Commission 4 – Positioning and Applications

http://www2.ceegs.ohio-state.edu/IAG-Comm4/

President: **D. Grejner-Brzezinska** (USA)
Vice President: **A. Kealy** (Australia)

Terms of Reference

To promote research that leverages current and emerging positioning techniques and technologies to deliver practical and theoretical solutions for engineering and mapping applications. Commission 4 will carry out its work in close cooperation with the IAG Services and other IAG entities, as well as via linkages with relevant entities within scientific and professional sister organizations.

Recognizing the central role of Global Navigation Satellite Systems (GNSS) in providing high accuracy positioning information today and into the future, Commission 4 will focus on developing tools that enhance and assure the positioning performance of GNSS-based positioning solutions for a range of geodetic applications.

The Sub-Commissions will develop theory, strategies and tools for modelling and/or mitigating the effects of interference, signal loss and atmospheric effects as they apply to precise GNSS positioning technology. They will address the technical and institutional issues necessary for developing backups for GNSS, integrated positioning solutions, automated processing capabilities and quality control measures.

Commission 4 will also deal with geodetic remote sensing, using Synthetic Aperture Radar (SAR), Light Detection And Ranging (LiDAR) and Satellite Altimetry (SA) systems for geodetic applications.

Structure

Sub-Commissions

SC 4.1: Alternatives and Backups to GNSS
Chair: G. Retscher (Austria)

SC 4.2: Geodesy in Geospatial Mapping and Engineering
Chair: J. Wang (Australia)

SC 4.3: Remote Sensing and Modelling of the Atmosphere
Chair: M. Santos (Canada)

SC 4.4: Applications of Satellite and Airborne Imaging Systems
Chair: Z. Li (UK)

SC 4.5: High-Precision GNSS Algorithms and Applications
Chair: Y. Gao (Canada)

SC 4.6: GNSS-Reflectometry and Applications
Chair: S. Jin (China)

Joint Study Groups

JSG 0.1: Application of time series analysis in geodesy
(joint with ICCT and all Commissions, see ICCT)
Chair: W. Kosek (Poland)

JSG 0.4: Coordinate systems in numerical weather models
(joint with ICCT and all Commissions, see ICCT)
Chair: Th. Hobiger (Japan)

JSG 0.8: Earth system interaction from space geodesy
(joint with ICCT and all Commissions, see ICCT)
Chair: S. Jin (China)

Joint Working Group

JWG 0.2.1: New technologies for disaster monitoring and management
(joint with GGOS, description see GGOS)
Chair: I.D. Doukas (Greece)

Steering Committee

- President: D. Grejner-Brzezinska (USA)
- Vice President: A. Kealy (Australia)
- Chair SC 4.1: G. Retscher (Austria)
- Chair SC 4.2: J. Wang (Australia)
- Chair SC 4.3: M. Santos (Canada)
- Chair SC 4.4: Z. Li (UK)
- Chair SC 4.5: Y. Gao (Canada)
- Chair SC 4.6: S. Jin (China)
- Representatives of Services:
  IGS: A. Krankowski (Poland)
- Members at large: P. Wielgosz (Poland)

Representatives of external bodies

ISPRS: Ch. Toth (USA)
FIG: G. Roberts (UK)
ION: L. Hothem (USA)

Sub-Commissions

SC 4.1: Alternatives and Backups to GNSS

Chair: G. Retscher (Austria)
Vice-Chair: V. Gikas (Greece)
Secretary: L. Bonenberg (UK)

Terms of Reference

To coordinate research and other activities that address broader areas of alternatives and backups to GNSS positioning using multi-sensor system theory and applications, with a special emphasis on integrated guidance, navigation, positioning and orientation of airborne and land-based platforms. The primary sensors of interest will be inertial navigation systems; however the important role of other emerging techniques used for indoor and pedestrian navigation environmental monitoring is also recognized. The Sub-commission will carry out its work in close cooperation with other IAG Entities, as well as via linkages with relevant scientific and professional organizations, such as ISPRS, FIG, IEEE and ION.

