Commission 1 - Reference Frames
web: iag.dgfi.badw.de

President: **Hermann Drewes** (Germany)
Vice President: **C.K. Shum** (USA)

Terms of Reference

Geodetic reference frames are the basis for three-dimensional, time dependent positioning in global, regional and national networks, cadastre, engineering, precise navigation, geo-information, geodynamics, sea level studies, and other geosciences. They are necessary to consistently estimate unknown parameters using geodetic observations, e.g., station coordinates, crustal motions, Earth orientation parameters. Commission 1 is focused on the scientific research associated with the definition and realization of global and regional reference frames as well as the development of analysis and processing methods for relevant geodetic observations. Different terrestrial and space-borne measuring techniques shall be investigated with respect to their strengths and weaknesses for parameter estimation, their respective precision, accuracy and reliability. The proper use of these techniques for geodetic research shall be coordinated and methods for the combination of heterogeneous measurements shall be studied and disseminated. The basis for globally unified reference frames for three-dimensional positioning and monitoring of motions, horizontal and vertical, over land, water and ice, shall be provided and disseminated among the scientific and users community as well as the appropriate IAG Services.

Commission 1 is identical with the Sub-commission B2 of the Scientific Commission B of the ICSU Committee on Space Research (COSPAR).

Objectives

The principal objective of the scientific work of Commission 1 is the basic research on:

- Definition, establishment, maintenance, and improvement of geodetic reference frames.
- Advanced development of terrestrial and space observation techniques for this purpose.
- Analysis and processing methods for parameter estimation related to reference frames.
- Theory and coordination of astrometric observations for reference frame purposes.

Additional objectives of the Commission are the international collaboration:

- For the definition and deployment of networks of observatories.
- With related scientific organizations, institutions, agencies, and IAG Services.

Structure

Sub-Commissions:

SC1.1: Coordination of Space Techniques
President: **M. Rothacher** (Germany)

SC1.2: Global Reference Frames
President: **Claude Boucher** (France)

SC1.3: Regional Reference Frames
President: **Zuheir Altamimi** (France)

SC1.3 a: Europe
Chair: **Joao Torres** (Portugal)

SC1.3 b: South and Central America
Chair: **Luiz Paulo Fortes** (Brazil)

SC1.3 c: North America
Chair: **Michael Craymer** (Canada)

SC1.3 d: Africa
Chair: **R. Wonnacott** (South Africa)

SC1.3 e: Asia-Pacific
Chair: **John Manning** (Australia)

SC1.3 f: Antarctica
Chair: **Reinhard Dietrich** (Germany)

SC1.4: Interaction of Celestial and Terrestrial Reference Frames
President: **Shen Yuan Zhu** (Germany)

Inter-Commission Projects:

IC-P1.1: Satellite Altimetry
(Joint with Commissions 2 and 3)
Chair: **Wolfgang Bosch** (Germany)

IC-P1.2: Vertical Reference Frames
(Joint with Commission 2)
Chair: **Johannes Ihde** (Germany)

Inter-Commission Study Groups:

IC-SG1.1: Ionosphere Modelling and Analysis
(Joint with Commission 4 and COSPAR)
Chair: **Claudio Brunini** (Argentina)

IC-SG1.2: Use of GNSS for Reference Frames
(Joint with Commission 4 and IGS)
Chair: **Robert Weber** (Austria)

Inter-Commission Working Groups

IC-WG 1: Quality Measures, Quality Control and Quality Improvement
(Joint with ICCT and Commission 2)
(Description: See ICCT)
Chair: **H. Kutterer** (Germany)

IC-WG2: Integrated theory for Crustal Deformation
(Joint with ICCT and Commission 3)
(Description: See ICCT)
Chair: **K. Heki** (Japan)

IC-WG3: Satellite Gravity Theory
(Joint with ICCT and Commission 2)
(Description: See ICCT)
Chair: **N. Sneeuw** (Canada)

Program of Activities

The Commission encourages, initiates and supports basic research in the field of geodetic reference frames, exchanges the experiences with the relevant IAG services and COSPAR entities, and disseminates the results. It assists in the coordination of geodetic techniques relevant for reference frames and elaborates concrete methods to improve its quality and reliability. Regular exchange of information via internet by e-mails and the Commission's homepage shall enhance the contact between various groups engaged in reference frames research. An annual bulletin is planned for publishing the results. A close cooperation will be established with the International Earth Rotation and Reference Systems Service (IERS), its Products Centres and Combination Research Centres and working groups. Emphasis will be laid on the assistance to individual countries in establishing their national reference frames.

Steering Committee

President: Hermann Drewes (Germany)
Vice President: C.K. Shum (USA)
President SC1.1: Markus Rothacher (Germany)
President SC1.2: Claude Boucher (France)
President SC1.3: Zuheir Altamimi (France)
President SC1.4: Shen Yuan Zhu (Germany)
Representatives of IERS/IDS/IGS/ILRS/IVS:
Werner Gurtner (Switzerland)
Chopo Ma (USA)
John Ries (USA)
Members at large:
John Manning (Australia)
Richard Wonnacott (South Africa)

Sub-Commission

SC 1.1 - Coordination of Space Techniques

President: **Markus Rothacher** (Germany)

Terms of Reference

The space geodetic observation techniques, including Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Global Navigation Satellite Systems (GNSS) such as GPS, GLONASS, and in future GALILEO, the French DORIS, as well as altimetry, InSAR, and the gravity missions, contribute significantly to the knowledge about and the understanding of the three major pillars of geodesy: the Earth's geometry (point coordinates and deformation), Earth orientation and rotation, and the gravity field as well as its time variations. These three fields interact in various ways and they all contribute to the description of processes in the Earth System. Each of the space geodetic techniques contributes in a different and unique way to these three pillars and, therefore, their contributions should be combined into a consistent Integrated Global Geodetic Observing System (IGGOS), the project of the IAG.

Sub-Commission 1.1 coordinates efforts that are common to more than one space geodetic technique, such as models, standards and formats. It shall study combination methods and approaches concerning links between techniques co-located at fundamental sites, links between techniques co-located onboard satellites, common modelling and parameterisation standards, and perform analyses from the combination of a single parameter type up to a rigorous combination on the normal equation (or variance-covariance matrices) and even the observation level. The list of interesting parameters includes site coordinates (e.g. time series of combined solutions), Earth orientation parameters, satellite orbits (combined orbits from SLR, GPS, DORIS, altimetry), atmospheric refraction (troposphere and ionosphere), gravity field coefficients, geocenter coordinates, etc. One important goal of SC1.1 will be the development of a much better understanding of the interactions between the parameters describing geometry, Earth rotation, and the gravity field as well as the study of methods to validate the combination results, e.g., by comparing them with independent geophysical information.

