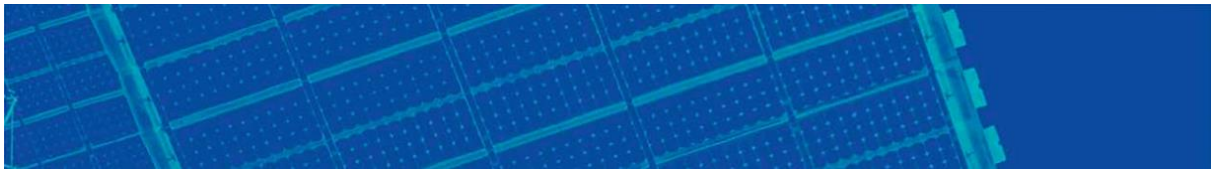
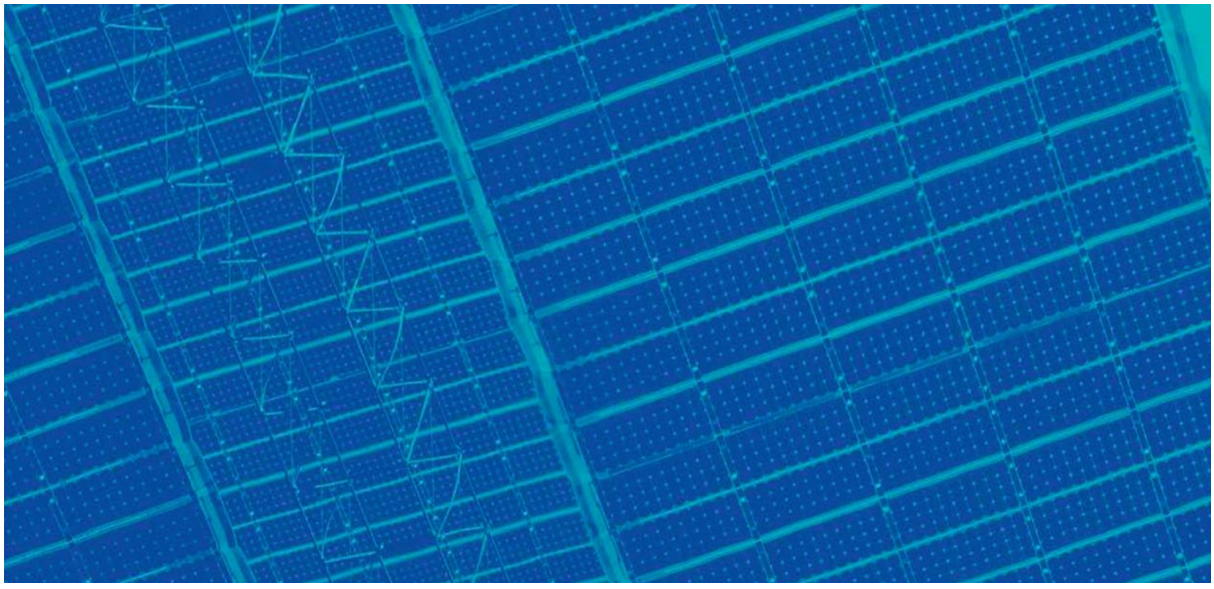
International Committee on
Global Navigation Satellite Systems



# RECOMMENDATIONS
# of
# THE WORKING GROUPS
# of the International Committee
# on Global Navigation Satellite Systems



31 October 2024

## EXPLANATORY NOTE

The International Committee on Global Navigation Satellite Systems (ICG), as an optimal cooperation mechanism, offers the benefit of providing a flexible forum in which global navigation satellite system (GNSS) providers and users come together to discuss all matters regarding the use of multiple GNSS signals.

The four ICG working groups (systems, signals and services (Working Group S); enhancement of GNSS performance, new services and capabilities (Working Group B); information dissemination and capacity-building (Working Group C); and reference frames, timing and applications (Working Group D)) address technical issues. Subgroups and task forces support the functions of the working groups by carrying out specific responsibilities and producing defined outcomes.

This compilation reproduces recommendations of the Working Groups adopted by ICG. For more details on the ICG Working Groups refer to the ICG information portal: https://www.unoosa.org/oosa/en/ourwork/icg/working-groups.html

When necessary, the compilation is to be read with the United Nations General Assembly documentation in the A/AC.105/ series on the annual meetings of ICG, held since 2006, in which recommendations undertaken by ICG are also reflected. Documents are available in all official languages of the United Nations and can be downloaded from the ICG information portal at: https://www.unoosa.org/oosa/en/ourwork/icg/annual-meetings.html

## LIST OF ACRONYMS

| | |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| ADB | Asian Development Bank |
| AFREF | African Geodetic Reference Frame |
| APSCO | Asia Pacific Space Cooperation Organization |
| ARAIM | Advanced Receiver Autonomous Integrity Monitoring |
| BADEC | BeiDou/GNSS Application Demonstration and Experience Campaign |
| BDS | Beidou Navigation Satellite System |
| BIPM | Bureau International des. Poids et Mesures |
| BOC | Binary Offset Carrier Modulation |
| BPSK | Binary Phase Shift Keying Modulation |
| BWA | Broadband Wireless Access |
| CAST | China Association for Science and Technology |
| CCSDS | Consultative Committee for Space Data Systems, The |
| CCTF | Consultative Committee for Time and Frequency |
| CDMA | Code Division Multiple Access |
| CfP | Call for Participation |
| CGPM | General Conference on Weights and Measures |
| CGS | China Geodetic System |
| COFDM | Carrier Offset Frequency Division Multiplex |
| COPUOS | Committee on the Peaceful Uses of Outer Space |
| CPGPS | Chinese Professionals on Global Positioning System |
| CSNC | China Satellite Navigation Conference |
| CTRS | Conventional Terrestrial Reference System |
| dB | Decibel |
| dBic | Decibels isotropic circular |
| DFMC | Dual Frequency Multi Constellation |
| DGNSS | Differential GNSS |
| DLR | Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center) |
| DOP | Dilution of Precision |
| DORIS | Doppler Orbitography and Radiopositioning Integrated by Satellite |
| DRR | Disaster Risk Reduction |
| DRR TF | Disaster Risk Reduction Task Force |
| ECOSOC | Economic and Social Council |
| ESA | European Space Agency |
| EXCOM | Executive Committee |
| EU | European Union |
| EUREF | Reference Frame Sub-Commission for Europe |
| EWS | Emergency Warning Service |
| FAA | Federal Aviation Administration |
| FEC | Forward Error Correction |
| FIG | International Federation of Surveyors |
| FDMA | Frequency Division Multiple Access |
| FM | Frequency Modulation |
| FoM | Figure of Merit |
| G2GTOs | GNSS to GNSS system time offsets |
| GAGAN | GPS-aided GEO Augmented Navigation |
| GB | Governing Board |
| GBAS | Ground Based Augmentation Systems |
| GEO | Geostationary Earth Orbit |
| GESTISS | Geospatial and Space Consortium for Innovative Social Services |
| GGOS | Global Geodetic Observing System |
| GGRF | Global Geodetic Reference Frame |