Objectives

- To follow the technical advances in navigation sensors and algorithms, including autonomous vehicle navigation, based on
  - positioning sensors and techniques such as pseudolites, INS, including MEMS IMU, wheel sensors, ultrasonic and magnetic sensors, and
  - positioning methods based on cellular networks and their hybrid use with GNSS.
- To investigate positioning sensors and techniques integrated in modern smart phones and other mobile devices.
- To follow the technical advances in vision-based sensors, such as CCD cameras in smart phones for indoor positioning and navigation.
- To standardize definitions and measurements of sensor related parameters.
- To study and report on the performance of stand alone and integrated navigation systems.
- To report on the development, possibilities and limitations of new emerging technologies.
- To stimulate new ideas and innovation in
  - navigation algorithms, sensor calibration, synchronization and inter-calibration,
  - real-time sensor information processing,
  - sensor and data fusion, and
  - automation techniques for information extraction from multi-sensor systems using expert systems.
- To study and monitor the progress in new applications (not limited to conventional navigation) of multi-sensor systems (transportation, engineering, car navigation, environmental monitoring personal navigation, indoor navigation, etc.).
- To promote research collaboration and to organize and to participate in professional workshops, seminars, and meetings.
- To promote research and collaboration with countries with no or limited access to modern multi-sensor technology.
- To establish a web page providing information on the SC 4.1 activities, technology updates, and professional meeting calendar.

Working groups

WG 4.1.1: Ubiquitous Positioning Systems
(joint with FIG)

Chair: A. Kealy (Australia)
Co-chair: G. Retscher (Austria)

Description

This WG group will focus on the development of shared resources that extend our understanding of the theory, tools and technologies applicable to the development of ubiquitous positioning systems. It has a major focus on:

- Performance characterization of positioning sensors and technologies that can play a role in the development of ubiquitous positioning systems.
- Theoretical and practical evaluation of current algorithms for measurement integration within ubiquitous positioning systems.
- The development of new measurement integration algorithms based around innovative modelling techniques in other research domains such as machine learning and genetic algorithms, spatial cognition etc.
- Generating formal parameters that describe the performance of current and emerging positioning technologies that can inform FIG and IAG members.

Specific projects to be undertaken include

- Reporting on the performance characteristics of a broad range of MEMS inertial sensors derived from extensive practical testing and benchmarking.
- Reporting on performance characterization of positioning technologies: the development, possibilities and limitations of new technologies.
- Establishing components of an open source platform for researchers to rapidly deploy sensors as well as evaluate and develop integration algorithms.

- Developing and report on taxonomy for users of ubiquitous positioning systems that shows the performance capabilities of sensors and typical applications.
- Establishing links between the outcomes of this WG and other IAG and FIG WGs.

WG 4.1.2: Interference and Jamming

Chair: A. Soloviev (USA)
Co-chair: TBD

Description

This WG group will focus on gaining a deeper understanding of the impact of unintentional interference and intentional jamming on GNSS navigation capabilities for civil users; and, methods for improving the robustness of GNSS receivers in interference and jamming environments. It has a major focus on:

- Characterization of the impact of interference and jamming on the GNSS performance via review of open-literature publications.
- Evaluation of algorithms and methods that enable radio-frequency (RF) awareness.
- Evaluation of GNSS signal processing methods for interference and jamming suppression that are not subject to international traffic in arms (ITAR) regulations and can be thus adopted by the civil community without any restrictions.
- Evaluation of multi-sensor fusion methods for improved interference robustness.

Specific projects to be undertaken include:

- Reporting on the characterization of interference/jamming impact.
- Reporting on algorithms and methods that enable RF awareness.
- Reporting on non-ITAR GNSS-only interference suppression technologies.
- Reporting on the benefits of multi-sensor fusion for enhancing the navigation robustness in interference/jamming environments.
- Establishing links between the outcomes of this WG and other IAG and FIG WGs.

WG 4.1.3: Emerging Technologies

Chair: K. Zhang (Australia)
Co-chair: L. Bonenberg (UK)

Description

This working group will focus on the investigation and development of emerging technologies for innovative positioning and tracking applications. This is not limited to traditional navigation and this WG hopes to cooperate with other WGs on other forms of navigations such as indoor positioning and pedestrian navigation. With new technologies depending on wireless communication this WG plans to monitor relevant changes in legislature and support industry and academy interested in this area. Group actions aim to extend our knowledge and enhance our capability in positioning and tracking in order to complement the GNSS.
Current group focus includes:

- Utilisation of emerging technologies by the industry.
- Promotion and knowledge exchange about new technologies.
- Reporting the development trends, possibilities and limitations of emerging positioning technologies, such as Locata, RFID, UWB and smart phones.
- Promoting the utilisation of new technologies by the industry.
- Developing innovative positioning algorithms using current and emerging technologies and theoretical and practical evaluation of these developments.
- Promoting industry and academy interest into licensing and legislature regime relating to the emerging technologies.
- Reporting on such legislature efforts.
- Generating formal parameters that describe the performance of emerging positioning technologies that can inform both FIG and IAG members.
- Establishing working links between this WG and other IAG and FIG WGs.