To the extent possible SC1.1 should also encourage research groups to develop new observation techniques connecting or complementing the existing set of measurements.

Sub-Commission 1.1 has the task to coordinate the activities in the field of the space geodetic techniques in close cooperation with all the IAG Services, especially with the IERS and its Working Group on Combination, and with COSPAR.

Objectives

The principal objectives of the scientific work of Sub-Commission 1.1 are the following:

- Study systematic effects of or between space geodetic techniques.
- Develop common modelling standards and processing strategies.
- Comparison and combination of orbits derived from different space geodetic techniques together with the IGS LEO Working Group.
- Explore and develop innovative combination aspects such as, e.g., GPS and VLBI measurements based on the same high-accuracy clock, VLBI observations to GNSS satellites, combination of atmospheric information (troposphere and ionosphere) of more than one technique, etc.
- Establish methods to validate the combination results (e.g., with global geophysical fluids data).
- Explore, theoretically and practically, the interactions between the gravity field parameters, EOPs, and reference frames (site coordinates and velocities), improve the consistency between these parameter groups, and assess, how a correct combination could be performed.
- Study combination aspects of GPS and InSAR.

Additional objectives of Sub-Commission 1.1 are:

- Promotion of international scientific cooperation.
- Coordination of common efforts of the space geodetic techniques concerning standards and formats (together with the IERS).
- Organization of workshops and sessions at meetings to promote research.
- Establish bridges and common activities between SC1.1 and the IAG Services.

Links to Services

Sub-Commission 1.1 will establish close links to the relevant services for reference frames, namely International Earth Rotation and Reference Systems Service (IERS), International GPS Service (IGS), International Laser Ranging Service (ILRS), International VLBI Service for Geodesy and Astrometry (IVS), and International DORIS Service (IDS).

Membership

President: Markus Rothacher (Germany)

Working Groups:

WG 1.1.1: Comparison and combination of precise orbits derived from different space geodetic techniques (joint with the IGS LEO WG)

This working group is taking over the role of the former CSTG Sub-commission on Precise Orbit Determination (POD) of Low Earth Orbiting (LEO) Satellites. It will work closely together with the IGS LEO Working Group, but will have a broader research field not focussing on GPS, but on the interplay between different tracking techniques. The main topics of the WG will be:

- Comparison and combination of satellite orbits derived from various tracking techniques, including SLR, DORIS, GPS, altimetry, K-band links, CCD, and possible future observation techniques. Satellite orbits ranging from LEOs up to geostationary satellites (GEOs) should be considered.
- Assessment of systematic errors between different orbit types and observation techniques.
- Study of improved force models and POD strategies based on the combination of techniques.

WG 1.1.2: Interaction and consistency between terrestrial reference frame, Earth rotation, and gravity field
(joint with Commission 2, Commission 3, and IGGOS)

This working group has to be a joint working group together with Commission 2, Commission 3, and IGGOS. Its main research topics are:

- Study the theoretical and practical interactions/relationships between parameters and models describing the Terrestrial Reference Frame (TRF), Earth rotation, and the gravity field (e.g., low degree harmonics of the gravity field, Love numbers...).
- Assess and study the consistency between products of these three fields.
- Investigate methods and techniques to combine geometry, Earth rotation, and gravity field parameters (e.g., by including LEO satellites into global solutions).

WG 1.1.3: Comparison and combination of atmospheric information derived from different space geodetic techniques
(Joint with IGS Troposphere WG, IGS Ionosphere WG, and IVS)

The task of this working group shall be the comparison and the combination of information about the atmosphere derived from different space geodetic techniques such as GPS, VLBI, InSAR, altimetry, etc. A very close cooperation with the IAG services, especially the IGS and the IVS are essential. Major research topics are:

- Investigate differences between tropospheric delay parameters estimated by different techniques; assess systematic biases between techniques and the accuracy of each individual technique; consider ways to combine and validate the information of different techniques.
- Study the accuracy of global or regional ionosphere maps or simple delays derived from different techniques; assess systematic biases; compare, combine, and validate results.

Sub-Commission

SC 1.2 - Global Reference Frames

President: **Claude Boucher** (France)

Terms of Reference

Sub-Commission 1.2 is engaged in scientific research and practical aspects of the global reference frames. It investigates the requirements for the definition and realization of the terrestrial reference frame, addresses fundamental issues of multi-technique global geodetic observatories (local ties, site effects…) and studies methods and approaches for the combined processing of heterogeneous observation data. The work will be done in close cooperation with the International Earth Rotation and Reference Systems Service (IERS), in particular with the ITRS Product Centre and the IERS Combination Research Centres (CRC), the other relevant IAG services (IGS, ILRS, IVS, IDS), and the IAG Project "Integrated Global Geodetic Observing System (IGGOS)". Theoretical aspects (e.g., quality measures, relativistic modelling) will be investigated in cooperation with the Inter-Commission Committee on Theory.

Objectives

The following research topics will form the fundamental objectives during the next period:

- Definition of the global terrestrial reference frame (origin, scale and orientation, time evolution, standards, conventions, models);
- Fundamentals of the realization of the global terrestrial reference frame (e.g., co-location problems: local ties; datum problems: coordinates origin, geo-centre; time evolution: linear and non-linear velocities, time series approach; long-term consistency with EOPs and ICRF);
- Analysis of strengths, weaknesses and systematic differences (biases) of individual techniques (VLBI, SLR, GPS, DORIS) and their contribution to specific TRF parameters;
- Combination methodology of individual techniques' solutions and analysis of the underlying models, parameters datum definitions etc.;
- Definition of common standards and models for all techniques.
- Practical implementation of the concept of Global Geodetic Observatories.
- Propagation of the ITRS/ITRF to national and international organizations.

Program of Activities

A Web site and mailing system will be established for a better exchange of information with regard to the mentioned objectives and with the respective components of the IERS, other services and the scientific community.

The necessity of the use of the ITRF as the reference frames for any kind of precise global positioning using space techniques shall be propagated among geodesy, other geosciences and society in general. It will also investigate the opportunity to formally adopt ITRF as primary realization of a common Earth fixed, Earth centred system in all applications: geodesy, surveying, mapping, navigation, geomatics etc. and clarify its relation with systems such as WGS84. Adequate activities have to be developed.

