Commission 1 – Reference Frames

http://iag.uni.lu

President: **T. van Dam** (Luxembourg)
Vice President: **G. Johnston** (Australia)

Terms of Reference

Reference systems and frames are of primary importance for much Earth science based research and applications, satellite navigation as well as for practical applications in geo-information. A precisely defined reference frame is needed for an improved understanding of the Earth's rotation and its gravity field, sea level change with time, tectonic plate motion and deformation, glacial isostatic adjustment, geocentre motion, deformation due to Earthquakes, local subsidence and other crustal displacements.

Commission 1 activities and objectives deal with the theoretical aspects of how best to define reference systems and how reference systems can be used for practical and scientific applications. Commission 1 will closely interact with the other IAG Commissions, ICCT, Services and GGOS components where reference system aspects are of concern. Commission 1 is identical with Sub-commission B2 of COSPAR.

Objectives

The main objectives of Commission 1 include:

- Definition, establishment, maintenance and improvement of the geodetic reference frames;
- Advanced terrestrial and space observation technique development for the above purposes;
- International collaboration for the definition and deployment of networks of terrestrially-based space geodetic observatories;
- Theory and coordination of astrometric observation for reference frame purposes.
- Collaboration with space geodesy/reference frame related international services, agencies and organizations;
- Promote the definition and establishment of vertical reference systems at global level, considering the advances in the regional sub-commissions;
- Work to maintain a reference frame that is valuable for global change studies.

Structure

Sub-Commissions

SC 1.1: Coordination of Space Techniques
Chair: T. Herring (USA)

SC 1.2: Global Reference Frames
Chair: C. Boucher (France)

SC 1.3: Regional Reference Frames
Chair: J. Torres (Portugal)
SC 1.3a: Europe
Chair: J. Ihde (Germany)
SC 1.3b: South and Central America
Chair: C. Brunini (Argentina)
SC 1.3c: North America
Chairs: J. Griffiths (USA), M. Craymer (Canada)
SC 1.3d: Africa
Chair: R. Wonnacott (South Africa)
SC 1.3e: Asia-Pacific
Chair: J. Dawson (Australia)
SC 1.3f: Antarctica
Chair: R. Dietrich (Germany)

SC 1.4: Interaction of Celestial and Terrestrial Reference Frames
Chair: J. Böhm (Austria)

Joint Study Groups

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

JSG 0.2: Gravity field modelling in support of height system realization
(joint with ICCT and Commission 2, description see ICCT)
Chair: P. Novák (Czech Republic)

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

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

JSG 0.9: Future developments of ITRF models and their geophysical interpretation
(joint with ICCT and IERS, description see ICCT)
Chair: A. Dermanis (Greece)

JSG 3.1: Gravity and height change intercomparison
(joint with Commissions 2, 3 and IGFS, description see Commission 3)
Chair: S. Rosat (France)

Joint Working Groups

JWG 1.1: Tie vectors and local ties to support integration of techniques (joint with IERS)
Chair: P. Sarti (Italy)

JWG 1.2: Modelling environmental loading effects for reference frame realizations (joint with IERS)
Chair: X. Collilieux (France)

JWG 1.3: Understanding the relationship of terrestrial reference frames for GIA and sea-level studies (joint with Commission 3)
Chair: T. Schöne (Germany)

JWG 1.4: Strategies for epoch reference frames (joint with IERS)
Chair: M. Seitz (Germany)

JWG 0.1.1: Vertical datum standardization
(joint with GGOS, IGFS, and Commission 2; description see GGOS)
Chair: L. Sánchez (Germany)

Program of Activities

The program of activities for Commission 1 includes:

- Encourage, initiate, and support theoretical and applied research activities related to reference frames;
- Enforce Research and Development activities that impact the reference frame determination and its accuracy, as well as, the best and optimal usage of reference frames in Earth Science applications;
- Closely interact with all established IAG Services: IVS, IGS, ILRS, IDS and the IERS, including their Combination Centres and Working Groups;
- If necessary, improve the theory and application of the transformation between Celestial and Terrestrial Reference Systems and application of the theory to improve the consistency between ICRF, ITRF and EOPs, in cooperation with IVS and IERS;
- Explore advanced methodologies for the combination of products and raw observations of space geodetic techniques;
- Investigate all systematic error sources and factors limiting the precision of space geodetic techniques and their combination;
- Within each regional sub commission, encourage and assist regional sub-commission countries to re-define and modernize their national geodetic systems so that they are compatible with the ITRF;
- Establish a dedicated Web site relating all Commission 1 activities.

Steering Committee

- President: Tonie van Dam (Luxembourg)
- Vice President: Gary Johnston (Australia)
- Chair SC1.1: T. Herring (USA)
- Chair SC1.2: C. Boucher (France)
- Chair SC1.3: J. Torres (Portugal)
- Chair SC1.4: J. Böhm (Austria)
- Representatives of Services:
  IERS: C. Ma (USA)
  IDS: P. Willis (France)
  IGS: J. Griffiths (USA)
  ILRS: G. Appleby (UK)
  IVS: O. Titov (Australia)
- Member at Large: L. Combrinck (South Africa)

Sub-Commissions

SC 1.1: Coordination of Space Techniques

Chair: Tom Herring (USA)

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, GALILEO, and COMPASS, and the DORIS system, as well as altimetry, InSAR, LIDAR, 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 are critical to the Global Geodetic Observing System (GGOS).

