Report of Working Group D: Interactions with National/Regional Authorities and International Organizations in Monitoring, Networks and Reference Frames

1. Working Group D met on 9 December to discuss the work plan and consider proposed recommendations for the ICG plenary on 12 December 2008 and further actions of the working group.

2. The group noted two specific assignments to WG D as stated in the ICG Work Plan are to:

(a) Define site quality, integrity and interference monitoring techniques
(b) Development of a common geodetic reference frame taking into account existing [regional] reference frames.

3. The members also reviewed the report from ICG 2, September 2008, and particularly noted the recommendation from that meeting, resulting from a paper by Boucher, et al., submitted to ICG titled: "Proposal To Establish A Working Group On Geodetic References Within The International Committee on GNSS (ICG)" with the stated objective of: "… recognize the International Terrestrial Reference System (ITRS) as the unique preferred system for geo-referencing in science and applications".

4. It was reaffirmed that a WG for reference frames would be very valuable. After lengthy discussion, the WG agreed to prepare the following four recommendations, summarized here, and included as attachment to this report. The WG D emphasizes that these recommendations are ***non-binding***, but represent the considerations of best scientific and technical practices.

5. Working Group D recommends to ICG:

(1) Establish a Task Force on Geodetic References (Task Force D1)

The proposed goals for the Task Force would be:

(a) to bring together all interested ICG participants (experts from the system and service providers, key user communities, etc);
(b) to review the present situation (existing documents, resolutions or practices);
(c) to discuss and agree upon a consistent terminology for geodetic references and related understanding;
(d) to prepare recommended practices for the realization of each GNSS Geodetic Reference and its alignment to the International Terrestrial Reference Frame (ITRF);
(e) to outline and encourage implementation plans in each relevant user community;
(f) to propose mechanisms for informing users of the current realization of a particular Geodetic Reference and any changes that may occur from time to time.

The proposed membership would include experts on Geodetic Reference issues from the System Providers, experts from the geodetic scientific community and from the user community drawn from the membership of the ICG.

(2) Establish a Task Force Time References (Task Force D2)

The proposed goals for the Task Force would be:

(a) to bring together all interested ICG participants (experts from the system and service providers, key user communities, etc);
(b) to review the present situation (existing documents, resolutions or practices);
(c) to discuss and agree upon a consistent terminology for timing references and related understanding;
(d) to prepare recommended practices for the realization of each GNSS Time Reference and its alignment to UTC;

(e) to outline and encourage implementation plans in each relevant user community;
(f) to propose mechanisms for informing users of the current realization of a particular Time Reference and any changes that may occur.

Membership of this Task Force would include timing experts nominated by the GNSS Service Providers and experts in national and international organizations nominated by the WGD of the ICG.

(3) Recommend the Alignment of Geodetic References and synchronization of Time References to international standards

Working Group recommends that:

(a) the geodetic reference for GNSSs be aligned as closely as possible to the ITRF,
(b) the internal System Times (ST) of GNSSs be synchronized as closely as possible to UTC (modulo 1 s),
(c) the GNSSs broadcast, in addition to their own ST:

(i) the time difference between ST and a real-time realization of coordinated universal time (UTC),
(ii) the time differences between various STs, such as GPS to Galileo Time Offset (GGTO) for GPS and Galileo,

(d) the realization of local geodetic datums for all civil activities be related to ITRF,
(e) reference time for all civil activities be UTC.

(4) Retroreflectors for Laser Ranging to GNSS Satellites

Working Group recommends to the ICG and its Providers' Forum that

(a) Retroreflectors for Laser Ranging be placed on all future GNSS Satellites, and;
(b) In so doing, GNSS Providers should follow Standards for Retroreflector arrays already established by the International Laser Ranging Service (ILRS) and endorsed by International Association of Geodesy (IAG), and;
(c) The appropriate strategies for infrastructure and procedures be developed by the IERS and the ILRS with appropriate input from the GNSS System Providers.