Specific techniques include:

- New RFID systems with stable transmitted signal strength.
- Smart phones as multi-sensor integrated platforms.
- Low-cost vision-based positioning techniques (single/ stereo cameras built in smart phones).
- UWB.
- Locata and other indoor/outdoor pseudolite systems.
- Multi-GNSS positioning techniques.

Specific algorithms include:

- Cooperative positioning.
- Ubiquitous positioning (cooperation with WG 4.1.1)
- Single camera-based positioning (cooperation with WG 4.1.4).

WG 4.1.4: Imaging Techniques

Chair: M. Elhabiby (Canada)
Co-chair: J.-A. Paffenholz (Germany)

Description

This WG will focus on the investigation and development of imaging techniques for different navigation problems. Vision Based Navigation (VBN) systems research work will cover two different research streams: the non-inertial vision navigation and the inertial-aided vision navigation approaches. Real time efficient implementation with fast computations will extend the working group research activities to geo-computations, digital signal processing, non-linear optimization and image matching. The working group research work will be connected to the navigation industry in general and UAV industry in specific.

It has a major focus on:

- Evaluation of algorithms and methods for visually aiding inertial and non-inertial navigation systems.
- Evaluation of estimating aircraft position and velocity from sequential aerial images.
- Real-time implementation of a vision based navigation algorithm, which comprises both accuracy and effectiveness (meaning the cheapness of the sensors used, computational load and complexity). The new algorithm is composed of two sections: relative position estimation and absolute position estimation, which are connected with each other through a switching scheme.
- Assessment on the relative position estimation based on stereo modelling of two sequential images.
- Evaluation of the absolute position estimation techniques through matching schemes using reference images.
- Building an effective academic and industrial network worldwide that can help and promote the research activities of the working group.
- Establishing working links between this working group and similar national and international working groups such as ISPRS, ASPRS, CGU, AGU, IAG and FIG working groups.

Specific techniques include:

- Multi-resolution techniques: Curvelet and wavelet transform for image matching.
- Linear and non-linear optimization for position estimation.
- Implementation of Speeded Up Robust Features (SURF) Algorithms for interest point detection, image matching an object recognition.
- Extended Kalman filter update using position estimated from image matching techniques.

SC 4.2: Geodesy in Geospatial Mapping and Engineering

Chair: J. Wang (Australia)
Vice-Chair: G. Roberts (UK)
Secretary: H.-K. Lee (South Korea)

Terms of Reference

Geodesy provides foundations for geospatial mapping and engineering. Modern geospatial mapping as a massive point positioning process has been evolving towards automatic operations, and at the same time, various engineering areas are increasingly relying on highly developed geospatial technologies to deliver improved productivities and safety with minimised negative environment impact. This Sub-Commission (SC) 4.2 will therefore endeavour to coordinate research and other activities that address the broad areas of the theory and applications of geodesy tools in geospatial mapping and engineering, ranging from construction work, geotechnical and structural monitoring, precision farming, mining, to natural phenomena such as landslides and ground subsidence. The SC4.2 will carry out its work in close cooperation with other IAG Entities, as well as via linkages with relevant scientific and professional organizations such as ISPRS, FIG, IEEE, ION, ISM.

Objectives

- To develop and promote the use of new geospatial mobile mapping technologies for various applications.
- To develop and report the modelling and quality control framework for geo-referencing procedures.
- To monitor research and development into new technologies that are applicable to the general field of engineering geodesy, including hardware, software and analysis techniques.
- To study advances in geodetic methods for precision farming, mining operations, and large construction sites.
- To study advances in monitoring and alert systems for local geodynamic processes, such as landslides, ground subsidence, etc.
- To study advances in the application of artificial intelligence techniques in engineering geodesy.
- To document the body of knowledge in the field of geospatial mapping and engineering geodesy, and to present such knowledge in a consistent frame work at symposia and workshops.
- To promote research into several new technology areas or applications through the SC4.2 Working Groups.