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 parameterization 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) as well as at 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, geocentre coordinates, and others. 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 developing methods to validate 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 GGOS, all of the IAG Services, and with COSPAR.

Objectives

The principal objectives of the scientific work of Sub-Commission 1.1 in collaboration with GGOS are the following:

- Study systematic effects of and between space geodetic techniques.
- Develop common modelling standards and processing strategies.
- Comparison and combination of orbits derived from different space geodetic techniques.
- 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, and the combination of atmospheric information (troposphere and ionosphere) of more than one technique.
- 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 plus extended models), improve the consistency between these parameter groups, and assess, how a correct combination could be performed.
- Study combination aspects of new geodetic methods such as Synthetic Aperture Radar (InSAR), LIDAR and optical image analysis methods.
- 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 and GGOS).
- 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 Global Geodetic Observing System (GGOS), 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) and the International gravity services.

Working Groups of Sub-Commission 1.1

WG 1.1.1: Creation of common geodetic coordinate time series

Chair: Laurant Soudarin (France)

This working group, formed in collaboration with the IERS, will explore methods for creating position time series for the different geodetic techniques so that they can be displayed in a common format and consistent reference frame. The working group will explore, in the format and interfaces for time series. A common tool that can be used to display and compare these results will also be developed. The working group will have a representative from each technique combination centre, a representative from the ITRS combination centre, and that the GGOS portal manager. There should also be representatives from the geophysics/geodynamics and oceanography communities who are seen as the primary uses of this product. The final product of this working group will be recommendations on how the geodetic community should proceed in developing common positional time series and making such results readily available to the broad scientific community.

WG 1.1.2: Investigate methods for merging geodetic imaging systems (InSAR, LIDAR and optical methods) into a geodetic reference system

Chair: Sebastian Leprince (USA)

With the development of new methods for studying surface deformations, such as InSAR, LIDAR and optical methods, this working group will explore the methods that should be used to ensure that these deformation measurements are made in a well-defined geodetic reference frame. Issues to be addressed include how to establish the reference frame for these classes of measurements, how to ensure the long-term stability of the reference frame, and to make recommendations for changes in future systems that would allow more robust reference frame realization.

SC 1.2: Global Reference Frames

Chair: 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 systems (TRS) and frames (TRF), addresses fundamental issues closely related to TRS, such as global geodetic observatories or methods for the combined processing of heterogeneous observation- data.

Terrestrial Reference Systems refer to an important domain of Geodesy, involving both the theoretical and the applied aspects, as well as deep connections with Astronomy, Earth Sciences and Geo-information. This necessitates several visions:

- An astronomical vision, using the TRS to study translational and rotational motions of the Earth in inertial space;
- An Earth Science vision, using TRS to build physical models of the Earth system, and its various components (solid earth, oceans, atmosphere, hydrosphere);
- A metrological vision, using TRS together with suitable coordinate systems (geographical coordinates, map projections…) to define geographical position of objects in the Earth's vicinity (geo-referencing).

The work in this SC will be carried out in close cooperation with the International Earth Rotation and Reference Systems Service (IERS), other relevant IAG services (IGS, ILRS, IVS, IDS), and the IAG Global Geodetic Observing System (GGOS). Theoretical aspects will be investigated in cooperation with the Inter-Commission Committee on Theory.

Beyond IAG, cooperation with other relevant international organizations such as IAU, FIG or ISO will also be developed.

Objectives

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

- Relativistic modelling, including extension of the IAU model to geodesy, investigations on the use of emission coordinate systems;
- External evaluation of TRF;
- TRF by multi-technique data analysis versus hierarchical combinations;
- Global Geodetic Observatories, concepts and practical implementation;
- TRF versus dynamical topographic models;

- Relation with standardization or certification activities (ISO, GEO...).

Links to Services

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

Working Groups of Sub-Commission 1.2

WG 1.2.1: External Evaluation of Terrestrial Reference Frames

Chair: Xavier Collilieux (France)

The scientific community has recognized the need for a highly accurate terrestrial reference frame (TRF) for Earth Science applications. Although geodetic measurements are very precise, uncertainty in the modelling of the measurements and correlations between estimated parameters make it complicated to assess geocentric station coordinates. While a precision at a few-millimetre level is thought to be achievable, it is difficult to supply a precise figure of the current coordinate accuracy. The reliability of the station velocities is notably essential to the study of climate change. Any error in the rate of the origin and scale definition of the TRF will especially map directly into the station velocities and into other products such as sea level rise estimates.

The aim of this task force is to review all the methods that could be used to assess the accuracy of the origin, scale and orientation (and/or their time variations) of a TRF. All the activities in which the adopted TRF has a quantitative influence will be studied in order to derive possible constraints on the TRF. Methods that involve datasets that have not been used to derive the TRF will be especially emphasized (tide gauges, gravity, geophysical models etc...). As an example, the quality of ITRF2008 will be investigated using various methods in order to derive the most complete error budget.

Objectives

- Investigate methods to evaluate TRF accuracy, especially TRF datum parameters;
- Supply an assessment of ITRF2008 quality using all available relevant methods.

Specific program activities

- Study all the activities in which the adopted TRF has a quantitative influence;
- Maintain a bibliography about TRF evaluation with any type of data and model;
- Evaluate the interest to derive external constraints on TRF datum fixation, i.e. on its origin, scale, orientation and their time evolutions.