| | |
|---|---|
| GHz | Gigahertz |
| GIS | Geographic Information System |
| GLONASS | Global Navigation Satellite System, Russia |
| GNSS | Global Navigation Satellite System |
| GNSS-PPP | GNSS-Precise Point Positioning |
| GNSS-R | GNSS-Reflectometry |
| GNSS-RO | GNSS-Radio Occultation |
| GNSS-TEC | GNSS-Total Electron Content |
| GPP | Ground Processor Prototype |
| GPS | Global Positioning System |
| GSA | European Global Navigation Satellite Systems Agency |
| GTRF | Galileo Terrestrial Reference Frame |
| GTRS | Geocentric Terrestrial Reference System |
| HEO | Highly Elliptical Orbit |
| IADC | Inter-Agency Space Debris Coordination Committee |
| IAG | International Association of Geodesy |
| IAU | International Astronomical Union |
| ICAO | International Civil Aviation Organization |
| ICG | International Committee on Global Navigation Satellite Systems |
| ICG/PF | ICG/Providers' Forum |
| IDM | Interference Detection and Mitigation |
| IDS | International DORIS Service |
| IERS | International Earth Rotation and Reference Systems Service |
| IGEX | International GLONASS Experiment |
| IGMA | International GNSS Monitoring and Assessment |
| iGMAS | International GNSS Monitoring and Assessment System |
| iGNSS | International Symposium on GPS/GNSS |
| IGS | International GNSS Service |
| IGSO | Inclined Geo-Synchronous Orbit |
| IHO | International Hydrographic Organization |
| ILRS | International Laser Ranging Service |
| IMO | International Maritime Organization |
| IMT | International Mobile Telecommunications |
| IOAG | Interagency Operations Advisory Group |
| IOC | Initial Operational Capabilities |
| ION | Institute of Navigation |
| IOP | Interoperability Plenary |
| IRNSS | Indian Regional Navigation Satellite System |
| ISECG | International Space Exploration Coordination Group |
| ISM | Integrity Support Message |
| ISO | International Organization for Standardization |
| ISRO | Indian Space Research Organisation |
| ITRF | International Terrestrial Reference Frame |
| ITRS | International Terrestrial Reference System |
| ITU | International Telecommunication Union |
| ITU-BR | International Telecommunication Union – Radiocommunication Bureau |
| ITU-R | International Telecommunication Union Radiocommunications |
| IUGG | International Union of Geodesy and Geophysics |
| IVS | In-vehicle Systems |
| IWG | Interoperability Working Group |
| JAXA | Japan Aerospace Exploration Agency |
| JPL | Jet Propulsion Laboratory |
| JTP | Joint Trial Project |
| KHz | Kilohertz |
| KPI | Key Performance Indicators |

| | |
|---|---|
| LBS | Location-Based Service |
| LCNS | Lunar Communications and Navigation Services |
| LCRNS | Lunar Communications Relay and Navigation Systems |
| LDPC | Low-Density Parity-Check |
| LDPCCC | Low-Density Parity-Check Convolutional Codes |
| LEO | Low Earth Orbit |
| LEO PNT | Low Earth Orbit Positioning, Navigation, and Timing |
| LNIS | LunaNet Interoperability Specification |
| LNSS | Lunar Navigation Satellite System |
| LPV | Localizer Performance with Vertical Guidance |
| MBOC | Multiplexed Binary Offset Carrier |
| MEO | Medium Earth Orbit |
| MEOSAR | Medium Earth Orbit Search and Rescue |
| MGA | Multi-GNSS Asia |
| MGET | Multi GNSS Ensemble Time |
| MGEX | Multi-GNSS Experiment |
| MGM-Net | Multi-GNSS Monitoring Network |
| MHz | Megahertz |
| MIIGAIK | Moscow State University of Geodesy and Cartography |
| NASA | National Aeronautics and Space Administration |
| NAVIS | International Centre for Research and Development of Satellite Navigation Technology |
| NGA | National Geospatial-Intelligence Agency |
| NHEWS | Natural Hazard Early Warning Systems |
| NMOs | National Mapping Agencies |
| OMA | Open Mobile Alliance |
| OS | Open Service |
| PD | Performance Document |
| PDOP | Position Dilution of Precision |
| PNT | Positioning, Navigation, and Timing |
| POD | Precise Orbit Determination |
| PPP | Precise Point Positioning |
| PS | Performance Standard |
| PVT | Position, Velocity and Time |
| QZSS | Quasi-Zenith Satellite System |
| R&D | Research and Development |
| RAIM | Receiver Autonomous Integrity Monitoring |
| RCSSTEAP-China | Regional Centre for Space Science and Technology Education in Asia and the Pacific |
| RDSS | Radio Determination Satellite Service |
| RF | Radio Frequency |
| RFI | Radio Frequency Interference |
| RFTA | Reference Frames, Timing and Applications |
| RINEX | Receiver Independent Exchange |
| RNSS | Regional Navigation Satellite Systems |
| RTCM | Radio Technical Commission for Maritime Services |
| RTK | Real Time Kinematics |
| SAR | Search and Rescue |
| SBAS | Satellite Based Augmentation System |
| SFCG | Space Frequency Coordination Group |
| SISURE | Signal in Space Ranging Error |
| SIRGAS | Geocentric Reference System for the Americas |
| SLR | Satellite Laser Ranging |
| SSV | Space Service Volume |
| ST | System Times |

| | |
|---|---|
| STSC | Scientific and Technical Subcommittee |
| SUSG | Space Use Subgroup |
| TARC | BeiDou Test and Assessment Research Center |
| TF | Task Force |
| ToR | Terms of Reference |
| TSG | Technical Specifications Group |
| TTFF | Time To First Fix |
| TUMSAT | Tokyo University of Marine Science and Technology |
| UN | United Nations |
| UNESCAP | United Nations Economic and Social Commission for Asia and the Pacific |
| UN-GGIM | United Nations Global Geospatial Information Management |
| UNOOSA | United Nations Office for Outer Space Affairs |
| URE | User Range Error |
| USNO | United States Naval Observatory |
| URSI | Union Radio-Scientifique Internationale |
| UT1 | Universal Time |
| UTC | Universal Time Coordinated |
| UTCOE | UTC Offset Error |
| VAL | Vertical Alert Limit |
| VLBI | Very Long Baseline Interferometry |
| VPL | Vertical Protection Levels |
| WG | Working Group |
| WG-B | Working Group B: Enhancement of GNSS Performance, New Services and Capabilities |
| WG-C | Working Group C: Information Dissemination and Capacity Building |
| WG-D | Working Group D: Reference Frames, Timing and Applications |
| WG-L | Working Group L: Lunar Positioning, Navigation, and Timing |
| WG-S | Working Group S: Systems, Signals and Services |
| WGS | World Geodetic System |
| WiMAX | Worldwide Interoperability for Microwave Access |
| WMO | World Meteorological Organization |
| WP | Work Plan |
| WRC | World Radiocommunication Conference |

## CONTENTS

## WORKING GROUP S:  SYSTEMS, SIGNALS AND SERVICES

18th Meeting of ICG, Wellington, New Zealand, 6 - 11 October 2024

**Recommendation 1 for Committee Decision**

| | |
|---|---|
| **Prepared by**: | **Working Group S (WG-S)** |
| **Date of Submission:** | **10 October 2024** |
| **Issue Title:** | **Emerging Low Earth Orbit Positioning, Navigation, and Timing (LEO PNT) Workshops** |

**Background/Brief Description of the Issue:**

The Working Group S has conducted two workshops focused on emerging Low Earth Orbit PNT systems, in 2023 and 2024. These workshops were aimed at better understanding what systems are being developed and how they might interact with Global Navigation Satellite Systems (GNSS).

**Discussion/Analyses:**

The workshops in 2023 and 2024, as we well as follow-on discussions within WG-S have led to additional questions and issues that require further coordination. By establishing routine workshops on this topic, Working Group S can continue to interact with the commercial LEO PNT providers and probe into some of the more complicated issues.