Working groups

WG 4.2.1: Mobile Mapping Technologies and Applications

Chair: J. Skaloud (Switzerland)
Co-Chair: K.-W. Chiang (China - Taipei)

Description

Mobile mapping technologies have been widely used to collect geospatial data for a variety of applications, for example, navigation and online geospatial information services. As mobile mapping sensors are becoming cheaper and easier to access, modelling and quality control procedures for major steps of mobile mapping should be further developed to ensure the reliability of geospatial data from mobile mapping systems. This working group will conduct its work through coordinated activities among the members of the group as well as in collaborations with other professional organizations, such as ISPRS/FIG.

Major objectives of this WG are:
- To monitor new trends in mobile mapping technologies.
- To evaluate the performance of geo-referencing and mapping sensors, such as IMU, GNSS, 3D cameras, optical vision sensors.
- To develop realistic mathematical and functional models for geo-referencing procedures.
- To develop a framework to evaluate the quality of geo-referencing and mapping results.
- To promote the use of geospatial mapping systems for various applications.

WG 4.2.2: Applications of Geodesy in Mining Engineering

Chair: A. Jarosz (Australia)
Co-Chair: J. Gao (China)

Description

Geodesy has been playing an important role in mining operations from geospatial mapping, modern navigation and guidance technologies used in automation at various mine sites to special orientation and location procedures used in underground operations. This working group will conduct its activities in close collaborations with other relevant international professional organizations, such as the International Society of Mining Surveying (ISM) and FIG.

Major objectives of this WG are to study, and report the use of:
- Modern geodesy in various mining sites.
- 3D mapping for mining.
- Navigation and guidance of mining machinery.
- Miner location technologies in underground mining operations.

WG 4.2.3: Geodetic technologies in Precision Farming

Chair: R. Bill (Germany)
Co-Chair: TBD

Description

Modern precision farming operations are highly dependent on high precision positioning, orientation and geospatial mapping, which are based on modern geodetic theory, techniques and services. This working group will coordinate professional activities to look into major geodetic aspects in precision forming areas in various parts of world.

Major objectives of this WG are to study, and report the use of geodetic tools in precision farming, in particular:
- Precise positioning and orientation of agricultural land-machinery and acquisition devices (such as geo-sensor networks, unmanned airborne vehicles, field robotics).
- Precise navigation and guidance for intelligent agricultural vehicles capable of automating tasks.
- Precise mapping, interpretation of space-time heterogeneities in the field, derivation of agricultural application maps.
- Web-based data infrastructures and services used in agricultural environment.

WG 4.2.4: Monitoring of Landslides & System Analysis

Chair: G. Mentes (Hungary)
Co-Chair: J. Guo (China)

Description

Landslides, as natural phenomena, have a local effect on structures and community infrastructure. Monitoring different types of landslides under various operational scenarios is a challenging task. The tools used in landslide monitoring range from conventional terrestrial measurement and alignment technology (optical, RF, etc.), Global Navigation Satellite Systems (GNSS), remote sensing, geotechnical instrumentation, and software systems such as GIS, decision support systems, etc. The WG will carry out its work in close cooperation with other related professional organizations such as ISPRS, FIG, ISM.

Major objectives of this WG are to study and report on:

- Development of new measuring methods.
- New dynamic and kinematic models of landslides.
- Integration of terrestrial and remote sensing measuring technology on multidisciplinary basis with the aim to develop an early alert system;
- Integrated workflow for landslide hazard management.

WG 4.2.5: Applications of Artificial Intelligence in Geospatial Mapping and Engineering Geodesy

Chair: A. Reiterer (Germany)
Co-Chair: U. Egly (Austria)

Description

Artificial Intelligence (AI) has become an essential technique for solving complex problems in many applications. In the areas of geospatial mapping and engineering geodesy, knowledge-based systems are emerging. To develop reliable intelligent systems, this working group will focus on some critical issues ranging from the understanding of the nature of intelligence to the understanding of knowledge representation and deduction processes, eventually resulting in the construction of computer programs, which act intelligently.

Major objectives of this working group are to study and report on, the following major areas:

- Intelligent quality control procedures in geospatial mapping process.
- Robust control of measurement- and guidance-systems.
- Knowledge based deformation analysis.
- Intelligent control of deformation alert systems.
- Evaluation of various complex data streams in geospatial mapping and engineering geodesy with, e.g. knowledge-based systems, genetic algorithms, and artificial neural networks.