WG 1.2.2: Global Geodetic Observatories

Chair: Perguido Sarti (Italy)

An effective integration of space geodetic instruments at the observing sites is a crucial issue for the computation of the terrestrial reference frame. In fact, the computation of the global terrestrial frame depends, on the one hand, on the number, distribution and quality of the co-located sites and, on the other hand, on the accuracy of the tie vectors that express the relative position of the co-located instruments.

The ITRF is a geodetic product that serves Earth and space sciences. Although, its significance and exploitation goes beyond scientific research: societal application, natural hazards mitigation and Earth observations go beyond purely scientific uses and has an impact on the whole society.

Geophysical research requires a wider concept of integration where co-locations are realized not only with space and terrestrial geodetic instruments but also with other geophysical sensors like seismometers, weather stations, lidars, radio-sondes, gravimeters, tide gauges, radiometers, etc…

In this perspective, the integration of geodetic and geophysical sensors must be realized at the highest level of precision providing the relative positions in a consistent frame at local and global scales.

The task force will examine and revise the state of the art in local tie surveying and tie vector estimation, spotlighting the current deficiencies and promoting cooperation on the relevant research topics. The definition of reference points for each instrument as well as the related calibration issues will also be considered, in close cooperation with individual technique services (IGS, IVS, ILRS, IDS, PSMSL, IGFS...). The most recent and highest standards achieved in the integration of geodetic instruments will be transposed to the problem of co-locating, operating and managing a wider class of geophysical instruments with the purpose of defining the guidelines for their effective co-location and integration towards the creation of multipurpose geophysical observatories.

Other types of considerations will be also investigated, such as operational issues, international governance, labelization, standardization and certification.

Objectives

- Revise the needs related to the co-location of geophysical sensors;
- Revise existing tie vector estimation processes methods and accuracies;
- Transpose the state of the art of tie vector estimation to non-geodetic instruments;
- Liaise with IERS, IAG and GGOS;
- Set guidelines on geophysical co-location surveying and management.

SC 1.3: Regional Reference Frames

Chair: João Torres (Portugal)

Terms of Reference

Sub-Commission 1.3 deals with the definitions and realizations of regional reference frames and their connection to 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 the 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 the vertical component with a special consideration of gravity and other data;
- Coordinate the activities of the regional sub-commissions focusing on exchange and share of competences and results;
- Develop and promote operation of GNSS permanent stations, in connection with IGS whenever appropriate, to be the basis for the long-term maintenance of regional reference frames;
- Promote actions for the densification of regional velocity fields;
- Encourage and stimulate the development of the AFREF project in close cooperation with IGS and other interested organizations;
- Encourage and assist countries, within each regional sub-commission, to re-define and modernize their national geodetic systems, compatible with the ITRF.

Program of Activities

- Organize inter-regional workshops 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 the full interaction with the IGS;
- Consider studying and promoting consistent specifications for the generation of GNSS-based velocity field solutions;
- Consider developing tectonic deformation models that will enable transformation of locations within a defined reference frame between different epochs;
- At regional levels, contribute to the realization and improvement of local surveys in the collocation sites, with full cooperation with the Sub-commission 1.2 Global Reference Frames.

SC 1.3a: Europe

Chair: Johannes Ihde (Germany)
Secretary: Alessandro Caporali (Italy)

Terms of Reference

EUREF, the Regional Reference Frame Sub-commission for Europe, deals with the definition, realization and maintenance of the European Reference Frames. EUREF is 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 and Cadastral Agencies (NMCA) in Europe.

Structure

- EUREF is composed of representatives from European IAG member countries;
- The TWG (Technical Working Group) is composed of members elected by the plenary, members in charge of special projects and ex-officio members.

Program of Activities

- Continue to develop the EUREF Permanent Network (EPN) in close cooperation with IGS, for the maintenance of the European Terrestrial Reference Frame, as a contribution to the ITRF and as an infrastructure to support practical applications for precise positioning and referencing geo-information;
- Extend the Unified European Levelling Network (UELN) and prepare it to be computed under a geokinematic approach using the European Combined Geodetic Network (ECGN) for a long-term maintenance of the European Vertical Reference Frame;
- Support new developments in reference frame realization and application by introducing new technologies like real-time data transfer and products, as well as Galileo for precise positioning;
- Establish a dense velocity field model in Europe for the long-term maintenance of the European reference frame;
- Consider the contribution to the IAG Program GGOS (Global Geodetic Observing System) using the installed infrastructures managed by the EUREF members;
- Promote the adoption of the reference systems defined by EUREF (ETRS89-European Terrestrial Reference System 1989 and EVRS - European Vertical Reference System) in the European countries and European-wide initiatives related to geo-referencing activities like INSPIRE;
- Organize annual symposia addressing activities carried out at national and Europe-wide levels related to the global work and objectives of EUREF.

SC 1.3b: South and Central America

Chair: Claudio Brunini (Argentina)
Vice-Chair: Laura Sánchez (Germany)

Terms of Reference

Sub-commission 1.3b (South and Central America) encompasses the activities developed by the "Geocentric Reference System for the Americas" (SIRGAS). As such, it is concerned with the definition, realization and maintenance of a modern geodetic reference infrastructure for South and Central America and the Caribbean. This includes a geometric reference frame consistent with ITRS/ITRF and a gravity field-related vertical reference system, defined and realized globally.