**Recommendation of Committee Action:**

*The Working Group on Systems, Signals and Services (Working Group S) should consider holding annual workshops focused on LEO PNT topics supported by WG-S, including compatibility and interoperability. These workshops will be organized by members of WG-S and a determination of who will organize and chair the next workshop will be determined at the annual International Committee on GNSS (ICG) meeting.*

*To further these discussions ICG members are encouraged to invite LEO PNT providers to join their delegation in support of the workshops.*

**Recommendation 2 for Committee Decision**

**Prepared by**: **Working Group S (WG-S)**

**Date of Submission:** **10 October 2024**

**Issue Title:** **Working Group S Workshops in 2025**

**Background/Brief Description of the Issue:**

The Working Group S made good progress on the issues outlined in its work plan in 2024. At the 18th Annual Meeting of the International Committee on Global Navigation Satellite Systems (ICG-18), the need for additional in-depth discussions on several areas of work was identified.

**Discussion/Analyses:**

Holding dedicated workshops in 2025 to discuss in more detail specific topics in the WG-S work plan, will provide an opportunity for collaboration and progress to be made on these areas of focus.

**Recommendation of Committee Action:**

*The Working Group on Systems, Signals and Services (Working Group S) recommends that the following workshops be organized in 2025 with support from the working group members and other ICG participants, as relevant:*

- *Timing Interoperability*
- *Precise Point Positioning (PPP) Interoperability*
- *International Global Navigation Satellite Systems Monitoring and Assessment (IGMA) and Performance Standards*
- *Interference Detection and Mitigation (IDM)*
- *Low Earth Orbit Positioning, Navigation, and Timing (LEO PNT) Compatibility and Interoperability*

**Recommendation 3 for Committee Decision**

**Prepared by**: **Working Group S (WG-S)**

**Date of Submission:** **10 October 2024**

**Issue Title:** **Update to Working Group S Work Plan**

**Background/Brief Description of the Issue:**

Working Group S last updated its work plan in 2015 at the 10th Annual Meeting of the International Committee on Global Navigation Satellite Systems (ICG-10). Since that time, several new topics have been routinely incorporated into the discussions of the working group. A new Task Force on Precise Point Positioning (PPP) has also been established and this topic is not currently referenced in the work plan.

**Discussion/Analyses:**

Updates to the work plan will include adding four new topics. These topics fit within the scope of the working group and have already been discussed on a regular basis. The updated Work Plan will reflect the work that is already taking place within the Working Group.

**Recommendation of Committee Action:**

*The Working Group on Systems, Signals and Services (Working Group S) recommends that the International Committee on Global Navigation Satellite Systems (ICG) endorse an update to its work plan.*
*The detailed work plan will include the following new areas of work:*

- *PPP Interoperability*
- *Civil Signal Authentication*
- *Low Earth Orbit Positioning, Navigation, and Timing (LEO PNT) Compatibility and Interoperability*
- *Lunar Positioning, Navigation. And Timing (PNT) compatibility (with Global Navigation Satellite Systems (GNSS)/Regional Navigation Satellite Systems (RNSS))*

*The revised text for the work plan will be as follows:*

*Under Compatibility and Spectrum Protection:*

- *Facilitate review of compatibility amongst systems operating near or designed for use by users on the moon and GNSS or their augmentations, [in coordination with Working Group L (WG-L)]*
- *Continue to engage with LEO PNT providers in order to maintain the standards for compatibility and spectrum protection that exist among GNSS and augmentations*

*Under Interoperability and Service Standards:*

- *Facilitate coordination on interoperability of precise point positioning service from its providers, in coordination with Working Groups B and D*

- *Support inclusion of emerging LEO PNT providers into existing frameworks to promote continued progress towards an interoperable system of systems*

*Under System of System Operations:*

- *The Working Group will organize workshops and other efforts related to LEO PNT, focused on promoting the development of standards for performance specifications and interoperability, and the interaction between emerging LEO PNT providers and the subgroups*
- *In an effort to maintain transparency, the Working Group will encourage discussion on civil signal authentication services by GNSS providers*

17th Meeting of ICG, Madrid, Spain, 15 - 20 October 2023

**Recommendation for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group S** |
| **Date of Submission:** | **19 October 2023** |
| **Issue Title:** | **Recommended Survey into GNSS Time Offset for Receiver Manufacturers** |

**Background/Brief Description of the Issue:**
Multi-GNSS Users' demand for high accuracy positioning, navigation, and timing services based on multi-GNSS fusion is raising more requirements for receiver manufacturers. Subject to the requirements, multi-GNSS receiver manufacturers should consider realizing interoperability between GNSS system time scales based on high accuracy GNSS-to-GNSS time offsets, and then support PNT fusion among systems. A more direct dialogue with multiGNSS receiver manufacturers is needed with the view to determine receiver GNSS-to-GNSS time offset estimation in different visibility conditions and the required accuracy of broadcast time offset parameters.

**Discussion/Analyses:**
To implement a dialogue with multi-GNSS receiver manufacturers it's necessary to conduct a survey on time offset accuracy requirements for multi-GNSS receivers. However, it seems difficult to engage a lot of manufacturers globally to attend a workshop on timing interoperability in-person because of complicated logistics and schedule as well as enormous cost. Therefore, it's suggested that GNSS providers carry out a survey domestically in a large scale and submit a report or summary to the ICG based on survey results, to push forward the improvement of GNSS time interoperability.

**Recommendation of Committee Action:**
*1. GNSS providers are encouraged to reach out to domestic receiver manufacturers (industry) to get feedback on multi-GNSS time interoperability requirements through a common list of questions and criteria developed by the Working Group (WG).*

*2. Timing experts from Working Group S, in coordination with Working Groups B and D, should organize a meeting or workshop to discuss the results of the receiver manufacturers' feedback.*

**Recommendation for Committee Decision**

**Prepared by**: **IGMA Task Force, WG-S**

**Date of Submission:** **October 19, 2023**

**Issue Title:** **Approval of the IGMA Joint Trial Project Terms of Reference (ToR) revision**

**Background/Brief Description of the Issue:**
IGMA Joint Trial Project (JTP) with International GNSS Service (IGS) was proposed in ICG10, November 2015, and recommended as the recommendation 10A/D.4.1. The following paragraph is extracted from the recommendation.

Recognising:
- The need for a global GNSS monitoring and assessment capability to assist with public confidence in GNSS service provision and interoperability.
- The role the International GNSS Service (IGS) has played in producing precise GNSS products since its inception in 1994, noting the evolution of products and services over time to meet user segment requirements.
- Utilizing existing resources such as IGS and providers monitoring and assessment systems (which may include signal quality monitoring) could maximize benefits in the early stage of the IGMA roadmap.

The ICG recommends that the IGMA TF and IGS initiate a joint trial project that will demonstrate a global GNSS Monitoring and Assessment capability.

IGMA JTP is aiming to validate the concepts of IGMA, which monitor GNSS performance and disseminate the assessment results from an international, trustworthy body, i.e. ICG, utilizing existing infrastructures and capabilities with IGS. The initial phase of IGMA JTP selected a limited set of four system level parameters: orbit and clock error, Signal in Space Ranging Error (SISURE), PDOP, and UTC Offset Error (UTCOE), and adopted a post-processing approach. User level performance parameters such as user positioning, timing accuracy of a combined solution with multiple constellations, and also real-time monitoring and assessment will be added into the later phase of the JTP.