Task Force D1 would be led by IGS and FIG (J. Dow and M. Higgins). Task Force D2 to be lead by BIPM (F. Arias)

6. In addition to these recommendations, it was noted that the activities of WG D are aligned with recommendations stemming from the International Symposium on Global Navigation Satellite Systems, Space-Based and Ground-Based Augmentation Systems and Applications Berlin, Germany, 11-14 November 2008. These recommendations are attached and are consistent with the goals of the broader ICG.

7. The group discussed additional issues and actions:

(a) It was strongly suggested that the ICG Work Plan be updated. The most recent version dates November 2006.
(b) Review and refine ICG Working Group Charters.
(c) Promote use of IGS guidelines for reference frame requirements, station installation and operation. (http://www.igs.org)
(d) Promote use of UNAVCO website for detailed information on GNSS station installation and operation. (www.unavco.org).
(e) Consider for future discussion: how geodesy and geodetic observations could be placed on a more legal basis. (See Ihde presentation).

(f) Use existing mechanisms to disseminate information on ICG and its work, e.g., IGS, FIG, EUPOS.
(g) Refer for laser ranging tracking strategy to the IAG service – International Laser Ranging Service. (See Pearlman's presentation).
(h) Continue support to realize AFREF. (See Wonnacott presentation).
(i) Keep Asia Pacific within plan as reference stations are needed in that area.
(j) Discuss plans for incorporating evolving GNSS and communications, standards and technology.
(k) Discussions with BIPM (Arias and Lewandowski) demonstrate that many are unaware of the treaties that are agreed to by governments with regard to the Convention of the Meter and how this affects ICG and GNSS. (See www.bipm.org).

8. It was also considered to have future WG D meetings or follow-on discussions in February at BIPM, in Munich in conjunction with the Munich SATNAV Summit, in early March and possibly at the EGU in Vienna, late April, date tbd.

ATTACHMENT

Working Group D - International Symposium on Global Navigation Satellite Systems, Space-Based and Ground-Based Augmentation Systems and Applications
Berlin, Germany, 11-14 November 2008

Recommendations

Recommendation 1

Recognising the present status of Global Navigation Satellite Systems (GNSS) and the prospects for continued development of a wide variety of applications critical to science, commerce, and infrastructure, the Symposium participants recommend:

The continuation of forums such as this one; bringing together system providers, geodetic infrastructure providers, end users, and industry.
Furthermore, these forums should be encouraged to discuss and propose specific recommendations for consideration by the International Committee on GNSS (ICG)

Recommendation 2

Recognising the densification of the ground-based GNSS infrastructure by the EUPOS initiative on the basis of IAG services and Sub-Commissions,
considering the varied degree of GNSS ground-based reference infrastructure development among different regions of the world,
noting the need to support the effort of African countries to implement a continental geodetic reference frame,
the Symposium participants
recommend that the ICG support the development of GNSS ground-based infrastructure in all regions of the world, taking into account the unique conditions present in each

Recommendation for Committee Decision

Prepared by: **Working Group D**

Date of Submission: **11 December 2008**

Issue Title: **Task Force on Geodetic References (Task Force D1)**

Background/Brief Description of the Issue:

There is an emerging demand to recognize the International Terrestrial Reference System (ITRS) as the unique preferred system for geo-referencing in science and applications. Activities of the geodetic community for promoting ITRS and improving its quality and availability have led to successive improved realizations of the ITRS in the form of the International Terrestrial Reference Frame (ITRF). The ITRF is produced by the services of International Association of Geodesy (IAG).

All of the currently developed or proposed global components of GNSS (GPS, GLONASS, Galileo and Compass) have stated an intention to realize Geodetic References for each system that are closely aligned to the ITRS. These Geodetic References are:

(a) World Geocentric System 84 (WGS84) used for GPS;
(b) PZ-90.02 used for GLONASS;
(c) Galileo Terrestrial Reference Frame (GTRF) used for Galileo, and;
(d) China Geodetic System (CGS`2000) used for Compass.