Objectives

The main purposes of the Sub-commission 1.3b are:

- To determine, maintain and make available a geocentric reference frame (a set of stations with high-precise geocentric positions and their variation with time, as a regional densification of the global ITRF;
- To support the SIRGAS countries in the establishment and maintenance of national geodetic reference networks as local densifications of SIRGAS in order to guarantee accessibility to the global ITRF at national and local levels;
- To establish a unified vertical reference system supporting the determination and precise combination of physical and geometric heights as well as their variations with time;
- Contribute to the GGOS program by developing and implementing state-of-the-art products based on the SIRGAS observational infrastructure;
- To promote, support, and coordinate the efforts of the Latin American and Caribbean countries to achieve these objectives.

Structure

The structure of the Sub-commission 1.3b is based on the functioning bodies of SIRGAS. There are currently three Working Groups:

- WG 1.3b.1: Reference System
  Chair: Virginia Mackern (Argentina)
- WG 1.3b.2: SIRGAS at National Level
  Chair: William Martínez (Colombia)
- WG 1.3b.3: Vertical Datum
  Chair: Roberto Luz (Brazil)

The SIRGAS Executive Committee (as it is named in the SIRGAS statutes) is composed of:

- SC 1.3b Chair: C. Brunini (Argentina)
- SC 1.3b Vice-Chair: Laura Sánchez (Germany)

- WG 1.3b.1 Chair: Virginia Mackern (Argentina)
- WG 1.3b.2 Chair: William Martínez (Colombia)
- WG 1.3b.3 Chair: Roberto Luz (Brazil)

Program of Activities

Since the SIRGAS countries are improving their national reference frames by installing an increasing number of continuously operating GNSS stations, it is necessary to outline the best strategy for the appropriate integration of those frames into the continental frame. This includes:

- Promotion of the IGS and IERS standards within the SIRGAS countries to ensure the adequate installation, maintenance, and analysis of continuously operating GNSS stations;
- Establishment of a SIRGAS National Processing Centre in all the member countries;
- Refinement of the SIRGAS station hierarchy. At present, two classes are considered: core and densification stations (the establishment of other categories is under consideration);
- Promotion of the adequate usage of SIRGAS as a reference frame by means of capacity building activities. This comprises SIRGAS schools on reference frames, scientific processing of GNSS data, atmospheric analysis based on the SIRGAS infrastructure, etc.;
- Experimental processing of the GLONASS observational data to identify a suitable analysis strategy and to evaluate if these results can be combined with the corresponding GPS products;
- Promotion and implementation of real-time services based on the SIRGAS infrastructure to make available the reference frame to more users;
- The kinematics of the SIRGAS frame, up to now, have been represented by linear station movements (i.e. constant velocities). This representation is not sufficiently precise due to existing seasonal variations in the station position time series and due to discontinuities caused by the frequent occurrence of seismic events in the SIRGAS region.

According to this, it is necessary:

- To model non-linear station movements within the reference frame computation;
- To implement a methodology aiming at a precise transformation between different epochs and, in general, between pre-seismic and post-seismic reference frame realizations in particular;
- To evaluate the feasibility of computing and using near-real time reference frames instead of those based on epoch station positions and constant velocities.

The establishment of a unified vertical reference system continues to be a big challenge of SIRGAS. The related activities concentrate on:

- Continental adjustment of the national vertical networks in terms of geo-potential numbers;
- Combined analysis of tide gauge registrations, GNSS positioning and satellite altimetry observations to determine the dynamic ocean topography at the classical vertical datums;
- Determination of potential differences between the reference tide gauges and the global reference surface;
- Stronger cooperation with the Sub-Commission 2.4b (Gravity and Geoid in South and Central America - GGSCA) to promote national initiatives regarding the modernization of the gravity reference networks and the computation of geoid models of high resolution.

Hourly SIRGAS ionospheric models (vTEC) based on the GNSS SIRGAS stations have been generated since 2006 on a regular basis. The SIRGAS ionospheric model is being upgraded to include a better distribution of the electron density based on the assimilation of ground- and space-based GNSS observations. In addition, SIRGAS is developing a service for computing water vapour estimations.

SC 1.3c: North America

Chairs: J. Griffiths (USA) and M. Craymer (Canada)

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 plate-fixed geometric reference frames for North America, including the North American Datum of 1983 (NAD83) and any possible successors;
- Maintenance and future evolution of vertical datums (ellipsoidal and orthometric), including the North American Vertical Datum of 1988 (NAVD88) and the International Great Lakes Datum (IGLD);

- 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.

Working Groups

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

Chairs: Michael Craymer (Canada) & Jake Griffiths (USA)

Program of Activities

To densify the ITRF reference frame in the North American region by organizing the computation of weekly coordinate solutions and their associated precision information for continuously operating GPS stations that are not part of the current IGS global network.

- A cumulative solution of coordinates 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.

WG1.3c.2: Plate-Fixed North American Reference Frame

Chair: J. Griffiths (USA)

Program of Activities

To establish a high-accuracy, geocentric reference frame, including velocity models, procedures and transformations, tied to the stable part of the North American tectonic plate which would replace NAD83 and 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.

WG1.3c.3: Reference Frame Transformations in North America

Chair: M. Craymer (Canada)

Program of Activities

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

SC 1.3d: Africa

Chair: R. Wonnacott (South Africa)

Terms of Reference

Sub-commission 1.3d (Africa) is concerned with the 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. The goal is to 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 the 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 stations network;
- 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.

