband based on real-world data; secondly, the implementation of novel techniques such as differential wifi and information grammar as approaches to improving the positioning solution achievable from traditional sensor fusion techniques and thirdly, robust, decentralised fusion algorithms for scalable and practical collaborative networks. Contributions to each of these three areas were made by RMIT University, Australia, the University of Melbourne, Australia, the Ohio State University, USA, TU Wien, Austria, Athens Technical University, University of Padova, Padova, Indian Institute of Technology, Kanpur, India. The full details around these approaches, the research hypotheses, datasets used, experimental setups and results are detailed in publications from the collaborating researchers.

This WG undertook a follow up to the outreach program in Sri Lanka in 2018. Working collaboratively with the Sabaragamuwa University (Geomatics Department), a workshop was conducted specifically with a knowledge transfer focus. A key aspect of this workshop was a data collection campaign to evaluate the performance of GAGAN the Indian contribution to GNSS. We expect to continue to deepen this relationship in the future. Members of this WG are also very active in promoting the women in positioning, navigation and timing (PNT) activities underway in other professional associations such as the ION and RIN.

WG members participated in various capacities in the following conferences:

- FIG Working Week, April 2019, Hanoi, Vietnam
- ION GNSS+ Conference, September, 2019, Miami, USA
- ION Pacific PNT, 2019, Honolulu, Hawaii
- 27th International Union of Geodesy and Geophysics (IUGG), 2019, Montreal, Canada
- International Navigation Conference, 2019, Edinburgh, Scotland
- Mobile Mapping Symposium, 2019, Shenzhen, China
- Ubiquitous Positioning, Indoor Navigation and Location Based Services (UPINLBS), 2019, Beijing, China
- Joint International Symposium on Deformation Monitoring (JISDM), May 2019, Athens, Greece
- Intergeo Congress 2019 September 2019, Stuttgart, Germany

WG 5.6 – Cost Effective Positioning

Chaired by Leonid A. Lipatnikov and Li Zhang

In 2019, FIG report 74 "Cost effective precise positioning with GNSS" was published. The report contains an overview of a vast variety of options enabling cost-effective use of precise GNSS positioning. High-precision low-cost GNSS hardware, software-defined receivers,

CORS networks, free data and information sources, versatile free open source software, free online post-processing and real-time correction services, and SBAS are discussed. Current trends and forecasts for technology development, adoption, and cost dynamics are analyzed. It is shown how the decrease of the user costs for high precision positioning may be shaped by the emerging applications including location based services, automatic UAV guidance, and self-driving cars. General recommendations for choosing a cost-effective positioning technology are proposed. Work on the second edition of the report is in progress.

WG members Participated in the following conferences:

- FIG Working Week, April 2019, Hanoi, Vietnam
- Geo-Siberia, April 2019, Novosibirsk, Russia
- Joint International Symposium on Deformation Monitoring (JISDM), May 2019, Athens, Greece
- Intergeo Congress 2019 September 2019, Stuttgart, Germany

3. Cooperation, Seminars and Workshops

3.1 Cooperation with Other Commissions

Commission 5 supported Commission 6's efforts to hold the Joint International Symposium on Deformation Monitoring (JISDM) in Athens, Greece during May 2019. Commission 5 focused on regional to global deformation, while Commission 6 focused on regional to local deformation.

Commissions 2 and 5 and the YSN are supporting efforts by the UN SCoG WG ETCB to develop a better understanding of capabilities by Nation and locating education and training resources for surveyors around the world.

Other areas include:

- Commission 4 regarding Hydrographic Surveying on the Ellipsoid
- Commission 6 and ISPRS on Laser Scanning
- Commission 6 on UAV Usage for Surveying
- Commission 7 and 3 on Cost-Effective Positioning
- Regional Capacity Development efforts in Asia-Pacific, Africa, and the Americas

3.2 Cooperation with Sister Organisations

Some other details on this were given above. Commission 5 has continued to maintain a successful working relationship with the International Association of Geodesy (IAG), the ION and the ISPRS. This was achieved by convening joint Technical Seminars on Reference Frames in Practice, technical sessions and holding joint administrative meetings on significant issues. Additionally multidirectional exchange on Seminars and Symposia are practised e.g.

During 2019, the following Technical Seminar on Reference Frame in Practice was held with sister organisations in Hanoi, Vietnam.

Report on Technical Seminar on Reference Frames in Practice on 20-21 April 2019 in Hanoi, Vietnam

Introduction:

The Technical Seminar on Reference Frames in Practice was held in Hanoi on 20-21 April 2019. The seminar generally covered vertical and geometric reference frames with a focus on examples for the Asia-Pacific region. An overview of involved international organizations (e.g., UN-ICG/OOSA) was also presented. BELS+ Training was completed on the second day providing practical, hands-on training. The Seminar was organized by FIG Commission 5, in conjunction with the International Association of Geodesy (IAG), the United Nations International Committee on GNSS (UN ICG), UN Global Geospatial Information Management – Asia Pacific (UN-GGIM-AP), BELS+, and the Vietnam Association of Geodesy, Cartography, and Remote Sensing (VGCR). The seminar was held in the InterContinental Landmark 72 Hotel in conjunction with the FIG Working Week 2019 at the Vietnam National Convention Center. Primary organisers were Daniel Roman (FIG Comm. 5) and Kevin Ahlgren (FIG Comm. 5).