SC 4.3: Remote sensing and modelling of the atmosphere

Chair: M. Santos (Canada)
Vice-Chair: J. Wickert (Germany)
Secretary: A. Krankowski (Poland)

Terms of Reference

The objective of this SC is to coordinate research dealing with the treatment, interpretation and modelling of measurements collected in the atmosphere for the purpose of improvements in geodetic positioning as well as for better understanding the atmosphere itself. Even though GNSS techniques are seen here as the primary research tools, other sensors also bring important information on the atmosphere and as such should be considered in the context of this Sub-Commission. Dedicated satellites, having on-board GNSS receivers, can also contribute to atmospheric studies by exploring the atmosphere-induced bending of GNSS signals while propagating through the atmosphere, to furnish round-the-clock weather data, monitor climate change, and improve space weather forecasts. Geodetic positioning can benefit and contribute to atmospheric models, such as Numerical Weather Prediction (NWP) models. Novel advancements in modelling the atmosphere as applied to positioning, error sources, instrumentation, dedicated missions, and real- or near real-time data access should also be contemplated. SC4.3 will foster linkages with sister scientific and professional organizations, such as IAG, ISPRS, FIG, IEEE and ION.

Objectives

- To explore the synergy that exists between Geodesy, meteorology and ionospheric sciences.

To encourage the processing of more and more LEO and also ground based data more and more also in near-real and/or real time.

- To study the application of readily available data from numerical weather prediction models (data provision, assimilation techniques).
- To study and suggest ways for homogenization of long term data set for climatologic investigations
- To investigate the development and enhancement of the GNSS-based sounding techniques, e.g. neutral atmosphere/ionosphere tomography, GNSS reflectometry/ scatterometry for altimetry, meteorology, soil moisture.
- To exploit the potential of new GNSS signals' structures for GNSS based atmospheric remote sensing.
- To suggest additional platforms for GNSS based atmospheric remote sensing (buoys, aircrafts, balloons, more dense ground networks, LEO constellations).
- To follow, study and contribute towards the technical and scientific advances in atmospheric research.

- To suggest standard definitions and terminology as per appropriate in the context of Geodesy and atmospheric sciences.

Program of activities

- To promote research collaboration among research groups worldwide.
- To organize and/or participate in scientific and professional meetings.
- To maintain a web page concatenating the Sub-Commission activities and reports.
- To encourage special issues of the Journal of Geodesy on atmospheric applications to Geodesy.

Study groups

SG 4.3.1: Ionosphere modelling and analysis

Chair: M. Schmidt (Germany)
Co-Chair: M. Karslioglu (Turkey)

Description

The general objective of this study group is the development of ionosphere models based on physics, mathematics and statistics. Within the next four years we will (1) focus on the development of appropriate parameter estimation and assimilation techniques based on the combination of different observation techniques. With respect to physical modelling we (2) will perform first steps by introducing physics-motivated functions such as the Chapman function into the parameter estimation process. Furthermore, we (3) will establish ionosphere models including near real-time applications by introducing Kalman filtering procedures. Other topics are the development of densification strategies of global models using regional approaches as well as applications, e.g. the study of the L3 GNSS frequency.

Working groups

WG 4.3.1: Standards for space weather products for geodetic and ionospheric studies

Chair: A. Krankowski (Poland)
Co-Chair: Irina Zakharenkova (Russia)

Description

The objective of this WG is to suggest common international standards for the dissemination of space weather products used in geodesy and ionospheric studies. This WG will work in close scientific collaboration with IGS, URSI and COSPAR IRI group.

WG 4.3.2 Inter-comparison and cross-validation of tomography models

Chair: Alain Geiger (Zürich, Switzerland)
Co-Chair: Witold Rohm (Wroclaw, Poland)

Description

This WG intends to address the main issues dealing with GNSS tomography. Promote the inter-comparison and cross-validation of different tomography models and approaches by using same data sets over same areas. Improve GNSS tomography by the integration of new GNSS measurements aiming at an increase in reliability of tomography results, by increasing number of observations and by incorporating cross-sectional observations. Promote the sharing of GNSS tomography technique data, results and software. Discuss the need of a “tomography service”.

WG 4.3.3 Integration of GNSS atmosphere models with NWP models

Chair: Jarosław Bosy (Wroclaw, Poland)
Co-Chair: Henrik Vedel (Met Office, Danmark)

Description

The main objective of this Working Group is to study of integration of GNSS atmosphere models with Numerical Weather Prediction (NWP) models for positioning and meteorological applications. It includes the assimilation of GNSS data processing products in NWP models, the use of NWP models in real-time positioning methods: RTK and PPP, the validation and comparison of different of GNSS atmosphere models using NWP outputs, investigation on new mapping functions based on the high resolution integrated models of the troposphere, and the real time water vapor models from GNSS data and NWP models outputs.