SC 1.3e: Asia-Pacific

Chair: John Dawson (Australia)

Terms of Reference

To improve regional cooperation that supports the realisation and densification of the International Terrestrial Reference frame (ITRF). This activity will be carried out in close collaboration with the Geodetic Technologies and Applications Working Group of the Permanent Committee for GIS Infrastructure in Asia and the Pacific (PCGIAP), 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 Asia Pacific region;
- To encourage the sharing of GNSS data from Continuously Operating Reference Stations (CORS) in the region;
- To develop a better understanding of crustal motion in the region;
- To promote the collocation of different measurement techniques, such as GPS, VLBI, SLR, DORIS and tide gauges, and the maintenance of precise local geodetic ties at these sites; and
- To outreach to developing countries through symposia, workshops, training courses, and technology transfer activities.

Program of Activities

The activities of this sub-commission will principally be those of the Asia-Pacific Reference Frame (APREF), see http://www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html, together with the Geodetic Technologies and Applications Working Group of the Permanent Committee for GIS Infrastructure in Asia and the Pacific (PCGIAP).

SC 1.3f: Antarctica

Chair: R. Dietrich (Germany)

Terms of Reference

Sub-commission 1.3f (Antarctica) is focusing on the definition and realization of a 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.

Structure

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

Program of Activities

- Organization of GPS campaigns in Antarctica, maintenance of the data archive;
- Extend activities for the operation of remote permanent GPS stations;
- 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;
- Provide homogeneous site velocities for e.g. glacial isostatic adjustment determination;
- Collaborate with IAG Sub-Commission 3.4 Cryospheric Deformation.

Organize meetings and workshops on Antarctic geodesy jointly with related SCAR activities in order to strengthen the international cooperation and to make optimum use of field logistics and infrastructure.

Working Groups of Sub-Commission 1.3

WG 1.3.1: Integration of Dense Velocity Fields into the ITRF

Chair: Carine Bruyninx (Belgium)

The main task of this WG is to study and promote consistent specifications for the generation of GNSS-based velocity field solutions and their combination in order to derive a unified dense velocity field in a common global reference frame.

Members

- Carine Bruyninx (Belgium)
- John Dawson (Australia)
- Ambrus Kenyeres (Netherlands)
- Jake Griffiths (USA)
- Mike Craymer (Canada)
- Laura Sanchez (Germany)
- Alvaro Santamaria Gomez (Spain)
- Juliette Legrand (Belgium)
- Zuheir Altamimi (France)

WG1.3.2: Deformation Models for Reference Frames

Chair: Richard Stanaway (Australia)

The primary aim of the WG is to develop tectonic deformation models that will enable transformation of locations within a defined reference frame between different epochs. Such deformation models are essential to support precise point positioning applications and CORS/NRTK operations within deforming zones.

Members

- R. Stanaway (Australia)
- Christopher Pearson (New Zealand)
- Paul Denys (New Zealand)
- Kevin Kelly (USA)
- Rui Fernandes (Portugal)
- Craig Roberts (Craig Roberts)
- Graeme Blick (New Zealand)
- Chris Crook (New Zealand)
- John Dawson (Australia)
- Mikael Lilje (Sweden)
- Laura Sanchez (Germany)
- Rob McCaffrey (USA)
- Norman Teferle (Luxembourg)

SC 1.4: Interaction of Celestial and Terrestrial Reference Frames

Chair: Johannes Böhm (Austria)

Terms of Reference

In recent years, significant progress has been made in astronomical and geophysical modelling for the analysis of space geodetic observations. Thus, there is the need to investigate the impact of those models on the terrestrial and celestial reference frames (TRF and CRF), and on the consistency between the TRF, CRF, and the Earth orientation (EOP) parameters. Special attention needs to be paid to Very Long Baseline Interferometry (VLBI) observations, since it is the only technique to provide consistent sets of TRF/EOP/CRF. However, the present realization of the ITRF (ITRF2008) is based on a combination of VLBI, GNSS, SLR, and DORIS observations, whereas the present realization of the ICRF (ICRF2) is determined from a single VLBI solution. Consequently, research has to be carried out to integrate the ITRF and ICRF solutions, and also new options like VLBI observations to satellites should be considered for future improvement of the consistency. The GAIA mission scheduled for launch in 2013 is expected to achieve an optical realization of the CRF with precision similar to or better than the ICRF2 and with at least an order of magnitude more objects. As the set of extragalactic objects suitable for both optical and radio observation is limited, such objects will have to be identified, and investigations have to be carried out to permit the best possible connection between the radio and optical CRF realizations.

Working Groups of Sub-Commission 1.4

WG 1.4.1: Geophysical and Astronomical Effects and the Consistent Determination of Celestial and Terrestrial Reference Frames

Chair: Zinovy Malkin (Russia)

WG 1.4.1 is created to promote and coordinate investigations of the impact of geophysical and astronomical modelling on the terrestrial and celestial reference frames (TRF and CRF) and the consistency between CRF, TRF, and Earth orientation parameters (EOP), the latter serving as the transformation parameters between TRF and CRF. The primary attention will be given to Very Long Baseline Interferometry (VLBI) as the only technique nowadays that can provide highly consistent global solutions for TRF, CRF, and EOP.

Objectives

- Encourage and develop cooperation and collaboration in theoretical studies, simulations, and processing of real data aimed at a better understanding of the impact of geophysical and astronomical modelling on TRF, CRF, and EOP derived from VLBI observations.
- Advance means of comparing models as well as TRF, CRF, and EOP realizations.
- Compare different theoretical models and their realizations used by VLBI analysis centres. Study the propagation of differences in those models to differences in geodetic and astrometric products.
- Develop practical recommendations for VLBI analysis centres and the IERS Conventions Centre on the optimal models to be used during processing of VLBI observations.