Links to Services

Sub-Commission 1.2 will closely be linked to the relevant services, in particular to the International Earth Rotation and Reference Systems Service (IERS), but also to the International GPS Service (IGS), International Laser Ranging Service (ILRS), International VLBI Service for Geodesy and Astrometry (IVS), and International DORIS Service (IDS).

Membership

President: Claude Boucher (France)

Working Groups

IC WG 1.2.1: Datum Definition of Global Terrestrial Reference Frames
(Joint with IERS and ICCT)
Chair: **Geoffrey Blewitt** (USA)

Terms of Reference

The Working Group is to deliver recommendations, in particular to the IERS, on possible datum definitions of Global Terrestrial Reference Frames (GTRFs) with the goal of improving the relevance, stability, quality, and understanding of GTRFs for various potential user groups. The principal objectives are:

- To assist the IERS Analysis Coordinator and ITRS Combination Centres by providing recommendations on datum conventions for future realizations of ITRF.
- To assist the ICCT in drafting conventional definitions of technical terms that refer to the various possible components of GTRFs.
- To identify the needs of potential user groups of GTRFs and address issues of datum definition that might benefit those groups.

- To compile a short summary document that references all recent published journal articles (not just those of the WG) relevant to datum definition of GTRFs, including a summary of the findings, conclusions, and significance of each paper, and to keep such a document updated as a reference document to assist research and informed discussion.

Program of Activities

- To study the different types of possible reference system definitions that might be important for different research fields (sea level, geoid, deformation, Earth orientation...) and for what measurements they are important.
- To assess the uncertainties and quality of the various realizations, how they are affected by geophysical processes, and how the effect of these processes can be modelled in time and space to allow a refined realization of the frames.
- To assess how a stable and consistent reference frame can be realized over decades with the limited number of stations and observations.
- To study datum definition in a relativistic framework, in particular in view of the CRS/TRS transformation.
- To study the impact of IAU non-rotating origin on TRS, if any.

WG 1.2.2: Global Geodetic Observatories
(Joint with IERS)

Chair: **Jim Long** (USA)

Terms of Reference

Global geodetic observatories play a fundamental role in the installation of the global reference frame. They establish the connection between different techniques and provide the basis for the realization of the unique datum.

Program of Activities

The reliability of global geodetic observatories, in particular of the local ties between different techniques' observing instruments, shall be investigated in view of the fundamental importance for the inter-technique analysis and combination. The co-location strategies will be investigated, as well as all aspect of local site survey measurement, processing and reporting. The group will in particular provide any guideline to be implemented in the IERS activities, as well as Technique Services.

WG 1.2.3: Integrated Theory for Crustal Deformation and Reference Frames
(Joint with Commission 3 and ICCT)

Chair: **Kosuke Heki** (Japan)

Terms of Reference

The effect of short-term crustal deformations, e.g., due to loading effects, on the reference frame parameters (heights, velocities, etc.) is important for the definition and realization of global reference frames: To which standard atmospheric pressure refer the coordinates (in particular the heights)? Have non-linear velocities (e.g., periodical) to be estimated?

(Detailed program description see in Inter-Commission Committee on Theory)

Sub-Commission

SC 1.3 - Regional Reference Frames

President: **Zuheir Altamimi** (France)

Terms of Reference

Sub-Commission 1.3 is concerned with definitions and realizations of regional reference frames and their connection to (and the densification of) the global International Terrestrial Reference Frame (ITRF). It offers a home for service-like activities addressing theoretical and technical key common issues of interest to regional organisations.

Objectives

In addition to specific objectives of each regional sub-commission, the main objectives of SC1.3 as a whole are:

- Develop specifications for the definition and realization of regional reference frames, including vertical datums, with full interaction with the Inter-Commission Project ICP 1.2 on Vertical Reference Frames.
- Develop and promote operation of GPS permanent stations, in connection with IGS whenever appropriate, to be the basis for the long-term maintenance of regional reference frames.
- Coordinate activities of the regional sub-commissions focusing on exchange and share of competences and results.
- Encourage and stimulate the emerging development of the AFREF project with close cooperation with IGS.
- Encourage and assist, within each regional sub-commission, countries to re-define and modernize their national geodetic systems, compatible with the ITRF.

Program of Activities

- Organize inter-regional workshop(s) addressing activities, results and key issues of common interest to the regional sub-commissions.
- Develop analysis strategies and compare methods for the implementation of the regional reference frames and their expression in the ITRF, with full interaction with the IGS.
- Consider establishing regional dense velocity fields for, primarily, the long-term maintenance of the regional reference frames.
- Contribute at regional levels to the improvement of local surveys in the collocation sites, with full cooperation with the Sub-commission 1.2 Global Reference Frames.

Links to Services

The regional reference frame activities are tied into the various IAG services through provision of data from individual sites to:

- International Earth Rotation and Reference Systems Service (IERS)
- International GPS Service (IGS)
- International Laser Ranging Service (ILRS)
- International VLBI Service for Geodesy and Astrometry (IVS)
- International DORIS Service (IDS)

Membership

President: Zuheir Altamimi (France)
SC1.3a Chair: João Agria Torres (Portugal)
SC1.3b Chair: Luiz Paulo Fortes (Brazil)
SC1.3c Co-Chairs: Michael Craymer (Canada), Richard Snay (USA)
SC1.3d Chair: Richard Wonnacott (South Africa)
SC1.3e Chair: John Manning (Australia)
SC1.3f Chair: Reinhard Dietrich (Germany)

Working Groups

WG 1.3.1: Inter-regional Technical Working Group

Terms of Reference

The main task of this WG is to develop harmonized and possibly common specifications for the regional reference frames implementation and ITRF densification.

Sub-Commission

SC 1.3a - Europe (EUREF)

Chair: **Joao Torres** (Portugal)

Terms of Reference

EUREF, the Regional Reference Frame Sub-commission for Europe, deals with the definition, realization and maintenance of the European Reference Frame, focusing on both the spatial and the vertical components, in close cooperation with the pertinent IAG components (Services, Commissions, and Inter-commission projects) and EuroGeographics, the consortium of the National Mapping Agencies (NMA) in Europe.