SC 4.4: Applications of Satellite and Airborne Imaging Systems

Chair: Z. Li (UK)
Vice- Chair: T. Wright (UK)
Secretary: H. Lee (USA)

Terms of Reference

The main objectives of this SC are to promote collaborative research in the development of satellite and airborne imaging systems, primarily including Synthetic Aperture Radar (SAR), Light Detection And Ranging (LiDAR) and Satellite Altimetry (SA) systems, for geodetic applications, and to facilitate communications and exchange of data, information and research results through coordinated efforts.

Objectives

- Development of methods, models, algorithms and software for geodetic applications of satellite and airborne imaging systems.
- Integration of satellite and airborne imaging systems with other geodetic/geospatial technologies such as GPS and GIS.
- Investigation of effects of field and atmospheric conditions on satellite and airborne imaging systems.
- Development and promotion of new geodetic applications of satellite and airborne imaging systems.
- Development of collaboration with sister organisations such as FIG and ISPRS, and liaison with image data providers.

Working groups

WG 4.4.1: Quality Control Framework for InSAR Measurements

Chair: Z. Li (UK)
Co-Chair: S. Samsonov (Canada)

Description

To investigate quality measures and quality control procedures and formulate a quality control framework for InSAR measurements. In particular, the objectives are:

- To investigate the optimal procedure for InSAR measurements
- To demonstrate how accurately InSAR can measure surface movements
- To demonstrate how accurately InSAR can map atmospheric path delays

WG 4.4.2: InSAR Observation and Modelling of Earthquakes, Volcanoes and Tectonics

Chair: T. Wright (UK)
Co-Chair**:** A. Hooper (Netherlands)

Description

To combine InSAR observations of Earth's surface movements, topography and terrestrial observations and modelling to advance understanding of the earthquake cycle, continental deformation and volcanic eruptions, and to quantify seismic and volcanic hazards.

WG 4.4.3: Landslide Hazard Mitigation using InSAR Techniques

Chair: R. Jover (Spain)
Co-Chair**:** R. Furuta (Japan)

Description

The main objectives of this working group is to promote collaborative research in the application of InSAR techniques for landslide measurement, monitoring and modelling and to stimulate communications and exchange of data, information and research outcomes through coordinated efforts. In particular, the primary objectives are:

- Development/improvement of InSAR techniques, algorithms and software for landslide measurement and monitoring.
- Investigation of the spatio-temporal evolution of landslides.
- Integration of InSAR data with in-situ observations, aerial/ground-based remote sensing measurements and geoinformation to improve our understanding of landslide mechanisms.
- Development of landslide models using InSAR measurements.

WG 4.4.4: Vertical land motion from Satellite Altimetry

Chair**:** H. Lee (USA)
Co-Chair: H. Wang (China)

Description

To develop optimal retracking and surface gradient correction algorithms for satellite altimeter measurements toward observing vertical crustal motion due to, e.g., glacial isostatic adjustment (GIA) and land subsidence. The primary focus is to study the application of satellite altimetry for observing vertical crustal motion.

WG 4.4.5: LiDAR and Laser Scanning

Chair: B. Yang (China)
Co-Chair: N. Tate (UK)

Description

To provide a focus for space-borne, airborne and terrestrial laser scanning activity internationally. There are currently four principal themes of research within the group: 3D modelling, data integration, mapping, and applications. In particular, the primary objectives are:

- To develop state-of-the-art laser scanning algorithms
- To collaborate with sister organizations (e.g. ISPRS and UK RSPSoc) to promote geodetic applications of laser scanning

SC 4.5: High-Precision GNSS Algorithms and Applications

Chair: Y. Gao (Canada)
Vice-Chair: P. Wielgosz (Poland)
Secretary: G. Liu (Hong Kong)

Terms of Reference

High-precision GNSS applications continues to grow, largely contributed to the rapid GNSS system developments currently underway including US's GPS modernization, the Russian GLONASS, European GALILEO and Chinese COMPASS systems. The increased number of satellites in view and improved system performance provide opportunities to create new high precision GNSS technologies and applications. Novel technologies are needed to address such opportunities and also challenges to further enhance the accuracy, availability and integrity of high precision GNSS applications, while the cost is to be dramatically reduced. SC4.5 will coordinate research efforts to identify important research problems in high precision GNSS and develop methods and technologies to support high precision GNSS applications. The research subjects include optimal use of signals from multiple GNSS systems, improved error modelling and mitigation methodologies, quality control and integrity monitoring, precise point positioning and RTK, low-cost precision GNSS, GNSS integration with enabling sensors, novel augmentation corrections and services, fast carrier phase ambiguity resolution. SC4.5 will also stimulate strong collaborations among researchers and international organizations, and develop strong linkage with the industry.