The TF established the original ToR in 2016, and IGS Governing Board (GB) endorsed IGS participation in the JTP through the IGS Monitoring Working Group, which was also created in 2016.

**Discussion/Analyses:**
IGMA TF is now focusing on establishing harmonized, common calculation methodologies with regard to the selected four parameters. The technical details in the ToR needed to be updated as the calculation methodologies discussion proceeded. In addition, there were some inconsistencies in the ToR due to the progress of the JTP.

IGMA TF prepared the draft revision of ToR and finalized it through “Line by Line review” on the 29th of August 2023 and agreed that it was ready for approval.

The ToR revision is now under IGS review until the end of October 2023, then the result of IGS review will be reported to IGS Governing Board (GB) and the continuous participation of IGS Monitoring WG is to be endorsed by the GB.

**Recommendation of Committee Action:**
*The Working Group on Systems Signals and Services recommends that the ICG adopt new revisions to the Terms of Reference Document for the IGMA Joint Trial Project that were agreed to by the IGMA Task Force in August 2023. If IGS, as the outcome of the internal review process, would have comments on the ToR revision, they should be notified to the ICG. In case no substantial changes are proposed to it, the adoption at ICG-17 by ICG would be effective.*

**Recommendation for Committee Decision**

**Prepared by**: **Working Group S**

**Date of Submission:** **19 October 2023**

**Issue Title:** **Incorporation of Emerging Low Earth Orbit (LEO) PNT Providers into ICG**

**Background/Brief Description of the Issue:**
Recognizing:

- The emergence of numerous new entities intending to provide PNT services, many utilizing Low Earth Orbit (LEO) satellites;
- The vital role played by ICG in promoting coexistence, cooperation, interoperability, and standardization among space-based PNT providers;
- The need for any PNT provider to thoroughly and transparently document expected and/or committed levels of performance to bolster confidence and promote adoption of the provider's services; and
- New providers' activities logically being relevant to the activities and responsibilities of several ICG Working Groups,

Working Group S should incorporate the views of LEO PNT system providers into its activities and work on ways to better interact with these providers.

**Discussion/Analyses:**
The plans for LEO PNT systems need to be better understood. The Workshop organized by WG-S in June 2023 attempted to gather information about the systems, but it has become apparent that further engagement and coordination is needed to ensure compatibility and interoperability with the existing GNSS providers.

**Recommendation of Committee Action:**
*ICG members should consider inviting domestic LEO PNT system providers (governmental and non-government) to participate in the ICG activities and its relevant working group meetings. This participation could be in various forms, including requesting ICG Observer Status if interested.*

*To further the discussions that took place at the June 2023 LEO PNT Workshop, WG-S will organize another workshop focused on matters of both interoperability and compatibility. WGS leads for the Workshop will be China, U.S. and ESA.*

16th Meeting of ICG, Abu Dhabi, United Arab Emirates, 9 - 14 October 2022

**Recommendation for Committee Decision**

**Prepared by**: **Working Group S**

**Date of Submission:** **13 October 2022**

**Issue Title:** **Incorporating Resilience into GNSS Interference Detection and Mitigation**

**Background/Brief Description of the Issue:**
Modern Multi-PNT (Positioning, Navigation, and Timing) Ecosystems are facing new trends, new challenges, and an emerging paradigm that creates a need to incorporate resilience into GNSS Interference Detection and Mitigation (IDM). With increased attack surfaces and the proliferation of technology and know-how, end-users will need to operate with the expectation of an increasing frequency of PNT disruptions. Spectrum protection of GNSS services and enforcement by the spectrum regulators, as well as detecting, locating, attributing, and removing sources of interference are necessary, but not sufficient to address real-time operational needs. End users of PNT systems will need to be prepared to expect interference and have the ability to withstand, operate through, and recover from disruption events. Both external and on-device IDM capabilities will be important to enable resilient response. Broader changes involving resilient system architectures and operational resilience will be essential as well.

**Discussion/Analyses:**
These new challenges will require development of new government policy to ensure that disruption or manipulation of PNT services does not undermine the liable and efficient functioning of its critical infrastructure. Governments must also increase their own nation's awareness of the extent to which critical infrastructure depends on, or is enhanced by, PNT services, and must ensure critical infrastructure can withstand disruption or manipulation of PNT services. To this end, national governments are encouraged to protect GNSS spectrum from interference, implement IDM capabilities, and engage the public and private sectors to identify and promote the responsible use of PNT services. National governments should also emphasize the importance of resilient PNT system architectures, including the incorporation of cybersecurity principles into their design.

**Recommendation of Committee Action:**
*To increase critical infrastructure resilience to GNSS disruptions and interference, the ICG recommends that the ICG members should consider the reinforcement of their IDM policy based on a three-prong approach: 1. (Service Aspect): National GNSS spectrum protection and enforcement and implementation of IDM capabilities; 2. (Hardware Aspect): PNT systems designed with resilient system architectures and systems incorporating cybersecurity principles for a holistic approach to threats; and 3. (End-User Aspect): End Users plan for and know how to respond to, withstand, operate through, and recover from PNT disruptions and interference, as well as understand and minimize the impact of PNT disruptions in downstream systems. In addition, the ICG members should consider the promotion of the principles of this recommendation to other UN member states, including the ICG WG C activities.*

15th Meeting of ICG, Vienna, Austria, 27 September - 1 October 2021

14th Meeting of ICG, Bengaluru, India, 8 - 13 December 2019

**WG-S RECOMMENDATION #1**
**Recommendation 14S-1 for ICG Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **12 December 2019**

**Issue Title:** **GNSS Spectrum Protection Booklet**

**Background/Brief Description of the Issue:**
Spectrum Protection and Interference Detection and Mitigation (IDM) have been included in the workplan of the ICG and the Working Group S since its inception. In an effort to expand beyond the reaches of the ICG, WG-S raised this topic to the broader UN at the Committee on the Peaceful Uses of Outer Space (COPUOS) Science and Technology Subcommittee at its annual meeting in 2015. The interest in this topic led to a recommendation for Working Group S to hold a seminar on the importance of spectrum protection and IDM, in conjunction with the UN Workshop on the Applications of GNSS, hosted by the UN at the Vienna International Centre in December 2015. The success of the first workshop led to subsequent regional workshops held in Nepal, Argentina and Fiji, between 2016 and 2019.

**Discussion/Analyses:**
A team of spectrum experts from WG-S put together material for the regional workshops covering a range of topics, from an introduction to what spectrum protection is, to the threat of the proliferation of GNSS jammers around the world. In order make this information more readily available there is great interest in collating this information into written format.

**Recommendation:**
*The ICG recommends that the WG-S Compatibility and Spectrum subgroup, in coordination with the ICG Secretariat, produce a draft booklet on GNSS/RNSS Spectrum Protection based on the briefing material used for the ongoing spectrum seminars:*

- *Fundamentals of GNSS*
- *Interference and Spectrum Management*
- *Interference Threats*
- *Methods of Interference Detection and Mitigation*
- *Current Interference Challenges*

*The ICG should consider formal endorsement of the draft booklet at a future meeting.*

**WG-S RECOMMENDATION #2**
**Recommendation 14S-2 for ICG Decision**

**Prepared by:** **WG-S in cooperation with WG-D**

**Date of Submission:** **December 12, 2019**

**Issue Title:** **Precise Point Positioning (PPP) Interoperability Task Force**

**Background/Brief Description of the Issue:**
Precise Point Positioning (PPP) enables global wide-area centimeter to decimeter level accurate positioning by using precise GNSS satellite orbits, clocks and additional signal corrections to users. Many GNSS, RNSS and SBAS providers have plans to utilise their augmentation signals of different frequencies, e.g., L1, L5, E5b, E6, B1C, B2a and B2b, and correction formats to deliver a precise positioning service(s) based on the PPP technique. In addition, these System-Provided PPP services will also have different service level performance including service coverage, accuracy, convergence time, etc.