Members

- Z. Malkin (Russia)
- J. Böhm (Austria)
- S. Lambert (France)
- C. Ma (USA)
- R. Haas (Sweden)
- H. Spicakova (Austria)
- R. Heinkelmann (Germany)
- D. MacMillan (USA)

WG 1.4.2: Co-location on Earth and in Space for the Determination of the Celestial Reference Frame

Chair: Sebastien Lambert (France)

VLBI is the only technique sensitive to the "quasi inertial" celestial reference frame, and the most recent realization of the International Celestial Reference System, the ICRF2, was determined in a VLBI-only solution. The other space geodetic techniques (GNSS, DORIS, SLR) define a dynamical celestial reference frame, but all techniques are combined to determine the International Terrestrial Reference Frame (ITRF) without adding the estimation of sources to that combination, thus causing inconsistencies between the ICRF and the ITRF.

The goal of WG 1.4.2 is to investigate the impact on the ICRF when combining VLBI observations with those from satellite techniques. Historically, this combination is based on local tie information at the co-location sites, but in the future troposphere ties and even space ties could also be used, i.e., observing the GNSS constellation or a dedicated micro-satellite like GRASP with VLBI, so that a fully consistent system is created.

Objectives

- Support the realization of a full combination of the VLBI/ GNSS/DORIS/SLR at the normal equation level including estimates of radio source coordinates. This should be done in close cooperation with the IERS Working Group on the Combination at the Observation Level;
- Investigate various analysis options (local and troposphere ties, twin telescopes) on the results (TRF, EOP, CRF);
- Analyze VLBI observations to GNSS satellites.
- Simulate the effect of VLBI observations to GNSS and SLR satellites and assess the impact on the CRF;
- Simulate future micro satellite missions like GRASP in VLBI analysis software packages;
- Simulate the benefits of the upcoming VLBI2010 equipment to propose recommendations for the near future.

Members:

- S. Lambert (France)
- Z. Malkin (Russia)
- C. Ma (USA)
- J. Böhm (Austria)
- R. Haas (Sweden)
- R. Heinkelmann (Geodesy)
- Y. Kwak (Korea)
- Le Poncin-Lafitte
- L. Plank (Austria)
- M. Seitz (Germany)
- V. Tornatore (Italy)

WG 1.4.3: Realization of Celestial Reference Frames

Chair: Chopo Ma (U.S.A.)

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 and the techniques analysis coordinators (in particular of the IVS), and requires a close cooperation between the different groups. The activities 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.

The International Celestial Reference Frame (ICRF2) realized by VLBI is currently defined by the radio positions of 295 extragalactic objects (IERS TN 35, Fey,

Gordon and Jacobs, eds., 2009). The ICRF2 was endorsed by the IAU in 2009 and by the IUGG in 2011. The noise floor is ~40 μas and the uncertainty of the axes is ~10 μas. Precise positions of 3414 extragalactic radio sources are included in the ICRF2 catalogue.

The GAIA (Global Astrometry Interferometer for Astrophysics) mission scheduled for launch in 2013 is expected to achieve an optical realization of the CRF with precision similar to or better than the ICRF2 and with at least an order of magnitude more objects. However, as the set of extragalactic objects suitable for both optical and radio observation is limited, one goal of the Working Group is to identify such objects, oversee the relevant observations, and analyze the data to permit the best possible connection between the radio and optical CRF realizations.

For geodetic use the CRF realization must be accessible from the ground. For the foreseeable future this connection will be through VLBI observations. In cooperation with the IVS and IERS, this Working Group will oversee the maintenance and improvement of the ICRF2, in particular the set of sources used for geodetic observations and the ICRF2 defining sources.

Joint Working Groups of Commission 1

JWG 1.1: Tie vectors and local ties to support integration of techniques

(Joint with IERS)

Chair: Peirguido Sarti (Italy)

Terms of Reference

Tie vectors are crucial elements of the combination of space geodetic solutions. Their accuracy straightforwardly refers to their capability of expressing the relative position of the co-located space geodetic instruments to conventional reference points. They enter the combination of space geodetic solutions as additional observations and can be eventually regarded as the fifth technique involved in the combination. Their role is not strictly limited to the provision of the necessary information for the combination since accurate tie vectors can also highlight the presence of technique- and site-specific biases. In particular, tie vectors can support the investigation of technique-dependent systematic errors and the ability of each technique to connect electronic and conventional reference points.

The whole process related to the planning of on-field operations and the surveying carried out with either terrestrial or GPS methods (i.e. the local tie procedure) needs to be constantly revised and when necessary improved. The definition of new local tie approaches remains central to the activity promoted by the working group. As a group of experts, the working group aims at promoting discussions and serving as a forum for the evaluation of existing as well as new procedures. Equally important, the working group aims at improving the existing analysis strategies applied to the local tie observations and to the data post-processing. The ultimate scope is to achieve the utmost level of accuracy of the tie vector. The consistency between tie vectors and space geodetic solutions is recognized as a crucial aspect on which the improvement of the International Terrestrial Reference Frame depends.