Objectives

The major objective of SC4.5 is to promote collective research efforts on the development of high precision GNSS methods and technologies and their novel applications, to facilitate timely dissemination of scientific findings, to stimulate strong collaborations among researchers and international organizations, and to develop strong linkage with the industry.

Program of activities:

- Identify and investigate important technical issues and problems in high precision GNSS.
- Identify and investigate emerging commercialization opportunities of high precision GNSS technologies.
- Publish white papers.
- Promote research collaboration among researchers.
- Develop strong linkage with the industry sector.
- Participate and organize international conferences and workshops.
- Collaborate with other international organizations.

Working groups

WG 4.5.1: Quality Measures for Network-based GNSS RTK

Chair**:** X. Meng (UK)
Co-Chair**:** H.-J. Euler (Switzerland)

Description

To study methods of quality control from both the end users and service providers' point of view. The research will focus on the assessment and improvement of the robustness and processing efficiency of Network-based GNSS RTK algorithms and software tools; the development of methods for integrity and completeness checking, time of arrival of corrections, impacts of incomplete and delayed messages; and the development of methods to increase the overall confidence and awareness of the positional accuracy.

WG 4.5.2: Precise Point Positioning and Network RTK

Chair: Sunil Bisnath (Canada)
Co-Chair: Sue Lynn Choy (Australia)

Description

To address and investigate issues related to the development of GNSS-based precise point positioning (PPP) and network RTK (Real-Time Kinematic) technology. The main research focus will include the development and integration of PPP and network RTK algorithms, high performance PPP and RTK in the context of multi-GNSS constellations, and methods and algorithms to improve the availability and reliability of PPP and RTK. Promoting innovative application development and increasing user adoption will be a continuous effort.

WG 4.5.3: Integer Ambiguity Resolution for PPP and PPP-RTK

Chair: X. Zhang (China)
Co-Chair: P. Henkel (Germany)

Description

To study methods and algorithms of integer ambiguity resolution for precise point positioning and investigate issues and problems related to ambiguity initialization time, success rate and reliability etc. The research will focus on the following areas: the development of new augmentation corrections to mitigate fractional initial phase biases to recover the integer property of the un-differenced ambiguities; the development of methods and algorithms for integer ambiguity resolution in precise point positioning; and the real-time implementation and standardization of PPP-based RTK systems.

WG 4.5.4: Multi-frequency, Multi-constellation Sub-cm RTK

Chair: B. Li (Australia)
Co-Chair: Y. Feng (Australia)

Description

To study efficient approaches for sub-cm RTK over longer baseline and high-precision large-scale network RTK solutions with multi-frequency, multi-constellation GNSS systems. The research task will focus on the following areas: the efficiency and reliability improvement of ambiguity resolution over longer baselines; new linear combinations for mitigating different error sources and improving the real time kinematic positioning solutions from the current centimetre level to sub-centimetre level; applications to geodesy, geodynamics, engineering and machine automations where sub-cm accuracy is of great interest.

SC 4.6: GNSS-Reflectometry and Applications

Chair: S. Jin (China)
Vice-Chair: M. Martin-Neira (Netherlands)
Secretary: S. Gleason (Canada)

Terms of Reference:

The Global Navigation Satellite System (GNSS) can be characterized as a highly precise, continuous, all-weather and near-real-time microwave (L-band) technique, which implies more and wider applications and potentials. Recently, the versatile reflected and scattered signals of GNSS have been successfully demonstrated to sound the land surfaces (including soil moisture), ocean, and the cryosphere as a new remote sensing tool. The GNSS reflected signals from the ocean and land surface could determine the ocean height, wind speed and wind direction of ocean surface, soil moisture, ice and snow thickness, which could supplement the traditional remote sensing techniques, e.g., radar altimetry and SAR. The focus of this Sub-Commission (SC4.6) is to facilitate collaboration and communication, and to support joint researches with promising GNSS-Reflectometry (GNSS-R) technique. Specific objectives will be achieved through closely collaborating with working groups and other IAG Commissions/Sub-Commissions. Meanwhile, close collaboration with the International GNSS Service (IGS), Institute of Navigation (ION) and IEEE Geoscience and Remote Sensing Society (IGRASS) will be promoted, such as joint sponsorship of international professional workshops and conferences.