**Discussion/Analyses:**
System providers agree on the importance of the topic of PPP interoperability and harmonization of key aspects of PPP services. This joint effort with WG's B and D should therefore concentrate on the objective of improving the PPP service interoperability.

**Recommendation of Committee Action:**
*The ICG will establish a Task Force within the WG-S Interoperability and Service Standards Subgroup, with participation from WG's B and D. Australia, Japan and the EU will provide the cochairs of the Task Force. The Task Force will draft a work plan focused on the objective of improving the interoperability of Precise Point Positioning (PPP) services.*

*Specifically, the Task Force will:*

- *Coordinate with the ICAO Navigation Systems Panel and the SBAS Interoperability Working Group in the ongoing discussions and work of the Task Force.*
- *Concentrate on establishing the foundational documents, baseline definitions and assumptions to develop common terminology on basic parameters for PPP service provision/broadcast.*
- *Encourage the publication and dissemination of PPP signal and system information.*
- *Continue discussions with Service Providers (governmental and commercial) about the issues raised at the 1st PPP Workshop and follow-on issues identified by the Task Force.*
- *Seek answers from Service Providers (governmental and commercial) to the questions formulated at the 1st PPP Workshop and follow-on issues identified by the Task Force (see attached questions).*

**WG-S RECOMMENDATION #1**
**Recommendation 13S-1 for ICG Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **08 November 2018**

**Issue Title:** **Performance Standard Template**

**Background/Brief Description of the Issue:**
At ICG-6 (2011), WG-A(S) approved Recommendation 4.1 to develop a template for individual GNSS providers to consider when defining open service performance. The goal was to reach consensus on a minimum common set of parameters with each system using its own definitions and calculation methods. Establishment of such a set of parameters ensures that GNSS service providers are harmonized in the services they provide, as well as supportive of transparency in GNSS service commitments to users. The Performance Standards Guideline Document has been developed and thoroughly reviewed by WG-S members in a deliberate and steady process over several years, and is a document that can help guide service providers in the development and revision of their performance standards.

**Discussion/Analyses:**
In 2016 at ICG-11, a team was created to fulfill the provision of Recommendation 4.1. Later that year, the team conducted a survey of members to determine which parameters were essential to be included in all standards (minimum common set), and which were optional. From the result of the survey, the team created a Guidelines document which went through extensive reviews by all team members, and the organizations they represent, and the final set was unanimously approved by all members of the team in June 2018. The document was then submitted to the WG-S for their consideration at their inter-sessional meeting in July.

**Recommendation:**
*The ICG recommends adoption of the "Guidelines for Developing Performance Standards" document as a template for all providers to consider when developing their performance standard (or their revisions or updates).*

*Attachment: PerformanceStandardsGuidelines(V1.0).docx "Guidelines for Developing Performance Standards"*

Attachment

# Guidelines for Developing Performance Standards (Version 1.0)

## Introduction

This document outlines guidance for creating open service performance standards for Global and Regional Navigation Satellite Systems (GNSS/RNSS). It was developed by the International Committee on GNSS, Working Group S (Systems, Signals, and Services), Subgroup for Interoperability and Service Standards, Performance Standards team. It is intended to be used by ICG member service providers.

GNSS/RNSS Service Providers in the ICG have agreed each to provide a performance standard document describing the level of service of the GNSS/RNSS for its stage of operation. This service applies only to the signal in space and not to actual receiver, atmospheric, or local effects. The Standard will incorporate the parameters identified in this guidance document, although the document format, definitions, and textual content are at the discretion of the service provider.

In this document, the term "performance standard" is used. Some organizations may refer to it by other terms, such as a service standard, open service standard, or service definition document. For the purpose of this document these terms are considered synonymous.

**Document Sections**
At a minimum, the Performance Standard should contain sections for each of the following:

Purpose. Description of the purpose of the document, describing why it is being produced and what it intended to provide.

Scope. Description of the scope of the document and what it is intended to cover given the state of the existing GNSS/RNSS service. Examples are range accuracy and availability, positioning and timing accuracy and availability, and continuity.

Service Definition. Definition of the service that is being provided, such as open service or standard positioning service.

GNSS/RNSS System Overview. Description of the GNSS/RNSS system from a high-level view, its components and capabilities.

Service Characteristics and Minimum Usage Assumptions. Description of the characteristics of the signal in space service, including signal interface specification with reference to where this information can be found, performance characteristics (including signal health settings), and user equipment assumptions.

Key Terms and Definitions. Identification and definitions for the key terms and parameters used in the Standard.

References. Detailed references to any of the documents mentioned in the Standard.

**Performance Standards & Service Definition**
The Performance Standard should describe the system service levels for the following parameters, grouped by categories. Parameters identified as [Key] are required to be included in the Standard. Those identified as [Optional] are recommendations for consideration, and may or may not be included. For each parameter, the Standard shall provide a definition that is unambiguous and testable.

**Satellite domain**
Slot Availability (maintenance of satellites to orbital slot parameters) [Optional]
Terrestrial Service Volume Coverage [Key]
Space Service Volume Coverage [Optional]

**Range domain**
Range Accuracy (all signals) [Key]
Range Accuracy (by Age of Data) [Optional]
Range Integrity [Optional]
Range Availability [Key]
Range Rate Accuracy [Optional]
Range Acceleration Accuracy [Optional]
Range Rate Integrity [Optional]
Range Acceleration Integrity [Optional]

**Position domain**
This section applies if position is provided as a service. This section requires a statement of receiver assumptions, such as elevation mask angle, ability to track all in view, single or dual frequency.

DOP Availability [Key]
Position Accuracy (Global Average & Worst Site)[Optional] Position
Availability [Key]

**Time domain**
Time transfer accuracy [Key]
UTC time dissemination accuracy [Key]

**Continuity**
Signal in Space Continuity [Optional]
Note: Continuity standard could be implemented after sufficient period for data collection following declaration of full operational capability of the system.

**Other**
Broadcast Polar Motion [Optional]
GNSS/RNSS Time Offset [Optional]
UT1-UTC Offset [Optional]
Carrier Phase Coherency [Optional]

**WG-S RECOMMENDATION #2**
**Recommendation 13S-2 for ICG Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **08 November 2018**

**Issue Title:** **IADC MEO/IGSO Orbital Debris Mitigation Study**

**Background/Brief Description of the Issue:**
There are guidelines for post-mission disposal for GEO and LEO region, however, there are no specific guidelines for GNSS/RNSS MEO and IGSO satellites post-mission disposal from international organizations.

**Discussion/Analyses:**
In the past few meetings of WG-S, reports on GNSS satellites disposal orbit for space debris mitigation were presented. Observation shows some GNSS retired spacecrafts are very likely close to other GNSS operational orbits. For system orbit safety, information on orbital debris mitigation plans need to be exchanged on a regular basis, and it requires the service providers to develop guidelines for GNSS MEO and IGSO satellite disposal together.