Program of Activities

- Continue to develop the EUREF Permanent Network (EPN) in close cooperation with IGS, for the maintenance of the European Reference Frame, as a contribution to the ITRF and as infrastructure to support other relevant projects, namely the European initiatives related with GALILEO.
- Extend the Unified European Levelling Network (UELN) and prepare it to be computed under a geokinematic approach.
- Implement the project European Combined Geodetic Network (ECGN) and investigate the discrepancies already identified in the combination of the EUVN (European United Vertical Network) results and the gravimetric geoid (project EUVN_DA), in close cooperation with IAG Commission 2.
- Establish a dense velocity field model in Europe for the long-term maintenance of the European reference frame.
- Consider the contribution to the IAG Project IGGOS (Integrated Global Geodetic Observing System) using the installed infra-structures managed by the EUREF members.
- Promote the adoption of the reference systems defined by EUREF (ETRS89-European Terrestrial Reference System and EVRS2000-European Vertical Reference System) in the European countries and European-wide organizations involved in geo-referencing activities.
- Organize annual symposia addressing activities carried out at national and European-wide level related with the global work and objectives of EUREF.

Membership

Chair: Joao Torres (Portugal)
Secretary: Helmut Hornik (Germany)

Representatives from European IAG member countries
Technical Working Group (TWG) members elected by the plenary
Members in charge of special projects and ex-officio members.

Sub-Commission

SC 1.3b - South and Central America (SIRGAS)

Chair: **Luiz Paulo Fortes** (Brazil)

Terms of reference

Sub-commission 1.3b (South and Central America) encompasses the activities developed by the "Geocentric Reference System for the Americas" project (SIRGAS). As such, it is concerned with the definition and realization of a unified reference frame for South and Central America, consistent with ITRF, besides promoting the definition and establishment of a unique vertical reference system in this region.

Objectives

The aims and objectives of the Sub-commission 1.3b are:

- To define, realize and maintain a geocentric reference system for South and Central America consistent with ITRF;
- To establish a geocentric datum, promoting the connection of the national geodetic networks to it;
- To promote the definition and establishment of a unique vertical reference system for this region;
- To facilitate the connection of pre-existing networks;
- To promote and coordinate the efforts of each country to achieve the defined objectives.

Program of Activities

The SIRGAS 2000 GPS campaign was carried out from May 10 to 19, 2000, in order to support the computation of a velocity field for South America and the activities of SIRGAS WG3. In total, 184 stations were established in the Americas, whose coordinates were computed and are available on the project website (http://www.ibge.gov.br/sirgas). The next project activities are:

- To conclude the determination of the velocity field for South America, based on independent computations using collocation and finite elements
- To carry out spirit leveling of the SIRGAS 2000 stations
- To connect the classical vertical networks between neighboring countries
- To compute geopotential numbers for stations of the national vertical networks
- To collaborate with the determination of the sea surface topography
- To contribute to the determination of a unified quasi-geoid for the region

Membership

Chair: Luiz Paulo Fortes (Brazil)
Vice-Chair: Eduardo Lauría (Argentina)
Chair WG1.3b.1: the SIRGAS WG1 President
Chair WG1.3b.2: the SIRGAS WG2 President
Chair WG1.3b.3: Laura Sánchez (Colombia)

Working Groups

WG 1.3b.1: Geocentric Reference Frame
WG 1.3b.2: Geocentric Datum
WG 1.3b.3: Vertical Datum

Sub-Commission

SC 1.3c - North America (NAREF)

Chair: **Michael Craymer** (Canada)
Co-chair: **Richard Snay** (USA)

Terms of Reference

To provide international focus and cooperation for issues involving the horizontal, vertical, and three-dimensional geodetic control networks of North America, including Central America, the Caribbean and Greenland (Denmark). For more information, see www.naref.org.

Objectives

In collaboration with the IAG community, its service organisations and the national geodetic organizations of North America, the aims and objectives of this regional sub-commission are to provide international focus and cooperation for issues involving the horizontal, vertical and three dimensional geodetic control networks of North America. Some of these issues include:

- Densification of the ITRF reference frame in North America and the promotion of its use;
- Maintenance and future evolution of vertical datums (ellipsoidal and orthometric), including the North American Vertical Datum of 1888 (NAVD88) and the International Great Lakes Datum (IGLD);
- Collocation of different measurement techniques, such as GPS, VLBI, SLR, DORIS, tide gauges, etc.;
- Effects of crustal motion, including post-glacial rebound and tectonic motions along, e.g., the western coast of North America and in the Caribbean;
- Standards for the accuracy of geodetic positions;
- Outreach to the general public through focused symposia, articles, workshops and lectures, and technology transfer to other groups.

Membership

Chair: Michael Craymer (Canada)
Co-chair: Richard Snay (USA)
Members: Per Knudsen (Denmark), TBD (Mexico), TBD (Caribbean)

Working Groups

WG 1.3c.1: North American Reference Frame (NAREF)

Chair: Michael Craymer
Members: B. Donahue (Canada), H. Dragert (Canada), C. Huot (Canada), M. Piraszewski (Canada), F.B. Madsen (Denmark), M. Cline (USA), B. Dillinger (USA), P. Fang (USA). R. Snay (USA), R. Ferland (Canada, IGS Representative)

Program of Activity

To densify the ITRF reference frame in the North American region by organizing the computation of weekly coordinate solutions and associated accuracy information for continuously operating GPS stations that are not part of the current IGS global network. A cumulative solution of coordinate and velocities will also be determined on a weekly basis. The working group will organize, collect, analyse and combine solutions from individual agencies, and archive and disseminate the weekly and cumulative solutions.

WG 1.3c.2: Stable North American Reference Frame (SNARF)

Chair: Geoff Blewitt
Members: M. Craymer (Canada), Mitrovica (Canada), D. Argus (USA), R. Bennet (USA), J. Davis (USA), T. Dixon (USA), T. Herring (USA), D. Lavalleee (USA), M. Miller (USA), W. Prescott (USA), R. Snay (USA), F. H. Webb (USA)

Program of Activity

To establish a high-accuracy standard reference frame, including velocity models, procedures and transformations, tied to a “stable North America” which would serve the broad scientific and geomatics communities by providing a consistent, mm-accuracy, stable reference with which scientific and geomatics results (e.g., positioning in tectonically active areas) can be produced and compared.

WG 1.3c.3: Reference Frame Transformations, Chair: Michael Craymer

Chair: Michael Craymer
Members: R. Ferland (Canada, IGS Representative), R. Snay (USA), T. Soler (USA)

Program of Activity

To determine consistent relationships between international, regional and national reference frames/datums, to maintain (update) these relationships as needed and to provide tools for implementing these relationships.

Sub-Commission

SC 1.3d - Africa (AFREF)

Chair: **Richard Wonnacott** (South Africa)

Terms of reference

Sub-commission 1.3d (Africa) is concerned with definition and realization of a unified continental reference frame (AFREF) for Africa which will be consistent and homogeneous with the global International Terrestrial Reference Frame (ITRF).

