# FIG Commission 5

## Report of Activities 2011-13

## 1. General

From the start of the 2011-14 term FIG Commission 5 has investigated practical solutions to global survey problems, and facilitated technical activities pertaining to the development, use and integration of technologies for positioning, measurement, survey infrastructure, and the associated standardisation, best practice and fundamental reference frame issues.

Our specific activities have been aimed at developing countries, low cost surveying technologies, implementation of modern geodetic reference frames, applications of geospatial and positioning infrastructure, and the professional development of the operational surveyor.

Throughout the current period, Commission 5 has focused work on achieving realistic tangible outcomes for our 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

During the period, the Commission 5 has focused our energy to ensure that the annual FIG Working Weeks in Marrakech, Rome, Abuja and Kuala Lumpur have been successful, as well as the FIG Regional Conference in Montevideo (Uruguay) and the FIG Pacific Small Islands Developing States Symposium in Suva (Fiji). To date Commission 5 has facilitated over 275 technical presentations at our technical sessions, special forums or meetings.

We have also effectively collaborated with our sister organisations at various events to promote and fulfil the objectives of our work plan, especially at events such as the General Assembly for the International Union of Geodesy and Geophysics (Melbourne, Australia), the annual International Committee on GNSS events (Tokyo (Japan), Beijing (China), Dubai, (UAE)) and the symposium series on Mobile Mapping Technology.

In addition to this, the Commission has been responsible for the Technical Seminar on Reference Frames in Practice, which have been convened jointly with

the with the International Association of Geodesy (IAG), the United Nations Global Geospatial Information Management – Asia Pacific (UN GGIM-AP), the International Committee on GNSS (ICG) and our Platinum FIG Corporate sponsors. We have held two technical seminars, one in Rome (Italy), and the other in Manila (Philippines). These seminars examined reference frames issues pertinent to each region. Smaller versions of this technical seminar have also been organised within the technical program of other FIG events.

The Commission has also recently prepared two publications which are to be released at the FIG Congress in Kuala Lumpur. The first is an updated version of FIG Publication No 49 - Cost Effective GNSS Positioning Techniques, and the second is a new publication consisting of technical fact sheets to form a "Reference Frames in Practice Manual".

Another key highlight for the Commission during the term so far was the development of a special edition for the Journal of Applied Geodesy which was undertaken with IAG and includes papers on Ubiquitous Positioning and Navigation Systems.

The ongoing success of FIG Commission 5 is largely due to the dedicated hard work of our Working Group Chairs and members from Commission 5. They have all been actively representing FIG at numerous related symposia around the world and whilst advancing the work of the working groups. Some of the major highlights so far of the working group activities are summarized as follows:

# 2. Working Groups

## WG 5.1 – Standards, Quality Assurance and Calibration

Chaired by David Martin

Standards continue to play important role in surveying. This is particularly true in the world where the details of instrumentation and techniques are not well understood by the average practicing surveyor. They are very reliant upon standards underpinning the correct functioning of their instruments.

The working group was active at the annual FIG Working Weeks. Looking back at the 2011 event in Marrakech was the session dedicated to GNSS CORS Infrastructure and Standards.

### FIG publication No. 9 on *Recommended Procedures for Routine Checks of Electro-Optical Distance Meters*

In Marrakech the working group organised a meeting to discuss future actions regarding the FIG publication No. 9 on *Recommended Procedures for Routine Checks of Electro-Optical Distance Meters*. At the meeting in Marrakech it was decided that the publication should be revised with additions for recommendations for hand held distance-meters and reflector-less instruments. There was also some discussion concerning FIG Publication No. 9. Unfortunately,

this work has been forced to put on hold but it is suggested that this should be included in the work plan for the period 2015-18 for the Commission.

**Proposal for a standard related to ITRS**

An important initiative is underway to submit to ISO a proposal for a standard related to ITRS. The French standardization agency AFNOR has proposed to ISO to establish an ad hoc structure dealing with standardization on geodetic references and that this structure should be established within the ISO TC 211 on Geospatial Information. The international working group is established even though progress is slow.

**ISO TC211, TC172/SC6 and other ISO issues**

Briefly, 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.

Another important standard under development under the supervision of ISO TC211is Geographic information – Calibration and validation of remote sensing imagery sensors – Part 1: Optical sensors:
"Imaging sensors are one of the major data sources for geographic information. The image data capture spatial and spectral measurements and are applied for numerous applications ranging from road/town planning to geological mapping. Typical spatial outcomes of the production process are a vector maps, Digital Elevation Models, and 3-dimensional city models. There are typically 2 streams of spectral analysis data, that is, the statistical method, which includes image segmentation and the physics-based method which relies on characterisation of specific spectral absorption features.