Participants:

There were 43 participants including presenters from around the world representing 20 different countries. Countries represented included Australia, Austria, Bangladesh, Belgium, Fiji, Germany, Italy, Japan, Mexico, New Zealand, Pakistan, Philippines, Qatar, Russian Federation, Singapore, Spain, Uganda, United States, and Viet Nam. Attendees represented a mix of academic, government, and commercial institutions. List of participants is given as Appendix A to this report.



Figure 1: RFIP 2019 Attendees

Technical Content:

The seminar focused on the theory and practice of 3D reference frames. Topics covered were:

- International Geodesy Initiatives and Geodetic Infrastructure:
 - ICG at the UN
 - UN-GGIM-AP
- Introduction to Reference Frames:
 - Introduction to Geodetic Reference Frame Theory
 - Introduction to Vertical Reference Frames
 - Reference Frames, Datum Transformations, and GIS

- Case Studies from the surrounding region:
 - Vietnam, Japan, USA, Russia, New Zealand, and Papua New Guinea

The presentations and final technical program are available on the FIG website at <http://www.fig.net/fig2019/rfip.htm>.



Figure 2: Hands-on Demonstration from NAVIS

Networking and Social Events:

There were excellent opportunities to network and socialize during the lunch and tea breaks, which the participants took advantage of. One of the highlights of the seminar was the dinner held on the first evening. Dinner was held at Buffett Poseidon and provided an opportunity to sample all of the local seafood dishes and continue networking.

Sponsorship:

The seminar was supported by Leica Geosystems, who provided a generous financial contribution, attended the seminar, and provided a brief presentation given by Neil Ashcroft, Regional Technical Support Manager – ASIA Geomatics. The UN-ICG provided financial support to seven participants from developing nations (shown in bold text in list of participants). The organisers FIG, IAG, UN-ICG, UN-GGIM-AP, BELS+, and VGCR would like to thank and acknowledge the sponsors for their generous support of this event.

3.3 Cooperation with UN

FIG and IAG are both supporting the UN International Committee on GNSS (UN ICG) as well as the UN Global Geospatial Information Management (UN GGIM) Committee. The UN GGIM has implemented the Global Geodetic Reference Frame (UN GGRF) that is being implemented by the UN GGIM SubCommittee on Geodesy (UN SCoG). The UN SCoG has several working groups including one on Education, Training and Capacity Building (WG ETCB). The FIG Leadership as well as Commissions 2 and 5 are working closely with ETCB to evaluate the geodetic and surveying capabilities of Nations and to catalog available training resources for surveyors around the world.

3.4 Cooperation with ISO

There has been ongoing interaction with ISO/TC211, the geographic information technical committee of ISO. Nic Donnelly is the Special Liaison from FIG to ISO/TC211. Work of particular interest to Commission 5 includes the review of ISO 19111:2019, spatial referencing by coordinates, the ongoing work on the Geodetic Registry and ISO 19161-1:2020, the new standard for the International Terrestrial Reference System. The update to

ISO 19111 is focussed particularly on better accounting for kinematic frames (time-dependent coordinates) and geoid-based vertical datums. It was revised in conjunction with the Open Geospatial Consortium (OGC), as is the case with many ISO standards, to ensure that the revised standard represents a wide industry view.

4. Events

2019

A summary of the Commission 5 activities at events in 2019 can be found on our website <http://www.fig.net/commission5/index.htm> but a partial list is given here:

- IAG-IGS meeting, Vienna, Austria, April 2019
- RFIP 2019, Hanoi, Vietnam, April 2019
- FIG WW 2019, Hanoi, Vietnam, April 2019
- Applications of Global Navigation Satellite Systems Workshop, Suva, Fiji, June 2019
- Multi GNSS Asia (MGA) Conference, Bangkok, Thailand, August 2019
- 8th Plenary Meeting of UN-GGIM-AP - Asia Pacific Capacity Development Network, Canberra, Australia, November 2019
- 14th Meeting of the International Committee on Global Navigation Satellite Systems (ICG-14), Bangalore, India, December 2019

2020

In 2020, Commission 5 will endeavour to send representatives to the following conferences:

- FIG Working Week 2020, 10 - 14 May, 2020, Amsterdam, Netherlands
- UN-GGIM-Americas/IAG/FIG Technical Seminar on Reference Frames in Practice at SIRGAS meeting in Bolivia.

5. Communication and Publications

Commission 5 has 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>

Daniel R. Roman,
Chair

Chair of FIG Commission 5
February 2020