**Recommendation:**
***The ICG recommends*** *that the IADC, in coordination with system providers and WG-S, conduct a study focused on Medium Earth Orbit and inclined Geosynchronous orbit debris mitigation and the current plans of GNSS providers.*

*Considering options for GNSS satellites (MEO/IGSO disposal like:*
*Stable Disposal (Graveyard Orbit)*
*Unstable Disposal (eccentricity growth)*
*Active de-orbit (use of solar sails, low thrust propulsion)*

*To analyze for each option for all GNSS (MEO/IGSO) for the next 200 years:*
*Risk of collision with own GNSS satellites*
*Risk of collision with satellites of other GNSS satellites*
*Risk of collision with GEO and IGSO satellites*
*Risk of collision with LEO satellites*

*The IADC will be asked to report/share progress annually with/ to the ICG through WG-S.*

*System Providers will continue to exchange information on their GNSS orbital debris mitigation plans in WG-S and identify experts to participate in the IADC study*.

12th Meeting of ICG, Kyoto, Japan, 3 - 7 December 2017

**WG-S RECOMMENDATION #1**
**Recommendation 12S-1 for ICG Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **02 December 2017**

**Issue Title:** **RNSS Protection Criteria**

**Background/Brief Description of the Issue:**
It is widely recognized that it is important to minimize non-RNSS emissions to RNSS so that the full benefits of RNSS are not negated by reduced performance due to interference.

International Telecommunication Union Radiocommunications (ITU-R) is responsible for managing international radio-frequency spectrum. Protection criteria for RNSS receivers operating in frequency bands allocated to RNSS are specified in ITU-R Recommendations. Adjacent Band Compatibility and unwanted emissions issues concern the interference emissions from non-RNSS sources outside of the RNSS frequency allocations. RNSS receivers are not fully able to avoid getting affected due to the proximity and high-power of adjacent band interference. It would be beneficial to quantify RNSS protection criteria for the above types of interference.

**Discussion/Analyses:**
At the 11th meeting of International Committee on Global Navigation Satellite Systems (Sochi, Russian Federation, November 2016), Recommendation 11S.1 «International Mobile Telecommunications (IMT)-GNSS Compatibility» was approved based on the theoretical and experimental studies assessing the potential impact from unwanted emission from IMT stations in the frequency bands below 3 GHz. These studies showed that there is a possible adverse impact of unwanted emission (including out-of-band, spurious and harmonic interference) from IMT stations on the RNSS frequency bands (1164 – 1300 MHz and 1559 – 1610 MHz). In these studies, RNSS protection criteria was taken from the following ITU-R Recommendations:

- Recommendation ITU-R M.1902 «Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 215-1 300 MHz».

- Recommendation ITU-R M.1903 «Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559-1 610 MHz».

- Recommendation ITU-R M.1905 «Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 1641 215 MHz».

WG-S held two intersessional meetings in 2017 in preparation for ICG-12 (Kyoto, Japan, December 2017). Adjacent Band Compatibility study was presented at the first WG-S intersessional meeting (Baska, Croatia, May 2017). As a result of this presentation, WG-S learned that the RNSS protection criteria specified in ITU-R Recommendations was not fully recognized for protecting RNSS from such interference mechanism. Thus, at the second intersessional meeting of WG-S (Paris, France, July 2017), WG-S agreed to create an ICG Recommendation to endorse of the applicability of RNSS protection criteria to adjacent band interference.

Within ITU-R, the protection criteria from unwanted emissions are usually more stringent than the criteria from co-frequency emissions. Therefore, it should be recognized that interference from non-RNSS services in the bands adjacent to RNSS is fairly treated when applying the same levels between the criteria for emissions from non-RNSS interference in the adjacent band and the criteria for the co-frequency emissions.

**Recognizing:**

a) that Recommendations ITU-R M.1902, 1903, 1905 contain protection criteria of RNSS from non-RNSS sources;

b) that the interference protection criterion of C/No degradation of 1 dB (equivalent to I/N of -6 dB) is used for the Adjacent Band Compatibility assessment;

c) that existing studies regarding interference from unwanted emissions use protection criteria referenced in recognizing a);

d) that the criterion in the above recognizing b) is consistent with the protection afforded by the application of Recommendations in recognizing a).

**Recommendation:**

*that ICG members should encourage national regulators to use the protection criteria in the relevant ITU-R Recommendations in recognizing a), in order to protect GNSS from non-RNSS interference sources, including unwanted emissions.*

**WG-S RECOMMENDATION #2**
**Recommendation 12S-2 for ICG Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **06 December 2017**

**Issue Title:** **3GPP Crowd Sourcing for IDM**

**Background/Brief Description of the Issue:**
The Working Group on Systems, Signals and Services of the International Committee on GNSS (ICG) has been discussing spectrum protection and interference detection and mitigation (IDM) for over 10 years, and has collected a great deal of information about this subject.

The Interference Detection and Mitigation (IDM) task force working under the Compatibility and Spectrum subgroup organized and completed the 6th IDM workshop focusing on both network-based and sensor-based (crowd sourcing) IDM capabilities in May 2017 in Baška.

WG-S participants have discussed how device-based, crowd-sourced GNSS interference detection could be made possible using the large number of active smartphones, most with GNSS. Based on the results of the workshop, and the subgroup meeting, WG-S proposes to engage with the leading smartphone standards developer, 3GPP, to incorporate such capabilities into their mobile device standards and enable access for crowd sourced applications.

**Discussion/Analyses:**
All System Providers have governmental and/or industrial members of the 3rd Generation Partnership Project (3GPP) that participate through one or more of the 7 telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).

WG-S participants have been seeking the views of their 3GPP members on the establishment of specifications for device-based GNSS interference detection.

Some access to the required chipset data is already possible in the most recent Android versions, but standards or specifications may be needed to enable sharing of the required data to enable authorized entities to determine where interference to GNSS occurs. September 2018 is a key milestone in the process of establishing 5G standards. The four step process is: Discussion Paper; Study Item – with the endorsement of 4 companies/members; Technical Report; Work Item – to modify specifications.

**Recommendation:**
*System Provider delegations to the ICG should Use the Providers Forum to reach consensus on whether or not to formally endorse a device-based detection standard through a communication to the 3GPP Technical Specifications Group (TSG) – February or June 2018 If device-based detection is endorsed by Providers, the ICG should:*

- *consider presenting this recommendation to the appropriate Plenary-level 3GPP Meeting*
- *consider how data from device-based detection can be integrated into national/governmental mitigation efforts – September 2018 and beyond.*

**WG-S RECOMMENDATION #3**

**Recommendation 12S.3 for ICG Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **06 December 2017**

**Issue Title:** **2nd ICG WG-S Timing Workshop**

**Background/Brief Description of the Issue:**
ICG WG-S (WG-A) system provider (5 of 6) participants conducted five workshops on interoperability between 2013 and 2015. These workshops were designed to receive industry feedback on the technical aspects of GNSS interoperability. Among the different topics that were addressed through questions to industry were the use of GNSS time offsets between systems to maintain interoperable service provision. The feedback received led to more in depth discussion within the WG-S Interoperability and Service Standards Subgroup in 2015 and 2016. WG-S Recommendation 4 from ICG-11 led to a timing workshop that was held in Paris in conjunction with the WG-S intersessional meeting in July 2017.

**Discussion/Analyses:**
At the 2017 Workshop, the participants concluded that all System Providers should continue to improve the alignment of their individual system times with UTCk to benefit users. It was also recognized that currently, the only GNSS to GNSS system time offsets (G2GTOs) that are being broadcast are relative to GPS system time. The participants identified a number of possible approaches for system time interoperability, including:

1. System time offsets are calculated at the user receiver level – No Action from System Providers;
2. System Providers broadcast additional GNSS to GNSS system time offsets (G2GTOs);
3. The development of a GNSS Ensemble time, such as the MGET proposal, with the broadcast of individual system time offsets relative to the ensemble time and agreed to hold a second workshop in 2018 focused on assessing possible approaches.