In each of the cases the quality of the end products fully depends on the quality of the measuring instruments that has originally sensed the data. The quality of measuring instruments is determined and documented by calibration."

ISO/TC 172/SC 6 deals more closely with classical surveying instruments. Standards deal with field procedures for testing geodetic and surveying instruments such as theodolite, total stations levels and GNSS in real-time kinematic (RTK). Several of these standards are in the Review Stage to be revised.

Several other standards under Technical Committee ISO/TC 172/SC 6 "Geodetic and surveying instruments" standards grouping are also presently under discussion and/or revision:

- Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments -- Part 4: Electro-optical distance meters (EDM measurements to reflectors)
- Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments -- Part 5: Total stations
- Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments -- Part 6: Rotating lasers
- Optics and optical instruments -- Ancillary devices for geodetic instruments -- Part 1: Invar levelling staffs.
- ISO 09849 Geodetic and surveying instruments - Vocabulary (Edition 3)
- ISO 12858-1 Optics and optical instruments -- Ancillary devices for geodetic instruments -- Part 1 Invar levelling staffs (Edition 2)
- ISO 12858-2; 1999 Amendment 1
- ISO 17123-5 Field procedures for testing geodetic and surveying instruments - Part 5 - Total stations (Edition 2)
- ISO 17123-6 Field procedures for testing geodetic and surveying instruments - Part 6 - Rotating lasers (Edition 2)
- ISO 17123-7 Field procedures for testing geodetic and surveying instruments - Part 7 - Optical plumbing devices
- ISO 17123-8 Field procedures for testing geodetic and surveying instruments - Part 8 - GNSS field measurement systems in real-time kinematic (RTK) (Edition 2)
- ISO 17123-9 Field procedures for testing geodetic and surveying instruments - Part 9 - Terrestrial laser scanners (TLS) A principal aim of Working Group 5.1 over the coming year 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.

A principal aim of Working Group 5.1 over the period has been 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.

In 2012 at the FIG Working Week in Rome, Nic Donnelly of Land Information New Zealand (LINZ) agreed to replace Ian Greenway as the FIG liaison to the ISO Technical Commission (TC) 211. Current work items include:

- 19119 – services (revision)
- 19157 – data quality (at FDIS stage so no real chance to change now)
- 19159-1 – calibration of remote sensitive imagery sensors (optical)
- 19160-1 – addressing: conceptual model
- 19161 – geodetic references
- 19162 – well known coordinate reference systems

Hans Heister is the FIG liaison to TC172/SC6.

### Future issues

Nic Donnelly, from Land Information New Zealand, spoke about the importance of Metadata standards. This is an important field - not just in surveying and geodesy. He is looking to establish a joint FIG/IAG working group to study this important subject.

FIG has decided to join the coalition developing the International Property Measurement Standards IPMS. The IPMS Coalition currently comprises following 20 members, including the FIG, who have signed the Declaration.

## WG 5.2 – Reference Frames

Chaired by Graeme Blick

### Education and Training

A strong focus of the Reference Frames Working Group 5.2 during the period so far has been on education and training. A strong need was identified to provide training on the use of Reference Frames in practice. Three successful Technical Seminars on Reference Frames were held. The inaugural meeting was held as part of the 2012 FIG Working Week in Rome with over 20 participants, the second was held following the 2013 South East Asia Survey Congress in Manila with around 40 participants, and the third was held as part of the joint FIG/UN-GGIM-AP Pacific Small Islands Developing States (SIDS) Symposium, Fiji in September 2013 with 20 participants from nearly all of the Pacific Island nations. These seminars have proved very successful with positive feedback and it is planned to continue to hold further workshops in the future.

Following the first seminar a need was identified to develop and publish a manual on reference frames. This is being produced as a series of two page fact sheets so that they can be easily updated and used individually. Contributions to the document have been made by various experts in their specific fields of interest. A draft manual has been developed and it is planned that this be released at the 2014 FIG Congress in Kuala Lumpur. The manual covers the following topics:

- Introduction
- Geodesy and Global Reference Frames
- Key International Geodetic Groups
- Global Terrestrial Reference Systems and Frames
- Regional and National Reference Frames
- Height Systems
- Standards and Traceability of Terrestrial Reference Frames
- Global Navigation Satellite Systems
- GNSS CORS Networks and Linking to ITRF
- Transforming Between Datums
- Reference Frame Parameter Estimation and Testing via the technique of Least Squares
- Transforming Between Datums in Non-static Reference Frames
- Least Squares Estimation

**Incorporating Deformation Models into Reference Frames**

Following the 2010 FIG Sydney Congress a small focus group was convened to work on issues around the establishment of 4 dimensional datums, i.e. those including a time variable component to account for the effects of crustal deformation. With the need for greater accuracy of national datums, there is an increasing requirement by countries to incorporate deformation models into their datum to model the effects of plate tectonic movements and episodic events such as earthquakes and volcanic deformation.