Discussion/Analyses:

There is a need to ensure that the Geodetic References realized for each of the GNSS sub-systems are well understood by all providers and all users. As well as the initial definition and realization of each Geodetic Reference, there is also a need for a clear understanding of any improvements that a particular GNSS provider may implement from time to time. An example of such an improvement would be a particular System Provider updating ground station coordinates due to plate tectonics. Such improvements are propagated to end users through the broadcast ephemeris and will appear in a particular region as an apparent update to the Geodetic Reference in that region.

With the growing number of global and regional navigation satellite systems and with increasing demand by users for improved accuracy, these Geodetic Reference issues will need to be carefully managed.

The ICG is a unique mechanism to ensure such management by bringing together the experts on Geodetic References in the System Providers, in the geodetic scientific community and in the user community.

Recommendation of Committee Action:

It is therefore recommended that the ICG establish a **Task Force on Geodetic References** (Task Force D1). The proposed goals for the Task Force would be:

(a) To bring together all interested ICG participants (experts from the system and service providers, key user communities, etc);
(b) To review the present situation (existing documents, resolutions or practices);
(c) To discuss and agree upon a consistent terminology for geodetic references and related understanding;
(d) To prepare recommended practices for the realization of each GNSS Geodetic Reference and its alignment to ITRF;
(e) To outline and encourage implementation plans in each relevant user community;
(f) To propose mechanisms for informing users of the current realization of a particular Geodetic Reference and any changes that may occur from time to time.

The proposed membership would include experts on Geodetic Reference issues from the System Providers, experts from the geodetic scientific community and from the user community drawn from the membership of the ICG.

Recommendation for Committee Decision

Prepared by: Working Group D

Date of Submission: 12/11/2008

Issue Title: Task Force D2 on Time References

Background/Brief Description of the Issue:

Global navigation satellite systems (GNSS) performance is closely tied to precise time synchronization. GNSS today provide the primary means of disseminating precise time. Precise time supports many aspects of the world's critical infrastructure, such as telecommunications, power and banking.

Discussion/Analyses:

With the proliferation of GNSS, coordination of navigation and UTC timing services is critical. Consequently, a common timing reference is essential.
This Task Force would address and make recommendations for timing standards. This would include coordination of navigation time scales and standards for precise time and time dissemination services, as well as promotion of the use of standard terminology and common quality metrics.
The Service Providers would appoint their experts on timing issues as members of the Task Force. Membership would also include experts from national and international institutions nominated by the ICG WGD and from appropriate user groups.

Recommendation of Committee Action:

It is therefore recommended that the ICG establish a **Task Force on Time References** (Task Force D2). The proposed goals for the Task Force would be:

(a) To bring together all interested ICG participants (experts from the system and service providers, key user communities, etc);
(b) To review the present situation (existing documents, resolutions or practices);
(c) To discuss and agree upon a consistent terminology for timing references and related understanding;
(d) To prepare recommended practices for the realization of each GNSS Time Reference and its alignment to UTC;
(e) To outline and encourage implementation plans in each relevant user community;
(f) To propose mechanisms for informing users of the current realization of a particular Time Reference and any changes that may occur.

Membership of this Task Force would include timing experts nominated by the GNSS Service Providers and experts in national and international organizations nominated by the WGD of the ICG.

Recommendation for Committee Decision

Prepared by: Working Group D

Date of Submission: 12/11/2008

Issue Title: Alignment of Geodetic References and synchronization of Time References to international standards

Background/Brief Description of the Issue:

The International Terrestrial Reference System (ITRS) has been recommended by the IAU and the IUGG for application in space and Earth sciences. Access to ITRS is primarily through the International Terrestrial Reference Frame (ITRF), and with an approximation ranging between 3 and 40 cm by WGS84, PZ-90, the Galileo Terrestrial Reference Frame (GTRS), the China Geodetic System 2000 (CGS'2000), and the regional densifications.