Objectives

In collaboration with the IAG community and its services organisations and the National and Regional Mapping Organisations of Africa, the aims and objectives of Sub-commission 1.3d (Africa) are:

- To define the continental reference system of Africa. Establish and maintain a unified geodetic reference network as the fundamental basis for the national 3-d reference networks fully consistent and homogeneous with the global reference frame of the ITRF;
- To realize a unified vertical datum and support efforts to establish a precise African geoid, in concert with the African Geoid project activities;
- To establish continuous, permanent GPS stations such that each nation or each user has free access to, and is at most 500km from, such stations;
- To provide a sustainable development environment for technology transfer, so that these activities will enhance the national networks, and numerous applications, with readily available technology;
- To understand the necessary geodetic requirements of participating national and international agencies and;
- To assist in establishing in-country expertise for implementation, operations, processing and analyses of modern geodetic techniques, primarily GPS.

Program of Activities

It is envisaged that regionalization of AFREF will follow an approach that consists of three major phases:

- The establishment of a framework of permanent or semi-permanent GPS base stations throughout the region that will become part of the worldwide IGS network of stations.
- The densification of the network of permanent or semi-permanent base stations, largely on a country-by-country basis, to determine the relationship between the national geodetic system and the ITRS, and to refine the transformation parameters necessary to relate the national systems to a common ITRF.
- The third and equally important phase of the project will be to address the development of a more refined geoid model for Africa and the definition of a common vertical datum for the continent. This will be done in collaboration with the IAG Africa Geoid Project (Project 2.3 Commission 2).

It is further planned to hold workshops and seminars to strengthen the science and knowledge of geodesy and GNSS within Africa and their application to the development of reference frames.

Membership

Chair: Richard Wonnacott (South Africa)

Sub-Commission

SC 1.3e - Asia and the Pacific

Chair: **John Manning** (Australia)

Terms of Reference

To provide a regional focus for cooperation in the definition, realisation and densification of the International Terrestrial Reference frame (ITRF). This activity will be carried out in close collaboration with the Regional Geodesy Working Group of the Permanent Committee for GIS Infrastructure in Asia and the Pacific which operates under the purview of the United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP).

Objectives

The objectives of the Sub-commission1.3e are:

- The densification of the ITRF and promotion of its use in the connection and enhancement of national networks;
- To promote the development of a regional vertical reference datum system
- To develop a better understanding of tectonic motions and plate boundaries within the region
- The development of an improved geoid by enhancement of the data from the regional gravity network and global gravity models
- Collocation of different measurement techniques, such as GPS, VLBI, SLR, DORIS, tide gauges, and maintenance of precise local geodetic ties at these sites.
- To outreach to developing countries through symposia, workshops, training courses, and technology transfer.
- Encourage the establishment of further continuous GPS base stations ,(accurately) positioned within ITRF, with data available both locally and to IGS.

Program of Activities

The activities of this sub commission will principally be carried out by the members of national surveying and mapping organisations through the PCGIAP Regional Geodesy Working Group and through the scientific members of the Asia Pacific Space Geodynamics Project (APSG**).**

In order to densify the ITRF reference frame in the Asia Pacific Region an annual geodetic observation campaign will be held each year to provide an opportunity to connect to national geodetic networks and to determine site velocities. These campaigns include several geodetic techniques:

- SLR, through cooperation with ILRS and WPLTN,
- VLBI, through APSG,
- GPS through PCGIAP.

Computations are undertaken in several countries from a common data set, which includes data from weekly epoch occupations, and continuously operation GPS which are not contributing to the IGS network. Only selected stations from the massive Japanese network are included.

The combination of results is being developed in the region and a PCGIAP workshop on Regional Geodesy will be held each year to strengthen regional cooperation, to discuss and analyse results of the geodetic campaigns, and to promote technology transfer.

Membership

Chair: John Manning (Australia)
Members of the Regional Geodesy Working Group of the Permanent Committee for GIS Infrastructure in Asia and the Pacific (PCGIAP)
Members of the Asia Pacific Space Geodynamics project (APSG)

Sub-Commission

SC 1.3f - Antarctica (SCAR)

Chair: **Reinhard Dietrich** (Germany)

Terms of reference

Sub-commission 1.3f (Antarctica) is focusing on the definition and realization of an unified reference frame for Antarctica which will be consistent with the global International Terrestrial Reference Frame (ITRF). It will establish close links to corresponding activities within the Scientific Committee on Antarctic Research (SCAR).

Objectives

- Maintenance and densification of the precise geodetic reference network in Antarctica by permanent observations and GPS campaigns;
- Realization of an unified vertical datum including GPS ties of tide gauges;
- Providing unified reference for other GPS applications like airborne gravimetry, ground truthing for satellite missions, geodynamics and glaciology;
- Develop technologies for remote geodetic observatories.

Program of Activities

- Organization of GPS campaigns in Antarctica, maintenance of the data archive.
- Data analysis and determination of the Antarctic GPS network as a regional densification of ITRF.
- Support airborne surveys and satellite missions with precise terrestrial reference.
- Organize meetings and workshops on Antarctic geodesy Joint with related SCAR activities in order to strengthen the international cooperation and to make optimum use of field logistics and infrastructure.

Membership

Chair: Reinhard Dietrich (Germany)

Membership and structure of SC1.3f is yet to be finalized in close collaboration with the SCAR program GIANT (Geodetic Infrastructure for Antarctica).

Sub-Commission

SC 1.4 - Interaction of Celestial and Terrestrial Reference Frames

President: **Shen Yuan Zhu** (Germany)

Terms of Reference

All of the high precision techniques in geodesy make use of a quasi-inertial reference frame. Radio source positions of VLBI must be in a barycentric quasi-inertial celestial reference frame, the orbits of satellites can be modelled easily in a geocentric inertial reference frame only, while laser gyroscopes measure the rotation vector with respect to a topocentric inertial reference frame. All these realizations of a celestial reference frame are slightly different; on the other hand, there is only one transformation between a celestial and the conventional terrestrial reference frame, established by the adopted precession and nutation model of the IERS Conventions and the EOP series of the terrestrial frame. Thus, systematic errors are induced in the terrestrial frames (and/or their EOP series) as realized by different techniques.