This group has focused on how deformation following episodic events such as an earthquake can be incorporated into a datum. The concept of a patch to model the deformation has been refined and this was trialled as a method to incorporate the effects of ground movements as a result of the recent Canterbury Earthquakes in New Zealand into their geodetic datum. Formats for deformation models were also refined, and a draft format circulated to interested parties for review. While the Canterbury Earthquakes are a highly relevant case study for this work, the aim was to develop deformation modelling processes that would be widely applicable internationally for earthquakes and other deformation events. Formats for the development of the deformation models have now been finalised and New Zealand has published its deformation model in this new format[1]. The use of forward and reverse patches has also been used in New Zealand to incorporate specific deformation events (such as earthquakes) into the deformation model.

The following papers and presentations have been given on the topic:

A High-Precision Deformation Model to support Geodetic Datum Modernisation in Australia, Stanaway, R., and Roberts, C. (2013): presented at the IAG Scientific Assembly, Potsdam, Germany.

Updating the NZGD2000 Deformation Model, Crook C. & Donnelly N. (2013): presented at the 125th New Zealand Institute of Surveyors Annual Conference, August 2013, Dunedin, New Zealand.

Using the Deformation model to Generate NZGD2000 Coordinates - A Practical Example, Donnelly, 2012: presented at the 124th New Zealand Institute of Surveyors Annual Conference, October 2012, Invercargill, New Zealand.

Four Dimensional Deformation Modelling, the link between International, Regional and Local Reference Frames (2012): Stanaway, R., Roberts, C., Blick, G., and Crook, C., FIG Working Week, Rome, Italy, 6-10 May 2012

ITRF Transformations in Deforming Zones to Support CORS-NRTK Applications; Stanaway, R., and Roberts, C. (2011): International Global Navigation Satellite

[1] http://www.linz.govt.nz/geodetic/datums-projections-heights/geodetic-datums/new-zealand-geodetic-datum-2000/deformation-model

Systems Society IGNSS Symposium, UNSW, Sydney, Australia 15-17 November, 2011

Modelling Deformation in a Kinematic Datum, Chris Crook (2011): in Earth on the Edge: Science for a Sustainable Planet, Proceedings of the IAG General Assembly, Melbourne, Australia, June 28 - July 2, 2011

Realisation of a Geodetic Datum Using a Gridded Absolute Deformation Model (ADM, R. Stanaway, C. Roberts, and G. Blick): in Earth on the Edge: Science for a Sustainable Planet, Proceedings of the IAG General Assembly, Melbourne, Australia, June 28 - July 2, 2011

Rigid Plate Transformations to Support PPP and Absolute Positioning in Africa Stanaway, R., and Roberts, C. (2011): FIG Working Week, Marrakech, Morocco, 18th-22nd May 2011

The Application of a Localised Deformation Model after an Earthquake (PDF 428KB), Winefield, Crook & Beavan, 2010: presented at the International Federation of Surveyors (FIG) Congress 2010, Sydney, Australia

The Implementation of a Semi-Dynamic Datum in New Zealand – Ten Years On (PDF 489KB), Blick & Grant, 2010: presented at the International Federation of Surveyors (FIG) Congress 2010, Sydney, Australia

Donnelly, N., Ritchie, J. and Amos, M. (2011). Re-establishment of the New Zealand Survey Control System following the 2010 Darfield (Canterbury) Earthquake, Proceedings of FIG Working Week, Marrakech, Morocco, 18-22 May. Online via www.fig.net/srl [accessed 4 February 2014].

Donnelly, N., Crook, C., Amos, M., Grant, D., Ritchie, J. and Roberts, C. (2014). Canterbury Earthquakes Deformation Model Accuracy, Proceedings of Surveying and Spatial Sciences Conference (LOCATE14), Canberra, Australia, 7-9 April (in press)

CORS Network and Datum Harmonisation in the Asia-Pacific Region Stanaway, R., and Roberts, C. (2010) XXIV FIG International Congress 2010, Sydney, Australia, 11-16 April 2010

**New Generation Datums**

The Cooperative Research Centre for Spatial Information (CRCSI) programme on Positioning in Australia has a project focused on the development of the next generation of geodetic datum. Several members of the working group are involved with this project.

With the rapid progress being made in the ability to generate real time Precise Point Positioning there is an increasing demand to have national datums that enable the generation and integration of real time coordinates in terms of the

official datum. These datum are likely to be 4 dimensional datum (dynamic) and tightly aligned with the ITRF.