An important by-product of the combination of space geodetic solutions is represented by the post-fit residuals. They are empirically determined during the combination process and express the discrepancies between space geodetic solutions and tie vectors. Particularly, the values of the post-fit residuals of the combination can serve as preliminary indicators of the quality of the space geodetic solution and/or tie information at one specific site. As such, they can highlight the necessity to investigate further the co-location and the techniques involved in the tie. This specific use of post-fit residuals is extremely interesting and promising although their handling requires much attention. Many factors may combine to the final post-fit residual value. The accuracy of the tie vectors has to be certain to effectively use the co-location post-fit residuals for inferring something about site dependent or technique

dependent systematic errors. This clearly highlights the need to attempt a revision of the quality of the existing tie vectors and possibly verify their formal accuracy not only empirically, on the base of the post-fit residuals themselves, but on the base of other factors such as their age and their length.

The working group should serve as a reference for the know-how and the good practice on co-location issues for the geodetic community. It should be ready to support new survey activities, assisting and advising remotely, and it should promote re-surveying if necessary. The link with the relevant branches of GGOS has to be ensured during the terms of the working group activity. Finally, the link between the working group and the single IAG technique services is considered essential and a permanent flow of relevant information must be constantly pursued.

Objectives

- Research objectives:
  - Revise existing local tie procedures
  - Investigate existing tie vector estimation processes
  - Develop and define new methods
  - Direct research towards the investigation of technique specific systematic effects
- Coordination objectives:
  - Liaise with IERS combination centres
  - Liaise with IAG technique service
- Outreach:
  - Support local tie operations and tie vector estimation
  - Spread the know-how
  - Set guidelines

Members

- Claudio Abbondanza (USA)
- Zuheir Altamimi (France)
- Giuseppe Bianco (Italy)
- Xavier Collilieux (France)
- John Dawson (Australia)
- Bruno Garayt (France)
- Maria Hennes (Germany)
- Ulla Kallio (Finland)
- Jim Long (USA)
- Chuck Meertens (USA)
- Valerie Michel (France)
- Axel Nothnagel (Germany)
- Mike Pearlman (USA)
- Jean-Claude Poyard (France)
- Pierguido Sarti (Italy)
- Jerome Saunier (France)
- Ralf Schmid (Germany)
- Manuela Seitz (Germany)
- Luca Vittuari (Italy)
- Pascal Willis (USA)

JWG 1.2: Modelling environmental loading effects for reference frame realizations

(Joint with IERS)

Chair: Xavier Collilieux (France)

Terms of Reference

The accuracy and precision of current space geodetic techniques are such that displacements due to non-tidal surface mass loading are measurable. Many scientific studies have already considered atmospheric loading corrections at the observation level. The modelling of other non-tidal loading effects has also been investigated by various authors. In parallel, a posteriori corrections have been shown to slightly decrease the variance factor of a Terrestrial Reference Frame (TRF) multi-technique combination but the improvement at some sites was also counterbalanced by degradation at others.

There still exist open questions regarding the application of loading corrections for the generation of operational geodetic products, either a priori or a posteriori: accuracy of the models in all frequency bands - sub-daily band is the most important for a priori corrections -, too few studies regarding available loading model agreement have been carried out, proper mass conservation of all contributions and degree 0 of each contribution, methods that should be use for interpolating the loading displacements, required model resolution, reference loads that are or should be used for geodetic products, contribution of ice melting at high latitude which is not modelled in current continental water loading models. The optimal usage of loading models is still to be defined in all possible applications.

The goal of this working group is to ensure that the optimal usage of a loading model is made for TRF computation.

Objectives

The principle objectives of the scientific work are to investigate if loading corrections are necessary for TRF adjustment and if necessary, investigate the optimal methods to deal with loading effects in the ITRF construction.

- Determine how best to apply loading corrections: observation level or daily averages?
- If corrections are applied at the observation level, how can the displacement signal be reapplied to the station displacement time series?
- Address whether all geodetic techniques see the same level of loading contributions. In particular, some studies have shown that GPS seems to have larger annual and semi-annual signals than other geodetic methods and calculations from geophysical fluid loading.

Specific program activities

- Compare and assess differences between existing load models for a given effect.
- Maintain a bibliography on the available models and their evaluation.
- Assessment of the propagation of loading model errors into the site coordinates and the ITRF.
- Define whether models should be applied at the observation level or in the post-processing. In this case, define the best method (if any) to handle loading effects at the observation level (filtering?, interpolation etc...).
- Tie results/findings to IERS conventions.
- Collect user opinions about what signals they need in station position time series (loading corrected or not).

Members

- Zuheir Altamimi(France)
- Johannes Böhm (Austria)
- Jean-Paul Boy (France)
- Tom Herring (USA)
- Laurent Metivier (France)
- Gerard Petit (France)
- Jim Ray (USA)
- Paul Tregoning (Australia)
- Tonie van Dam (Luxembourg)
- Christopher Watson (Australia)
- Xiaoping Wu (USA)

JWG 1.3: Understanding the relationship of terrestrial reference frames for GIA and sea-level studies

(Joint with Commission 3)

Chair: Tilo Schöne (Germany)

Terms of Reference

The combination and assimilation of GNSS information into Glacial Isostatic Adjustment (GIA) models, the correction of GIA effects on altimetry or tide gauges, or combined studies using information from the different sources requires a common understanding of the individual reference frame realizations.

Today the ITRF realization and their respective updates form the basis for the individual space geodetic techniques. But, in every researcher's daily life, individual realizations are used. For example, the IGS time series are in a respective IGS frame close to ITRF, or satellite orbits for radar altimetry are using DORIS-augmented frames. GIA models employ their own ITRF-independent reference.