Objectives

The major objective of the Sub-commission is the study of the interaction of the celestial reference frame and the terrestrial reference frame. Observing data link the terrestrial stations with the celestial sources or the satellites. Any error in the former will affect the latter, and vise versa. In order to remove or reduce systematic errors in the final products, we must begin from the celestial frames. At first we have clearly to understand their theoretical definitions and the relation (transformation) between their different realizations. This includes

- **Resolutions of the XXIVth IAU General Assembly** concerning the revision of the reference systems. The numerical implementation of these resolutions requires some approximations. What kind of approximation is suitable for a given accuracy requirement? Resolution B1.4 (post-Newtonian parametrization) must be worked out before being translated into computer software.
- **Standards:** In the observation equations a lot of constants, "corrections" or "disturbing" models will be involved. In geodesy there are two important standards: IERS Conventions and IAG Fundamental Parameters. We must study whether they are consistent with each other. If not (completely), how will they influence the reference frame and the products? The Sub-commission will cooperate with the "Inter-commission Committee on Geodetic Standards". If this Committee recommends any change or improvement of the Standards, its effect on the realization of reference frames has to be studied.
- **Modelling:** There are uncertainties in each model and/or constant (except the defined ones). But their effects depend on many factors which may cause special systematic errors, e.g. the height of the satellites (different gravity and drag perturbations), the wavelength of the tracking techniques (different ionospheric and tropospheric effects); one-way or two-way tracking (two clocks or one clock), phase centre (electronic or mechanic). The study of the effects of model errors for each individual case, and search the way to remove or reduce them is a long term objective of the Sub-commission.
- **Algorithms:** There are complications when different software uses different standards instead of the internationally agreed ones. Each s/w adopts its own solution strategy and procedure (least-squares or iterative, one-step or two-step, etc.). The solved for parameters may also be different and might absorb certain random and even systematic errors. In order to understand the effects of these differences, the Sub-commission needs a close cooperation and assistance from the Services and Analysis Centres.
- **Datum:** In VLBI one cannot solve source positions and station coordinates completely unconstrained. Any condition for station coordinates (or baselines etc.) is a kind of datum definition. This datum problem affects the realized celestial as well as the terrestrial reference frame. Similarly, for satellite techniques it is impossible to solve orbits, stations, EOP (including UT1), nutations completely unconstrained. One must at least fix UT1 and a nutation value at one epoch and fix the precession constant. All these imply a certain datum definition the effects of which have to be studied.

Links to Services

There will be a close cooperation with the International Earth Rotation and Reference Systems' Service (IERS) and the International VLBI Service, but also with the International Laser Ranging Service (ILRS) and International GPS Service (IGS).

Membership
President: Shen Yuan Zhu (Germany)

Working Groups

WG 1.4.1: Theoretical Aspects of the Celestial Reference System

Terms of Reference

The effects of the new IAU definitions, the relation between barycentric system (as realized by VLBI) and the geocentric system shall be studied. The celestial and the terrestrial ephemeris origin replaced in 2003 the vernal equinox and the traditional first axis of the terrestrial intermediate frame. Consequently, the earth rotation angle replaced the apparent sidereal time. The Earth orientation parameters consisting of the difference between UTC and UT, the polar motion parameters, and the nutation residuals, connect the CRF and the TRF. That makes it possible to represent each of these frames by the other one plus the earth orientation parameters. A change or error in one of the two frames must therefore be compensated by a corresponding change in the other frame and/or the earth orientation parameters, and any error in the orientation parameters must be reflected by a change in at least one of the two reference frames.

WG 1.4.2: Realization of Celestial Reference Frames (CRF and Transformations)

Terms of Reference

To achieve further progress regarding the realization of celestial reference frames it is essential to review the current status, to identify deficiencies and to make proposals for improvements. This task is closely related to various components of the IERS (e.g., ICRF PC, CRCs) and the techniques centres (IVS, ILRS, IGS, IDS), and requires a close cooperation between the different groups. The working group shall focus on all space geodetic techniques contributing to the CRF realization, i.e., VLBI to realize a barycentric CRF, satellite methods to realize a dynamic reference frame, and optical methods (future astrometry missions). The activities shall include the survey of the current status of CRF realization, a review regarding the implementation of IERS Conventions and IAG Fundamental Parameters and different space techniques for CRF realization.

WG 1.4.3: Systematic Effects in the CRF Determination

Terms of Reference

It is well-known that the accuracy achieved today is mainly limited by technique- and/or solution-related systematic biases (effects), which are often poorly characterized or quantified. This issue should be addressed regarding the determination of the celestial reference frame. The WG shall ensure a close cooperation between other relevant groups (e.g., ICRF PC, IVS, ILRS, IGS, IDS). The tasks include the definition of pilot projects regarding CRF determination, CRF computations by different groups with different software, identification and description of inconsistencies (systematic effects, refined models).

WG 1.4.4: Interaction Between Celestial and Terrestrial Reference Frames

Terms of Reference

A major goal of this WG is to investigate the interaction between the celestial and terrestrial reference frame and the transformation between both (precession, nutation, EOP), and to improve the consistency between ICRF, ITRF and EOP. The WG should ensure a close relation with various components of the IERS (Analysis Coordinator, CRCs, combination centres, product centres, etc.) and with the GGFC. Two different fields shall be addressed, the mathematical and the physical consistency between ICRF, ITRF and EOPs. The first item is the major goal of the IERS combination research centres. The WG should focus on the second aspect. The major tasks include the effect of errors in the CRF on the terrestrial reference frame and other related products, and vise versa, the realization of the NNR-condition for the ITRF (e.g. deformations) and its interaction with EOP determination, comparison with geophysical models, and the interaction with the gravity field.

WG 1.4.5: Satellite Gravity Theory
(Joint with Commission 2 and ICCT)

Terms of Reference

Satellites are mainly observed from stations with coordinates given in the terrestrial reference frame. Their orbits, however, have to be computed (integrated) in an inertial system. The adequate realization of the celestial inertial system in satellite dynamics shall be studied.

(Detailed program description see in Inter-Commission Committee on Theory)

Inter-Commission Project

IC-P 1.1 - Satellite Altimetry

(Joint with Commissions 2 and 3)

Chair: **Wolfgang Bosch** (Germany)

Terms of Reference

Satellite Altimetry has evolved to an operational remote sensing technique with important interdisciplinary applications to many geosciences. For geodesy, the potential operational, precise and near global mapping and monitoring of the Earth surface is of particular importance. The construction of high-resolution global mean sea surface and potentially its variability will help to globally unify height reference systems. Altimetry contributes to essential improvements of the Earth gravity field. Even with the new dedicated gravity field missions CHAMP, GRACE and GOCE, satellite altimetry will be needed for the determination of the high resolution gravity field. Mapping and monitoring of seasonal and secular changes of the mean sea level helps to understand fundamental processes of the System Earth: the ocean water mass redistribution, one component of the global hydrological cycle, has impact to the Earth center-of-gravity, to Earth rotation by the ocean angular momentum functions, the temporal variations of the Earth gravity field, as well as studies of sea level rise and its impact on environment. The multiple application suggests that satellite altimetry will become a core element of a global observing system. This includes, but is not limited to, the following scientific and organisational aspects:

- the combination of multiple altimeter mission data with different space-time sampling and the adaption and cross calibration of new technologies like laser altimetry (GLAS on ICESat), interferometric altimetry (Cryosat), delay-doppler altimetry (proposed by ABYSS), wide swath-altimetry (proposed on Jason-2), and potentially airborne and spcaeborne LIDARs. A reliable vertical reference system for altimetry is one of the most crucial prerequisite.
- a coordination among space agengies, processing centres, data providers, value-adding entities and the users together with a scientific feedback to ensure data and product quality and improvements for orbits and geophysical parameters. A scientific service appears to provide a most convenient platform.