Preliminary work has begun and this will be of relevance to this working group as we consider the development of new datums in the future. Particular areas of focus currently are the incorporation of remote sensing measurements (such as Synthetic Aperture Radar) and large 4D adjustments.

The following papers and presentations have been given on the topic:

Donnelly, N., Crook, C., Haasdyk, J., Harrison, C., Rizos, C., Roberts, C. and Stanaway, R. (2014). Dynamic Datum Transformations in Australia and New Zealand, Proceedings of Surveying and Spatial Sciences Conference (LOCATE14), Canberra, Australia, 7-9 April (in press)

Haasdyk, J., Donnelly, N., Harrison, C., Rizos, C., Roberts, C. and Stanaway, R. (2014). Options for Modernising the Geocentric Datum of Australia, Proceedings of Surveying and Spatial Sciences Conference (LOCATE14), Canberra, Australia, 7-9 April (in press)

**eGeodesy**

Geodesy is now very much an international science and one of its challenges has been the development of common data exchange formats so that data from different countries and States can be integrated and used for global and national datum development. A small group was set up with the aim of this work to facilitate seamless transfer of survey and adjustment data within the geodetic community. The working group is made up of representatives from New Zealand and Australia, but the model should be suitable for use in any jurisdiction.

The most substantial piece of work has been the use of the data model to develop a Geography Markup Language (GML) compliant schema. The advantage of compliance with GML is that the transfer format will then be more widely supported by software vendors, as many already support GML. A GML standard has been published by the International Standards Organisation (ISO), so the use of GML should ensure wide support for the geodetic transfer format being developed. The Use Case documentation has been developed, which outlines the major behaviours expected of an automated geodetic management system. Nic Donnelly (New Zealand) spent several months at JPL looking into the topic and meeting with North American colleagues who expressed interest in the work.

A major milestone for the eGeodesy programme was reached with the draft model, XML application schema and associated documentation being published.

The following papers and presentations have been given on the topic:

http://icsm.govspace.gov.au/egeodesy/egeodesy-model/

Donnelly, N., Fraser, R., Haasdyk, J. and Tarbit, S. (2013). GeodesyML – A GML Application Schema for Geodetic Data Transfer in Australia and New Zealand, Proceedings of Spatial Sciences & Surveying Conference 2013 (SSSC2013), Canberra, Australia, 15-19 April. Online via http://www.lpi.nsw.gov.au/surveying/publications/technical_papers [accessed 4 February 2014].

Fraser R., Donnelly, N. (2010). Progress Towards a Consistent Exchange Mechanism for Geodetic Data in Australia and New Zealand, Proceedings of FIG Congress 2010, Sydney, Australia, 11-16 April. Online via www.fig.net/srl [accessed 4 February 2014].

## WG 5.3 – Geodetic and Positioning Infrastructure

Chaired by Neil D. Weston

The national developments regarding geodetic and positioning infrastructure was as intense as usual during 2012. Many countries are developing their infrastructure to meet the demands of the users. The development of national GNSS CORS is rapid. The International GNSS Service (IGS) is playing a very important role to develop standards and recommendations on how a reference station should be set up. These issues were raised and discussed at FIG events such as the Reference Frame Technical Seminar and Working Week in Rome, and at other related symposiums. WG 5.3 has actively participated in the development of technical sessions and creation of presentations for technical seminars and Working Weeks during the period. Guidelines on how to build a CORS within the United States can be found at the following link - http://www.ngs.noaa.gov/PUBS_LIB/CORS_guidelines.pdf

It has also contributed to the revision of the FIG publication no 49 on "Cost Effective GNSS Positioning Techniques" as well as the coming FIG publication "Reference Frames in Practice Manual". Concerning publications, The Federal Geographic Data Committee in the United States has developed an A-16 Portfolio Management Implementation Process for datasets and data themes. There are 16 data themes in all, four of which are managed by the National Geodetic Survey, NOAA. The NGS managed themes are 1) Airborne Gravity, 2) Continuously Operating Reference Stations (CORS), 3) Geoid Models and 4) National Geodetic Survey Datasheets. The coordinator of each theme provides inter-agency coordination and leadership, planning, content and implementation within the community.

This working group also provided presentations and assistance with technical sessions, and often together with our sister organisations IAG, at several occasions as e.g. the ICG-7 (Beijing, China), the PPP-RTK and Open Standards Symposium (Frankfurt, Germany) and the IGS Workshop (Olztyn, Poland).

A proposal to investigate 'standardization needs' for geodetic references, has been submitted by France to the International Standardization Organization (ISO) in early 2012. This proposal was specifically sent to the ISO Technical

Committee 211 on Geographical Information / Geomatics. This proposal was approved in June by ISO TC 211 under the title of Project 19161. FIG endorses this initiative and needs to be actively involved in this effort in the future.