Many studies now use information or combinations of the above techniques with the different reference frame realizations. This leads to inconsistencies and misinterpretations. This project is proposed to evaluate the different reference frame realizations. The focus will be on the reference frame realizations in GNSS, DORIS, radar altimetry, and GIA modelling.

Objectives

- To provide a reference document for GNSS, DORIS, and radar altimetry satellite missions that indentifies discrepancies in the reference frames.
- To suggest implementation/combination schemes, where possible.

Program of Activities

- Review the individual radar altimetry and satellite missions with the following goals:
  - Evaluate the type of reference frames;
  - Evaluate the handling of loading tides and conventions used;
  - Evaluate time-variable gravity field effects in orbit determination;
  - Possibly extend results to the use of geocentre motion for sea level studies.
- Review the GNSS reference frame realizations
  - Review ITRF2008/IGS08 realization (IGS repro, TIGA)
  - Evaluate handling of loading tides, and other conventions
- Review the DORIS reference frame realization
  - Review in view of the realizations used in RA processing for satellites carrying DORIS;
  - Evaluate the handling of loading tides and conventions used.
- Review the reference frame realization in GIA models.

Members

- Matt King (United Kingdom)
- Pascal Willis (France)
- Sergei Rudenko (Germany)
- Daniela Thaller (Germany)
- Christopher Watson (Australia)
- Xiaoping Wu (USA)
- Xavier Collilieux (France)
- Tonie van Dam (Luxembourg)
- Mirko Scheinert (Germany)
- Mark Tamisea (United Kingdom)
- Erik Ivins (USA)
- Maik Thomas (Germany)
- Cecep Subarya (Indonesia)

JWG 1.4: Strategies for epoch reference frames

(Joint with IERS)

Chair: Manuela Seitz (Germany)

Terms of Reference

The International Terrestrial Reference Frame (ITRF) is based on a mathematical model, which describes the station movement as a piece-wise linear function of time. This motion is mainly driven by lithosphere plate motion and crustal deformations, which are assumed to be linear and constant over long time periods. Thus, the ITRF provides a very high long-term stability. Even if the linear component dominates the station motion, most of the station positions show additional non-linear effects. The most important causing reasons are atmospheric and hydrospheric mass load changes, which lead to seasonal and long-period position variations, and seismic events causing co-seismic abrupt and post-seismic exponentially decreasing movements of the stations. The approximation of non-linear seismic station motions within the ITRF is performed by estimating offsets and piece-wise constant velocities. Loading effects are not considered as they are very difficult to model or parameterize. One possible solution to overcome this problem would be to compute time series of epoch reference frames, which would provide the station positions at consecutive epochs. The mentioned types of non-linear station motion would be captured very well by such time series of epoch reference frames. A second advantage of epoch reference frame would be that a new solution could be available with a short time delay after a seismic event, when updated coordinates are requested.

Today, GPS-based weekly reference frames are a standard product of the IGS and serve as a near real-time reference frame. The datum of these frames is realized by an alignment to ITRF, which depends on the set of stations used for the alignment - due to station non-linear motions – and which does not account for a motion of the centre of figure w. r. t. the centre of mass. Epoch reference frames based on the combination of the four different techniques contributing to the ITRF would provide geocentric frames consistent to the ITRF.

The national reference frames consist of station positions at a certain epoch or are fixed to a moving plate and do often not consider regional station motions. Station positions resulting from today's measurements are derived in the actual ITRF or epoch reference frames and need to be transformed to the officially defined national reference frames. Especially, in the case of seismic active areas, the network geometry changes significantly over time and cannot be well represented by the current ITRF with linear station motions. Strategies must be developed, which allow for a transformation with a minimal reduction of accuracy.

Objectives

The primary objective of the Working Group is to develop strategies for the computation of epoch reference frames, by combining the space geodetic techniques VLBI, SLR, GNSS and DORIS on the normal equation level and to assess their potentials in accuracy, stability and global availability to provide recommendations to the IERS.

The development of computation strategies for epoch reference frames will comprise the following main topics: (i) evaluation of the individual contribution of techniques to an epoch reference frame, (ii) analysis of the technique and combined solutions w. r. t. a suitable temporal resolution of the reference frame, (iii) development of strategies for the weighting of the techniques and the implementation of the terrestrial difference vectors (local ties) for epoch reference frame computations, (iv) study of the datum realization for combined epoch solutions, and (v) finally, the accuracy and stability of the reference frame series will be assessed and recommendations to the IERS will be prepared.

The application of epoch reference frames, in particular on regional level, are a further important aspect, which will be kept in mid. But the full consideration of this topic would be beyond the scope of the actual WG and might be the topic of a subsequent WG.

Planned Activities

- Analysis of the need for an epoch reference frame for practical and scientific applications;
- Development of strategies for the computation of epoch reference frames;
- Analysis of possible frequencies of epoch TRF (weekly, monthly, quarterly, …);
- Set-up of a webpage for dissemination of information and presentation and communication of research results;
- Organization of conference sessions / workshops;
- Contribution to international meetings and conferences;
- Common publications of WG members.

Members

- Thomas Artz (Germany)
- Juan Baez (Chile)
- Mathis Bloßfeld (Germany)
- Xavier Collilieux (France)
- Hermann Drewes (Germany)
- Guido Gonzales (Mexico)
- Erricos Pavlis (USA)
- Takeshi Sagiya (Japan)
- Laura Sanchez (Germany)
- Manuela Seitz (Germany)
- Hana Spicakova (Austria)
- Peter Steigenberger (Germany)
- Daniela Thaller (Switzerland)