The time scale endorsed by the 15th General Conference of Weights and Measures (1971) for worldwide time coordination and dissemination is Coordinated Universal Time (UTC). The International Bureau of Weights and Measures (BIPM) provides coordination for the maintenance and dissemination of UTC.

GPS time is steered to UTC (USNO) (modulo 1 s), GLONASS time is steered to UTC (SU). Galileo time will be steered to an ensemble of European realizations of UTC, keeping the seconds of the GPS time.

Discussion/Analyses:

Interoperability of the various GNSS could be seriously affected by the adoption of different geodetic and time references.

The ICG is a unique mechanism to enable GNSS Service Providers to align their Geodetic and Time References to the ITRS and UTC for the operation of their systems. The ICG can also assist GNSS users to conform to the international references.

Recommendation of Committee Action:

C*onsidering*

(a) the international value of having many GNSS operational with a composite contribution of several tens of satellites,
(b) the desirability of using all systems interchangeably,
(c) that international geodetic reference is ITRS as realized by ITRF,
(d) that international reference time scale is UTC which is locally represented by UTC(k),
(e) the use by GPS of references very close to UTC and ITRF,
(f) the GLONASS efforts to approach UTC and ITRF,
(g) the Galileo design referring to UTC and ITRF,
(h) that other important satellite navigation systems are now being designed and developed*),
(i) the need to refer all civil activities worldwide to common internationally recognized geodetic and time references,

**) Compass, IRNSS, QZSS, various SBAS, …*

WG D recommends to the ICG

(a) that the geodetic reference for GNSSs be aligned as closely as possible to the ITRF,
(b) that the internal System Times (ST) of GNSSs be synchronized as closely as possible to UTC (modulo 1 s),
(c) that the GNSSs broadcast, in addition to their own ST:
    (i) the time difference between ST and a real-time realization of UTC,

(ii) the time differences between various STs, such as GGTO for GPS and Galileo,

(d) that the realization of local geodetic datums for all civil activities be related to ITRF,

(e) that reference time for all civil activities be UTC.

Recommendation for Committee Decision

Prepared by: Working Group D

Date of Submission: 11 December 2008

Issue Title: Retroreflectors for Laser Ranging to GNSS Satellites

Background/Brief Description of the Issue:

Satellite Laser Ranging (SLR) involves precise range measurement between an SLR ground station and a retroreflector- equipped satellite using laser pulses corrected for refraction, satellite center of mass, and the internal delay of the ranging machine.

Several aspects of SLR are of particular interest to the ICG:

(a) SLR can perform a completely independent Quality Assurance on the computation of the orbits of GNSS satellites;
(b) SLR is fundamental to the definition and realization of the International Terrestrial Reference System through its ability to measure the position of the center of mass of the earth and to define and constrain the scale of and realization of the ITRS;
(c) SLR can help to ensure that the realization of each Geodetic Reference used in a GNSS is consistent with the International Terrestrial Reference Frame (ITRF).

There are also many important scientific applications for SLR, including:

(a) Precision Orbits and Calibration of Altimetry missions (Oceans, Ice) and other Low Earth Orbiting (LEO) missions;
(b) Plate Tectonics and Crustal Deformation;
(c) Static and Time-varying Gravity Field;
(d) Earth Orientation and Rotation (Polar Motion, length of day);
(e) Total Earth Mass Distribution.

Discussion/Analyses:

While some GNSS satellites already carry retroreflectors, the contribution of SLR to science and to the interests of GNSS System Providers and users would be considerably enhanced if all future GNSS satellites were to carry a suitable retroreflector array.

Recommendation of Committee Action:

It is therefore recommended to the ICG and its Providers Forum that:
(a) Retroreflectors for Laser Ranging be placed on all future GNSS Satellites, and;
(b) In so doing, GNSS Providers should follow Standards for Retroreflector arrays already established by the International Laser Ranging Service and endorsed by International Association of Geodesy (IAG), and;
(c) The appropriate strategies for infrastructure and procedures be developed by the IERS and the ILRS with appropriate input from the GNSS System Providers.