The International GNSS Service IGS) is one of the most important organisations and FIG has a very strong relationship with them. One of the major projects currently underway is the "repro2" which involve the re-processing all the GNSS data collected at the IGS reference stations. Supplemental data is included from a number of regional networks to strengthen the ties around the globe.

Another area with significant interest is in the real-time sector. In the United States, the National Geodetic Survey will hold a symposium of all the real-time network operators to discuss how each network provider can benefit by following an agreed upon set of standards and guidelines. The goal is to ensure network providers are tied to the national reference frame and the coordinates they produce in their software packages are consistent from one regional network to the next. The symposium is set to take place on March 20, 2014.

Probably the biggest endeavour the geodetic agencies in the United States are working on is to move to a geometric datum that is aligned to the ITRF. The initial plans are to switch the current horizontal datum in the United States (NAD83) sometime in 2020. Although final implementation is a long way off, a significant amount of work has to be performed on the legislative side. A grass-roots effort will begin soon to educate the positioning communities about the impacts and benefits to switching to a 3-D geometric datum.

New Appointment: Dr. Neil D. Weston, Deputy Director of the National Geodetic Survey, NOAA, will serve as the U.S. representative to the Working Group on Global Geodetic Reference Frame for Sustainable Development. Dr. Weston also served as a member of the U.S. Delegation during the 3rd Committee Meeting of the UN-GGIM Conference in Cambridge, England last summer.

## WG 5.4 – Kinematic Measurements

Chaired by Volker Schwieger

The geodetic world and therefore the surveying profession are moving from static to kinematic measurements, consequently Commission 5 established this new Working Group (WG) for the term 2011-14. The working group has consisted of an active group of practitioners and academics from four continents. The two technical main points for the group has been multi-sensor-systems related to monitoring and machine guidance. Covered topics are e.g. synchronisation of measurement and modelling of movements. The main task is to facilitate the interchange of knowledge about kinematic measurements among practitioners and researchers at FIG Working Weeks and Regional Conferences. Beside dedicated sessions at the Working Weeks, joint conferences with other organisations like the Mobile Mapping Technology and the Machine Control and Guidance are also the focus of the WG.

The technical main points identified by Working Group 5.4 are multi-sensor-systems related to monitoring and to machine guidance. This was the reason to support the 3rd International Conference on Machine Control and Guidance (MCG 2012) that was held in Stuttgart, Germany on 27 - 29 March 2012. A total of 33 papers were accepted. The conference papers were included in sessions about the topics: Global Navigation Satellite Systems, Kinematic Measurements, Sensor Integration, Data Management and Communication, Control Algorithms, Agriculture and Construction. The content of the lectures ranged from scientific contributions (e.g. regarding the development of new control algorithms) to best-practise reports of construction companies as well as presentation about teaching possibilities in the field of machine control.

In collaboration with FIG Commission WG 5.5 and IAG Woking Group "Ubiquitous Positioning" a special issue for the Journal of Applied Geodesy on the topic "Ubiquitous Positioning and Navigation Systems" was finalized including a peer review process and publication. This journal was edited by Kealy, Schwieger and Retscher. Issue No 4 of the 2013 volume includes contributions covering all topics of the joined Working Groups: from GNSS and multi-sensor-systems to control and guidance issues. In the FIG family peer-reviewed publication is a new step trying to win researchers for activity within the FIG commissions. The papers are investigating new technologies and techniques for multi-sensor systems delivering enhanced positioning and navigation capabilities have been invited. Also papers that describe new integration architectures, algorithms and applications for multi-sensor systems are particularly encouraged.

The WG chair also contributed to a paper entitled "Innovative and Cost-effective Spatial Positioning" that was published jointly with Mikael Lilje, the Commission Chair. The paper was selected as FIG Paper of the Month January 2014. In the paper, static and kinematic survey methods are investigated with respect to their economic benefit with other words their cost-effectiveness. The paper was successfully launched at the FIG Working Week in Abuja and at the Geo-Siberia in Novosibirsk, Russia. Further request to the authors are already known.