The interdisciplinary relevance of satellite altimetry with overlaps between research areas of various IAG commissions justify to establish the project as a joint project of commissions 1, 2, and 3.

Objectives

The primary objective of the joined commission project is to identify the scientific requirements to ensure a long and precise time series of utmost consistent altimeter observations with up-to-date geophysical corrections, consolidated geocentric reference and long-term stability. It has to be elaborated, how satellite altimetry is going to contribute to a global observing system, how the data of different missions is to be harmonized and how fast updates of orbits and geophysical parameters can be achieved in order to support scientific and operational applications. More specific, it is required to obtain precise knowledge about the inherent vertical reference system of altimetry and the long-term stability of the altimeter sensors itself, and of auxillary sensors (radiometer). It is also envisioned that this project will provide a forum to foster innovative ideas for research and applications of satellite altimetry relevant to strengthening of the realisation of vertical component of the ITRF and to diverse areas of geosciences.

Program of Activities

- To study the contribution of satellite altimetry to the realisation and stability of the vertical component of the ITRF implied by precise orbit determination, geocenter variations, miscentering of reference frame, as well as long-term performance of altimeter - and auxillary sensors.
- To investigate by an interdisciplinary working group the rationale, feasibility and scope of an International Altimeter Service in order to serve scientific and operational applications of satellite altimetry. The group shall strive for a broad support by other scientific entities.

Links to Services

There will be installed links in particular to the International Earth Rotation and Reference Systems' Service (IERS), the International Gravity Field Service (IGFS) and the Permanent Service for Mean Sea Level (PSMSL).

Membership

Chair: Wolfgang Bosch (Germany)
Representative of Commission 1: C.K. Shum (USA)
Representative of Commission 2: Martin Vermeer (Finland)
Representative of Commission 3: Richard Gross (USA)

Working Groups

WG-ICP 1.1.1: Rationale, Feasibility and Scope of an International Altimeter Service
WG-ICP 1.1.2: Reference System and Long-term Stability of Satellite Altimetry

Inter-Commission Project

IC-P 1.2 - Vertical Reference Frames

(Joint with Commission 2)

Chair: **Johannes Ihde** (Germany)

Terms of Reference

The Earth's surface may be characterized by its geometry and the potential of the Earth gravity field. The determination of heights includes both of these aspects, the geometric part and the geopotential part. Presently, space geodetic techniques allow an accuracy in geometric positioning of about 10^{-9} in global and continental scales. Gravity field parameters, including the physical height components, can at present be determined only 2 to 3 orders of magnitude less accurate than the geometric parameters. Moreover, the current height reference frames around the world differ in their vertical datum (e.g., the mean sea-level at the fundamental tide gauges) and in the theoretical foundations of the height systems. There is no global height reference system defined and realized like the International Terrestrial Reference System (ITRS). A considerable progress in the definition and realization of a global vertical reference system will be attained from the data of the new gravity field missions. Based on the classical and modern observations, the Project on Vertical Reference Frames shall study the consistent modeling of both, geometric and gravimetric parameters, and provide the fundamentals for the installation of a unified global vertical reference frame.

Objectives

- To elaborate a proposal for the definition and realization of a global vertical reference system (World Height System – WHS);
- To derive transformation parameters between regional vertical reference frames;
- To establish an information system describing the various regional vertical reference frames and their relation to a world height frame (WHF).

Program of Activities

- Harmonization of globally used height data sets;
- Study of combination procedures of height data sets from different techniques;
- Study of information on regional vertical systems and their relations to a global vertical reference system for practical applications;
- Unification of regional (continental) height systems.

Membership

Chair: Johannes Ihde (Germany)

Members: Alireza A. Ardalan (Iran), Carine Bruyninx (Belgium), Milan Bursa (Czech Republic), Tonie van Dam (Luxemburg), Gleb Demianov (Russia), Will Featherstone (Australia), Christopher Jekeli (USA), Adolfientje Kasenda (Australia), Bill Kearsley (Australia), Roland Klees (Netherlands), Gunter Liebsch (Germany), Markku Poutanen (Finland), Laura Sanchez (Colombia), Tilo Schöne (Germany), Steve Shipman (UK), Jaroslav Simek (Czech Republic)

Inter-Commission Study Group

IC-SG 1.1 - Ionosphere Modelling and Analysis

(Joint with Commission 4, IGS and COSPAR)

Chair: **Claudio Brunini** (Argentina)
Vice Chair: **Susan Skone** (Canada)

Terms of Reference

As a result of many years of research the climatology of the ionosphere is today quite well known. However, variations of the solar activity and emissions of plasma from the solar corona change the conditions of the Sun-Earth environment and can dramatically disturb the ionosphere mean conditions.

The development of sophisticated high technological systems for navigation, telecommunication, space missions, etc., created the need of predicting the meteorological conditions of the space around the Earth, giving rise to a branch of knowledge that today is called space weather.

Disruptions of the ionosphere caused by massive solar flares can interfere with or even destroy communication systems, Earth satellites and power grids on Earth. A stringent application of ionosphere models would be to provide real-time corrections and integrity information for aircraft navigation and precision approach.

Ionosphere models are important for many space geodesy observing techniques to correct the delay caused by the ionosphere on the propagation of electromagnetic wave, typical applications being single frequency GPS and GLONASS positioning or real time ambiguity resolution.

The Earth's ionosphere has been studied for more than one hundred years using different observational techniques. A large contribution to the knowledge of the bottom-side ionosphere was done by a global network of 100-200 vertical incidence ionosondes, that started operation during the International Geophysical Year 1957-1958. Incoherent backscatter radars were used after 1958 to extend the exploration of the ionosphere to its topside. In 1957 the space age began enabling topside ionosondes onboard satellites, observations of Faraday rotation on trans-ionosphere signals emitted by geostationary satellites, Doppler method with rockets and satellites and in situ techniques aboard spacecrafts.