**Recommendation:**
*Working Group S, under the direction of the Interoperability Subgroup, should conduct a second System Time Workshop in 2018, in coordination with WG-D.*

11th Meeting of ICG, Sochi, Russian Federation, 6 - 11 November 2016

**Recommendation 11S.1 for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group S** |
| **Date of Submission:** | **10 November 2016 (Original submission in November 2012, revised in November 2013 and 2014)** |
| **Issue Title:** | **International Mobile Telecommunications (IMT)-GNSS Compatibility** |

**Background/Brief Description of the Issue:**
It is widely recognized that compatibility is one of the key elements to ensure interoperability between RNSS systems. In parallel it is also important to minimize non-RNSS emissions entering into RNSS spectrum so that the benefits of interoperability are not negated by reduced performance due to interference.

Because international spectrum issues are under the responsibility of the International Telecommunication Union (ITU), it is essential to keep track of activities at the ITU that could impact RNSS spectrum. In particular, when new allocations are being considered for inclusion in the Radio Regulations, it should be ensured that these do not have the potential to cause harmful interference into RNSS.

According to the decisions of World Radiocommunication Conferences 2012 and 2015, frequency bands below 3 GHz 470 – 694 MHz, 694 – 790 MHz, 790-862 MHz and 1427 – 1518 MHz were identified for the International Mobile Telecommunication (IMT) systems. In some frequency bands this identification has global status.

There are Global Navigation Satellites systems (GNSS) operating in the frequency band below 3 GHz which have allocations for radio-navigation satellite system (RNSS). At the same time according to 4.10 of Radio Regulations: "Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies".

Main frequency bands of the global navigation satellite systems are 1164-1215 MHz, 1215- 1300 MHz and 1559 – 1610 MHz. Frequency bands identified for IMT do not overlap by their main emission with GNSS frequency bands. However it can impact on frequency bands of global navigation systems (1164 – 1300 MHz and 1559 – 1610 MHz) by unwanted emissions from IMT including out-of-band and spurious emissions. In the GNSS frequency band 1559 – 1610 MHz impact of the second harmonic of IMT stations that use frequency bands 694 – 790 MHz and 790 – 862 MHz is possible, as well as impact of spurious emissions of IMT stations that use frequency band 1427 – 1518 MHz. In the GNSS frequency band 1164 – 1300 MHz impact of the second harmonic of IMT stations that use frequency band 470 – 694 MHz is possible, as well as impact of spurious emissions from IMT stations that operate in the frequency band 1427 – 1518 MHz.

**Discussion/Analyses:**
At the 9th meeting of International Committee on Global Navigation Satellite Systems (Prague, Czech Republic 9 – 14 November 2014) theoretical estimations on this matter were presented. Theoretical estimations showed that there is a possible adverse impact of unwanted emission levels (including out-of-band, spurious and harmonic interference) from base/mobile IMT stations on the frequency bands of global navigation systems (1164 – 1300 MHz and 1559 – 1610 MHz). At the inter-sessional meeting of

WG-S (Vienna, Austria, 7-10 June 2016), experimental estimations were presented. These experimental estimations confirmed the results of previously presented theoretical estimations.

WG-S also agreed to continue monitoring mobile service channel plans and recognized the importance of the activities to prevent potential harmonic interference into RNSS.

Thus, one of the main tasks of WG-S is conducting studies that are aimed to prevent potential out-of-band and harmonic interference on RNSS systems, as well as investigation of specific IMT spectrum utilization plans within relevant Administration's and regional groups.

**Recommendation of Committee Action:**

- *ICG members are encouraged to actively participate in the ITU-R and regional work on new IMT spectrum allocations to ensure that proposals do not impact existing and future GNSS operations.*

- *The ICG members are recommended to encourage their administrations to ensure the protection of RDSS/RNSS from the unwanted emissions of new IMT spectrum allocations including adjacent band interference, spurious interference and harmonic interference, as a result may require the implementation of more stringent limits for IMT unwanted emissions levels in RDSS/RNSS bands.*

- *Members may also consider forming links with other satellite groups already defending satellite spectrum.*

**Recommendation 11S.2 for Committee Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **10 November 2016**

**Issue Title:** **Protection from Provider Signal Patents**

**Background/Brief Description of the Issue:**
The ICG has created an open and transparent environment among the GNSS service providers, which has led to significant accomplishments in adopting principles of compatibility, interoperability, and transparency in civil service provision since its inception in 2005. Transparency in civil service provision is a key component to ensuring that interoperability at the user level can be achieved by manufacturers developing receivers using open signals from multiple GNSS.

**Discussion/Analyses:**
WG-S recognizes that there have been cases where at least one GNSS Provider's open service signals were subject to signal structure design patents filed by one or more private entities working within the GNSS program of a system provider. This may have resulted in a request for payments of royalties by users of such signals and/or from manufacturers of receivers using such signals. These types of patents can undermine the ability of the ICG to encourage interoperable open civil service provision.

**Recommendation:**
*The ICG agrees that demanding payment of any kind for open signal structure patents is contrary to the spirit of international GNSS cooperation. GNSS providers are encouraged to ensure that current and future signals will not be subject to patent claims. In addition, the ICG recommends that nations which have issued or may issue such patents, ensure that they are not used for collection of royalties.*

**Recommendation 11S.3 for Committee Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **10 November 2016**

**Issue Title:** **Workshop on Performance Monitoring**

**Background/Brief Description of the Issue:**
The ICG recommended the establishment of the IGMA Trial Project during its ICG-10 meeting in 2015. Specifically, it was recommended that the IGMA Task Force and IGS initiate a joint trial project that will demonstrate a global GNSS Monitoring and Assessment capability.

This project was successfully initiated during 2016. However, additional discussions are needed to identify the next steps, which may include real-time monitoring and expanding the list of parameters that are monitored.

**Discussion/Analyses:**
Building upon the work of the trial project between ICG and IGS, additional discussion is needed to examine further aspects of monitoring and to include feedback from the public.

This will include discussions on the methods and technologies for GNSS Monitoring and assessment including Signal Quality Monitoring. It will also include a report on the IGMA activities in an effort to make the public aware of the trial project and its status.

**Recommendation:**
*The IGMA Task Force should organize a workshop on Performance Monitoring, to take place in Shanghai in conjunction with the China Satellite Navigation Conference in May 2017*

*The Workshop will address the following:*

- *IGMA Activities and the status of the IGMA-IGS trial project*
- *Need/benefit for GNSS signal quality monitoring, and the feasibility of establishing this within the ICG in the future*

**Recommendation 11S.4 for Committee Decision**

**Prepared by:** **Working Group S**

**Date of Submission:** **10 November 2016**

**Issue Title:** **Timing Workshop**

**Background/Brief Description of the Issue:**
ICG WG-S (WG-A) system provider (5 of 6) participants conducted five workshops on interoperability between 2013 and 2015. These workshops were designed to receive industry feedback on the technical aspects of GNSS interoperability. Among the different topics that were addressed through questions to industry were the use of GNSS time offsets between systems to maintain interoperable service provision. The feedback received led to more in depth discussion within the WG-S Interoperability and Service Standards Subgroup in 2015 and 2016.