Sample publications;

- Kealy, A., Retscher, G., Schwieger, V.: Preface to the Special Edition of the JAG on Ubiquitous Positioning and Navigation Systems. Journal of Applied Geodesy, Heft 4, de Gruyter, 2013.
- Beetz, A, Schwieger, V.: Automatic lateral control of a model dozer. Journal of Applied Geodesy, Heft 4, de Gruyter, 2013
- ..and all the other publications of this Journal of Applied Geodesy Issue No 4.
- Zhang, L., Schwieger, V.: Investigation regarding different antennas Combined with low-Cost receiver. FIG Working Week, Abuja, Nigeria, 06.-10.05.2013.
- Schwieger, V., Lilje, M.: Innovative and Cost-effective spatial positioning. FIG Working Week, Abuja, Nigeria, 06.-10.05.2013 and Interexpo Geo-Siberia, Novosibirsk, Russia, 24.-26.04.2013.
- Beetz, A., Schwieger, V.: Automatic Lateral Control of a Dozer. FIG Regional Conference, Montevideo, Uruguay, 26.-29.11.2012.

- Scheider, A., Beetz, A., Schwieger, V.: Post-Processed Kinematic Low-Cost GPS. Proceedings on 3rd International Conference on Machine Control & Guidance, Stuttgart, 27.-29.03.2012.
- Schwieger, V.: Challenges of Kinematic Measurements. FIG Working Week, Rome, Italy, 06.-10.05.2012.
- Schwieger, V., Beetz, A.: Road Construction Machine Guidance: Overview and hardware-in-the-Loop-Simulator. Proceedings on International Conference on Innovative Technologies for an Efficient Geospatial Management of Earth Resources, Almaty, Kazakhstan, 18.-19.09. 2012.
- Schwieger, V., Böttinger, S., Zheng, B. (Editors): Proceedings on 3rd International Conference on Machine Control & Guidance, Stuttgart, 27.-29.03.2012.
- Zhang, L., Stange, M., Schwieger, V.: Automatic Low-cost GPS Monitoring System using WLANCommunication. FIG Working Week, Rome, Italy, 06.-10.05.2012.
- …and all publications of in the Session "Multi Sensor Systems" at FIG Working Week Rome
- …all publications of in the Session " Measurement Applications of Unmanned Vehicles Multi Sensor Systems" at FIG Working Week Rome

## WG 5.5 – Ubiquitous Positioning

Chaired by Allison Kealy

This working group is coordinated jointly with IAG sub commission 4.2.2.

Ubiquitous positioning systems typically rely on the fusion of multiple sensors, signals or measurements to deliver a position solution in environments that are 'difficult' for Global Navigation Satellite System (GNSS), or to broadly address GNSS vulnerabilities. To fully deliver a ubiquitous positioning capability requires an understanding of the performance capabilities of the sensors used to augment or replicate that of a GNSS. The focus of this working group has been to integrate disparate research initiatives internationally with the overall goal of developing a resource of approaches, models, techniques and data that was freely available. To achieve this, a number of field campaigns with contributions from international universities, publications, technical seminars and tutorial have been held over the period under review. The working group also maintained a strong and active presence at many international events through participation in coordinating workshops, scientific and organizing committees, delivering short courses and tutorials, publishing papers and presentations, session chairing, etc.

The Working Group has been active at the FIG Working Weeks during the period under review. At the Working Week in Marrakesh the members discussed the objectives of the group's activities and the discussions included:

1. a redefinition of ubiquitous positioning systems,
2. provision of complete and representative data sets for use by the positioning user community via a dedicated web portal,
3. a focus on collaborative positioning techniques; and

4. broadening the use of sensors beyond MEMS inertial sensors to include other alternative positioning technologies.

The working group has been very active at a number of international events as;

- FIG Working Week with papers and session chairs.
- Mobile Mapping Technology (MMT) Symposium, Krakow Poland in 2011. This included participating as part of the scientific program committee, presentation of working group outcomes as well as the coordination of two pre symposium tutorials;
  Title: Mobile mapping technology: paradigm shift and future trends
  Title: Applications of MMT in land transportation systems and infrastructure from planning through
- IAG Commission 4 together with ISPRS co-sponsored the 7th International Mobile Mapping Symposium, Tainan, Taiwan, May 1-3, 2013; http://conf.ncku.edu.tw/mmt2013/
- 2011 International Union of Geodesy and Geophysics (IUGG) General Assembly, Melbourne, Australia. Presentations and posters as part of our on-going collaborations with the International Association of Geodesy (IAG). Working group co-chair Allison Kealy and member Dorota Brzezinska are the current vice president and president of IAG Commission 4, Positioning and Applications. This will continue to strengthen links between the two organisations.
- ION GNSS 2011, 2012 and 2013. Participation with papers, involved in the technical program.
- International Symposium on Location-Based Services, Vienna, Austria. Co-chair Guenther Retscher played an important role in involving the FIG in this event which offers a wealth of knowledge for FIG members interested in alternative positioning technologies.
- International GNSS Symposium, Sydney, Australia. Papers presented on behalf of the working group on emerging issues in collaborative navigation.
- Together with IAG commission 4 and ISPRS co-sponsored and co-organized, a field campaign on Indoor Positioning, at the RMIT and Melbourne Universities, Australia, July 8-12, 2013.
- Significant involvement and presence at the ION Pacific PNT Conference, Honolulu, Hawaii, April 22-25, 2013; http://www.ion.org/meetings/pnt2013program.cfm. Several papers authored collaboratively with FIG/ISPRS/IAG members were presented.
- Significant involvement and presence at the International GNSS Symposium, Gold Coast, Australia, July12-19, 2013; http://www.ignss.org/Conferences/IGNSS2013Conference/2013ConferenceVenueInformation/tabid/113/Default.aspx