Using large data bases of classical observations covering different geographical regions and different solar and geomagnetic conditions, several empirical ionosphere models were established. Among them, the International Reference Ionosphere (IRI) is probably the most widely used. IRI is continuously revised and updated through international cooperative effort of different type sponsored by the Working Group created by the Committee on Space Research (COSPAR) and the Union of Radio Sciences (URSI).

Today ground-based and space-based GPS observations, and in a less extent observations of other space geodetic dual-frequency observing techniques, e.g., satellite altimetry, bring an unprecedented opportunity for ionosphere studies and may well revolutionize science and technology of the ionosphere meteorology. They provide high quality ionosphere information, with global coverage, simultaneity and time continuity and are easy and free available for ionosphere scientists.

Objectives

A first valuable step toward exploiting the GPS potentiality for ionosphere studies was already done by the IGS in 1998 creating the Ionosphere Working Group. In the framework of this group, five centres are computing and making accessible on a regular basis several GPS-derived ionosphere products, mainly two-dimensional worldwide grids of vertical total electron content.

We believe that the efforts to maintain a regular service for processing GPS data to form VTEC maps should be continued, but we are convinced that the effort should be pursued to fully exploit such amount of high quality data and to maximize the benefits for the scientific community.

Therefore, we propose the creation of a study group on Ionosphere Modelling and Analyses, in co-operation with IGS and possibly with COSPAR, to support the already existing Ionosphere Working Groups.

The principal objectives of the Study Group may be summarized as follows:

- To establish a scientific link between geodetic and aeronomy experts in order to maximize the benefit of the ionosphere information provided by geodesy.

- To analyse the ionosphere products derived from GPS and other space techniques and to explore the better use for scientific and practical purposes.

- To study possible improvements of the existing products.

- To propose new products that could be obtained from ionosphere information of GPS and other space techniques.

Program of Activities

An effective two-way link between geodesists and aeronomy physicists will play a key role for both, improving the rather simple physical ionosphere models – either deterministic or stochastic – that are currently used by geodesists, and interpreting the physical phenomena that take place in the complex environment configured by the ionosphere and the Earth magnetic field, under the action of the solar electromagnetic radiation and the solar wind, imbedded in the interplanetary magnetic field.

The planned activities of the Study group are in the first year are the collection and validation of existing physical ionosphere models. They shall then be represented by different methods, e.g., spherical harmonics and wavelets.

The models shall be compared with geodetic observations represented in similar models. The effects on geodetic observables and parameters (reference frames and positions) shall be studied.

Links to Services

The Study Group shall be linked to the corresponding working groups in the IGS and COSPAR.

Membership

Chair: Claudio Brunini (Argentina)
Vice Chair: Susan Skone (Canada)

Members:
Dieter Belitza (USA),
Norbert Jakowski (Germany),
Reinhard Leitinger (Austria),
Sandro Radicella (Italy),
Chris Rizos (Australia),
Stefan Schaer (Switzerland),
Michael Schmidt (Germany),

Inter-Commission Study Group

ICSG 1.2 - Use of GNSS for Reference Frames

(Joint with Commission 4 and IGS)

Chair: **Robert Weber** (Austria)

Terms of Reference

Up to now the operating satellite navigation systems GPS and GLONASS allow a huge user community an easy access to reference frames very close to the most recent realization of the ITRS. The IAG Services IERS (International Earth Rotation and Reference Systems Service) and IGS (International GPS Service) provide the necessary products to tie these frames to the ITRF, which is based upon a set of estimated coordinates and velocities of stable stations observed by all space techniques. The design of the upcoming GALILEO system, its envisaged accuracy and the long-term stability implies, that also GALILEO will become a highly valuable technique for the ITRF. The modernization of GPS and the completion of the GLONASS system will further improve the situation.

The goal of Study Group 1.2 is to evaluate and support the use of Global Navigation Satellite Systems for the definition and densification of the International Terrestrial Reference Frame (ITRF).

Objectives

The principal objectives of the WG will be:

- Document the potential contributions of Global Navigation Satellite Systems to reference frame establishment and maintenance.
- Investigate the ties and their time evolution between GNSS Broadcast Frames like WGS84, PZ-90 and the upcoming GALILEO Reference Frame, and the ITRF.
- Examine deficiencies in the stability of the global GNSS station network, especially focusing on stations contributing to the ITRF2000 catalogue.
- Prepare a consolidated feedback concerning GPS, GLONASS and GALILEO frame establishment and improvement based on relevant experience in areas such as receiver site selection, installation and maintenance.
- Investigate the individual strengths and shortcomings of GPS, GLONASS and GALILEO for Reference System Realisation and work out synergies.
- Study the ties of regional and local frames realized by a permanently increasing number of active real-time GNSS networks.

Program of Activities

Planned activities in the upcoming two years are to compile a clear picture of the individual strengths and shortcomings of GPS and GLONASS for Reference System Realisation. This also includes inspection of stability of global GNSS ITRF core stations, the question of site-selection and maintenance and a documentation of the ties between the GPS and GLONASS broadcast frames WGS84, PZ-90 and the ITRF. Furthermore the contribution of the permanently increasing number of regional and local real-time GNSS networks for frame densification will be investigated.

Later on the Study Group will focus on the upcoming GALILEO system. Based on the agreed reference network design we will investigate the quality of the tie and anticipated time evolution of the GALILEO Reference Frame with the ITRF. In addition the group will concentrate on expected synergies using a real GNSS observation network covering three satellite navigation systems for reference frame maintenance.

A Web-site will be established for a exchange of information, communication, presentation and outreach purposes. The Study Group will hold working meetings at international symposia. Achievements will be summarized in a mid-term review in 2005 and a final document in 2007 and will be presented at the upcoming IAG Conference and at the next IUGG General Meeting.

Links to Services

This Study Group should coordinate closely with the IAG Services IERS and IGS, in particular with the existing GNSS Working Group of the IGS. On condition of approval of the IGS Governing Board both groups may establish a Joint Working Group with united member and objectives lists.

Membership

Chair: Robert Weber (Austria)

Members: Y. Bar Sever (USA), N. Beck (Canada), C. Boucher (France), C. Bruyninx (Belgium), W.Gurtner (Switzerland), R. Galas (Germany), R. Langley (Canada), J. Manning (Australia), H. van der Marel (Netherlands), H.P. Plag (Norway)