Objectives:

- To promote and extend GNSS Reflectometry/Scatterometry developments and tests as well as environment remote sensing applications, including GNSS-R receiver, antenna, signals, system and experiments.
- To improve the existing estimation algorithms, inversion theory and temporal-spatial resolution in GNSS reflectometry from the ocean and land surface and supplement the traditional remote sensors, e.g., Satellite Altimetry and SAR.
- To coordinate data from GNSS-R campaign experiments and provide environment remote sensing products through fusing with other terrestrial and satellite observations.
- To address coastal ocean topography, ocean surface roughness characteristics (wind speed/direction and wave height), ice motion, wetland monitoring and surface soil moisture and snow/ice thickness as well as the condition of sea ice, glacial melting and the freezing/thaw state of frozen ground.

- To facilitate collaboration and communication with mutual Remote Sensing related communities (Oceanography, Hydrology, Cryosphere, Geodesy).

Program of Activities:

This SC will establish WGs on relevant topics, and promote GNSS Reflectometry/Scatterometry developments and remote sensing applications. Chair/Co-Chair will work closely with members and other IAG Commissions/Sub-Commissions to obtain mutual goals. Also we will organize international workshops and symposiums to provide a platform for GNSS-R communication and collaboration and jointly sponsor special sessions at IAG Symposia and other workshop/conferences with IGARSS and ION.

Working Groups

WG 4.6.1: GNSS-R Development and Experiment

Chair: M. Martin-Neira (Netherlands)
Co-Chair: F. Fabra (Spain)

Description

The PARIS (PAssive Reflectometry Interferometric System, also called GNSS-Reflectometry) was successfully designed to use GNSS reflected signals from Earth's surface to act as multiple passive altimetric ranging signals and a bistatic scatterometer. This effort will be dedicated to GNSS-Reflectometry technique development, experiments and processing, e.g., GNSS-R test and applications in land and ocean surface. In particular, the WG goals are:

- To provide GNSS-R technique information and new developments, including GNSS-R receiver, antenna, signals, and simulations.
- To organize GNSS-R experiments in ocean coast, bridge, aircraft and LEO satellites and analyze and test the GNSS-R for land and ocean surface applications.

WG 4.6.2: GNSS Scatterometry

Chair: S. Gleason (Canada)
Co-Chair: M. Clarizia (UK)

Description

This WG is primarily focused on the study of ocean wind and wave retrieval using scattered GNSS signals as well as ocean sensing applications, including looking into the signal scattering statistics and analyzing the achievable surface resolution for different instrument configurations. The primary goals of this WG is:

- To improve the scattering signal quality and estimated theory for ocean wind and wave retrieval using different instrument and GNSS-R carrier configurations.

WG 4.6.3: GNSS Ocean Altimetry

Chair: S. d'Addio (Netherlands)
Co-Chair: E. Cardellach (Spain)

Description

The ocean surface roughness characteristics can be detected in some cases using GNSS reflected signals comparable with other remote sensors . Further research is needed in detailed analysis of the electromagnetic field scattering theory, power and Delay-Doppler parameter retrieval methods and characterizing the L-band surface slopes' probability density function. The primary goal of this WG is:

- To improve GNSS Altimetry for all currently available GNSS signals and to demonstrate more applications in oceans through closely collaborating with Commission 2, e.g. Altimetry, Gravimetry, ICESat, etc.

WG 4.6.4: Soil and Cryosphere detection by GNSS-R

Chair: M. Jacobson (USA)
Co-Chair: N. Floury (Netherlands)

Description

The soil moisture, ice and snow thickness are related to the amplitude of the reflected signal as a function of the incidence angle or relative amplitudes between different polarizations, which can be retrieved from the GNSS reflected signals. This effort is to develop GNSS reflectometry and multipath for land surface mapping, wetland monitoring and surface soil moisture and snow/ice thickness as well as the condition of sea ice, glacial melting and the frozen state. The primary goal of this WG is:

- To improve the estimate theory and sensitivity to soil moisture, snow and ice condition from the GNSS reflected signals and to precisely determine the soil moisture, ice status and features.