In 2011, members of working group 5.5 undertook major collaborative endeavours at Ohio State University, USA and the University of Melbourne, Australia. These field based collaborations have generated significant data sets the analysis of which formed the basis of work in 2012.

In 2012 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 University of Nottingham from May 14 to 18, 2012. 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. The employed platforms in the tests include a train on the roof of the Nottingham geospatial building, mobile mapping vans, a personal navigator and a foot tracker unit.

In terms of the tests, the data from the different platforms was recorded simultaneously. The personal navigator and a foot tracker unit moved on the building roof, then trough the building down to where it logged data simultaneously with the vans, all of them moving together and relative to each other. The platforms then logged data simultaneously covering various accelerations, dynamics, etc. over longer trajectories. Promising preliminary results of the field experiments showed that a positioning accuracy on the few meter level can be achieved for the navigation of the different platforms.

In 2013 this Working Group continued its work on collaborative positioning and navigation using a variety of sensors on different platforms. To achieve this, WG5.5 carried out its work in close cooperation with the International Society for Photogrammetry and Remote Sensing (ISPRS) Commission 1 "Sensors and Platforms for Remote Sensing," and IAG sub commission 4.1.1 also entitled "Ubiquitous positioning. A key highlight of 2013 was a field campaign on indoor positioning conducted at RMIT University, Melbourne, Australia. Another significant outcomes was the publication of a special edition of the Journal of Applied Geodesy which included representative work from members of WG 5.5 and 5.4. This journal was edited by Kealy, Schwieger and Retscher.

Representative publications from the group include:


- Kealy, Allison, Guenther Retscher, and Volker Schwieger. "Preface to the Special Edition of the JAG on Ubiquitous Positioning and Navigation Systems."Journal of Applied Geodesy 7.4 (2013): 227-230.
- Alam, N., Kealy A. & Dempster A. G. An INS-Aided Tight Integration Approach for Relative Positioning Enhancement in VANETs. IEEE Transactions on Intelligent Transportation Systems PP(99): 1-6, 2013.
- Alam, N., Kealy A. & Dempster A. G., 2013. Cooperative Inertial Navigation for GNSS-Challenged Vehicular Environments. IEEE

Transactions on Intelligent Transportation Systems,14(3):1370-1379.
- Kealy, A., Alam, N., Efatmaneshnik, M., Toth, C., Dempster, A. G. & Brzezinska, D. Collaborative Positioning in GPS-challenged Environments. International Association of Geodesy Symposia Series 139, Springer, 2013.
- Kealy A., G. Retscher, A. Hasnur-Rabiain, N. Alam, C. Toth, D. A. Grejner-Brzezinska, T. Moore, C. Hill, V. Gikas, C. Hide, C. Danezis, L. Bonenberg, G. W. Roberts (2013): Collaborative Navigation Field Trials with Different Sensor Platforms. in: Papers presented at the 10th Workshop on Positioning, Navigation and Communication WPNC 2013, March 20-21, 2013, University of Applied Sciences Dresden, Germany, 6 pgs.
- Kealy A., A. Hasnur-Rabiain, N. Alam, C. Toth, D. A. Grejner-Brzezinska, V. Gikas, C. Danezis, G. Retscher (2013): Cooperative Positioning using GPS, Low-cost INS and Dedicated Short Range Communications. in: Papers presented at ION Pacific PNT 2013, April 22-25, 2013, Honolulu, Hawaii, USA.
- Kealy A., A. Hasnur-Rabiain, N. Alam, C. Toth, D. A. Grejner-Brzezinska, V. Gikas, G. Retscher (2013): Cooperative Positioning Algorithms and Techniques for Land Mobile Applications. in: Papers presented at the 8th International Symposium on Mobile Mapping Technology, May 1-3, 2013, Tainan, Taiwan, 6 pgs.

Further information about the Working Group and the field experiments may be found at http://ubpos.net/. Measurement data from the campaign are freely accessible from this website.

# 3. Cooperation

## 3.1 Cooperation with Other Commissions

The Commission has continued to work with the other FIG Commissions as required. This work has been primarily with Commission 6 on topics relating to deformation measurement, Machine Control and Guidance, Unmanned Aerial Vehicles (UAVs), calibration of instruments, long range measurement, satellite and terrestrial imagery measuring techniques (in particular mobile and static laser scanning). This cooperation involved holding joint technical sessions and meetings at FIG related events as well as co-sponsoring symposiums. Examples of the latter are;

- Quality of Geodetic Measurements (Munich, Germany)
- Geo-Siberia (Novosibirsk, Russia)
- 7th International Symposium on Mobile Mapping Technology (Krakow, Poland)
- Innovative Technologies for an Efficient Geospatial Management on Earth (Ulanbaatar (Mongolia), Ust-Kamenogorsk (Kazakhstan), Almaty (Kazakhstan))
- International Conference on Machine Control and Guidance

## 3.2 Cooperation with Sister Organisations

### Cooperation with International Association of Geodesy (IAG)

The close working relationship with the IAG has continued to grow during the 2011 - 14 period. The support provided by the President Prof. Chris Rizos and IAG representatives has been fantastic. We achieved our success by convening joint technical sessions and holding joint administrative meetings during the FIG Working Weeks, the IUGG General Assembly, and other at symposiums. In collaboration with the IAG, Commission 5 examined significant issues relating to geospatial and positioning infrastructure and applications, reference frames, and also the created a "Reference Frame in Practice Manual" for the geodetic surveyor.

### Cooperation with United Nations (UN)

The cooperation with UN based groups or agencies continue to flourish. Commission 5 sustained its involvement with the International Committee on Global Navigation Satellite Systems (ICG). The ICG was formed several years ago as a result of recommendations of the UN Committee on the Peaceful Use of Outer Space (COPUOS). At these meetings reports are given on the status of major GNSS sub-systems and the activities of related task forces. FIG Commission 5 Chair, Mikael Lilje co-chairs a working group on Geodetic and Timing References. ICG meetings have been held annual in Tokyo (Japan), Beijing (China) and Dubai (UAE). FIG thanks the efforts by Mr Matt Higgins who has continued to provide information to our Commission from ICG meetings.

Commission 5 has also actively worked with the United Nations Global Geospatial Information Management – Asia Pacific (UN GGIM-AP). Please note, the UN GGIM-AP was previously known as the Permanent Committee for GIS Infrastructure Asia-Pacific (PCGIAP). Our work with the UN GGIM – AP has been mainly concerned with the development of the Asia Pacific Reference Frame through technical seminars or workshops at FIG symposiums. The issues addressed in these seminars ranged from vertical / height systems for disaster management or sea level monitoring, GNSS CORS infrastructure and applications to building the capacity of surveyors in the Asia Pacific region. FIG thanks the support provided by Dr. John Dawson, Chair Working Group 1 - Geodetic Reference Framework for Sustainable Development – UN GGIM AP.

# 4. Events, Communications and Publications

FIG Commission 5 representatives have participated in many events during the 2011 - 14 period. Numerous reports of events or newsletters detailing our activities have been produced and they can be found on our websites -

- http://www.fig.net/commission5/
- http://www.fig.net/annual_review/index.htm
- http://www.fig.net/commission5/news/news_1.htm
- http://www.fig.net/commission5/newsletters/newsletters.htm

- http://www.fig.net/commission5/reports/reports.htm

The following is a list of events FIG Commission 5 have attended -

- General Assembly for the International Union of Geodesy and Geophysics, IAG (Melbourne, Australia)
- ICG-6, International Committee on GNSS (Tokyo, Japan)
- The Geodetic Infrastructure in Europe, CLGE (Umeå, Sweden)
- 3rd International Colloquium - Scientific and Fundamental Aspects of the Galileo Programme (Copenhagen, Denmark)
- UAV-g, ISPRS (Zurich, Switzerland)
- 3rd and 4th International Conference on Machine Control and Guidance (Stuttgart and Braunschweig, Germany)
- ICG-7, International Committee on GNSS (Beijing, China)
- PPP-RTK and Open Standards (Frankfurt, Germany)
- IGS Workshop (Olztyn, Poland)
- Interexpo Geo-Siberia (Novosibirsk, Russian Federation)
- 12th South East Asia Survey Congress in Manila, Philippines
- ICG-8, International Committee on GNSS (Dubai, UAE)
- FIG Commission 5,6 Workshops: Innovative Technologies for an Efficient Geospatial Management on Earth (Ulanbaatar, Mongolia and Ust-Kamenogorsk, Kazakhstan and Almaty, Kazakhstan)

**Mikael Lilje**
**Chair**
Chair of FIG Commission 5

March 2014