**Discussion/Analyses:**
Recognizing that GNSS time offsets can affect interoperability, some Providers are broadcasting time offsets relative to other systems. In order to better assess the advantages of this type of offset, further discussion among timing experts is needed.

**Recommendation:**
*The ICG WG-S should work with WG-D, to include BIPM and the IGS, to organize an expert workshop on timing to discuss GNSS time offsets among the systems. The workshop will take place in conjunction with the IGS Workshop, to be held in or near Paris, on 3 – 7 July 2017.*

10th Meeting of ICG, Boulder, Colorado, United States, 1 - 6 November 2015

**Recommendation 10A.2.1 for Committee Decision**

**Prepared by:** **WG-A Compatibility Sub-Group**

**Date of Submission:** **07/16/2015**

**Issue Title:** **Campaign of protection of RNSS operations**

**Background/Brief Description of the Issue:**
By investigating the interference detection and monitoring for the protection GNSS, it was found that the accrual implementation of the protection measures of GNSS is becoming more important. For this purpose, it is essential to recognize the international regulations or guidelines such as ITU Radio Regulations and ITU-R Recommendations. However, it would be necessary to reflect these international Regulations/guidelines to each nation's domestic regulations/guideline, in order to enforce them in effective ways.

**Discussion/Analyses:**
In order to implement the measures for the protection of RNSS, it would be essential to completely understand both a regulatory and operational status of RNSS.

For this purpose, the followings knowledge would be required at least;

- Relevant provisions of the ITU Radio Regulations
- Relevant ITU-R Recommendations
- User's domestic/regional regulations concerning non-licensed emission limits including intentional radio emission limits and electromagnetic emission limits.

**Recommendation of ICG WG-A:**
*The ICG recommends that GNSS providers and GNSS user community member states promote the implementation of the protection measures of GNSS operations in their nations and/or regions as well as other parts of the world.*

**Recommendation 10A.2 for ICG Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **05 November 2015**

**Issue Title:** **UN COPUOS Agenda Item on Spectrum Protection and IDM**

**Background/Brief Description of the Issue:**
The ICG Working Group A has been discussing spectrum protection and interference detection and mitigation (IDM) for several years, and has collected information about this subject. However, the discussions and information collected have been limited to ICG members and participants. At the 2014 meeting of the United Committee on the Peaceful Uses of Outer Space (UN COPUOS) Scientific & Technical Subcommittee (STSC), the subject of GNSS interference detection and mitigation was raised as a topic of interest, specifically with regard to the prevalence of GNSS jammer devices. UN COPUOS has broad reach across UN countries, with [82] member states. In order to expand the discussion on this topic beyond the members of the ICG, and to further expand on what was previously discussed within the STSC, the ICG should reach out to UN COPUOS through the STSC on this topic.

**Discussion/Analyses:**
The long term goal of this recommendation will be for the Science & Technology Subcommittee (STSC) or UN COPUOS to establish a multi-year agenda item focused on National Efforts to protect RNSS Spectrum, and pursue GNSS interference detection and mitigation in member states.

**Recommendation:**
*Working Group A should prepare a presentation on its spectrum protection and IDM activities for the February 2016 session of the UN COPUOS STSC.*

*Under this agenda item, Member States will be asked to report:*

- *National RNSS Spectrum Allocations and consistency with ITU Allocations*
- *Regulations regarding Non-licensed emissions limits from RF emitters and non-emitters*
- *Planned or existing Laws and Regulations related to the manufacture, sale, export, import, purchase, ownership, and use of GNSS jammers*
- *Domestic efforts to detect and mitigate GNSS interference*

**WG-A Recommendation #3**

**UPDATE TO:**

**Joint Recommendation 9A.4.1 for ICG Decision**

**Prepared by:** **Working Groups A, B and D**

**Date of New Submission:** **5 November 2015**

**Issue Title:** **ICG Open Service Monitoring Information Portal**

**Background/Brief Description of the Issue:**

1. Currently GNSS monitoring activities are conducted by each Provider through its own service/analysis center with different information services.

− *These centers may be associated under the ICG umbrella*

− *Information about each center may be available on the ICG portal*

2. Both existing and prospective system's centers may provide raw data, products, and information about the service of GNSS OS monitoring, free of charge.

3. [To archive the goal of international recognition of monitoring and assessment results, these centers should use a unified list of characteristics to be monitored: with unified definitions; unified calculation methods; the technical capability to assure international recognition of the accuracy and other characteristics based on national standards.]

**Discussion/Analyses:**

At the present time, GNSS Providers do their own service monitoring through service/analysis centers. As the Providers work to make their systems more interoperable, the users gravitate toward solutions that use signals from multiple GNSS constellations. As a result, there is an increased need to be able to access standardized data produced by the service/analysis centers, for all GNSS signals. Additionally, having this information available at a single location makes it much easier and quicker to access the information that is needed. Multilateral cooperation by all GNSS Providers can enable this kind of service to be offered through the creation of an ICG portal.

**Recommendation:**

*WG-A recommends that existing monitoring service centers for GNSS open services establish a link to the new ICG portal designed by the ICG Secretariat.*

- *This portal will allow GNSS users worldwide to easily find GNSS monitoring information and products by just looking for the ICG webpage.*

- *Eventually, open service monitoring and analysis centers linked to the ICG portal will use an ICG-recommended list of open service parameters to be monitored that are defined and calculated using accepted techniques and procedures based on a consensus among GNSS service providers.*

# 4 Existing Civil Service Monitoring Information Sources

| Name | Country | URL |
|---|---|---|
| Information Analysis Center | Russia | http://glonass-iac.ru/en/ |
| US Coast Guard Navigation Center | U.S. | http://www.navcen.uscg.gov/ |
| William J. Hughes Technical Center WAAS Test Team | U.S. | http://www.nstb.tc.faa.gov/index.htm |
| European GNSS Service Centre | EU | http://www.gsc-europa.eu/ |
| iGMAS Service Center | China | |
| QZ-vision | Japan | http://qz-vision.jaxa.jp/USE/en/index |
| | India | |
| IGS portal | IGS | http://igs.org/ |

ICG International Committee on Global Navigation Satellite Systems

**WG-A Recommendation #4**

**Joint Recommendation 9A-D.4.1 for ICG Decision**

**Prepared by:** **IGMA Task Force**

**Date of New Submission:** **5 November 2015**

**Issue Title:** **IGMA - IGS Joint Trial Project**

**Background/Brief Description of the Issue:**
IGMA was established as a joint ICG sub-group by recommendation of WG-A (ICG-6, 4.2 an later became a Task Force of WG-A, B, and D, ICG-7 4.1, which includes the IGMA work plan and charter).

Recognizing the on-going activities of Providers to expand their monitoring capability to track and monitor multiple constellations.

The Subgroup/Task Force has conducted a number of meetings and collected proposals on the parameters set to be monitored by IGMA.

**Discussion/Analyses:**
Recognizing:

- The need for a global GNSS monitoring and assessment capability to assist with public confidence in GNSS service provision and interoperability;

- The role the International GNSS Service (IGS) has played in producing precise GNSS products since its inception in 1994, noting the evolution of products and services over time to meet user segment requirements;

- Utilizing existing resources such as IGS and providers monitoring and assessment systems (which may include signal quality monitoring) could maximize benefits in the early stage of the IGMA roadmap**.**

**Recommendation:**
*The ICG recommends that the IGMA TF and IGS initiate a joint trial project that will demonstrate a global GNSS Monitoring and Assessment capability.*

*In advance of launching the joint trial project, the following items are to be determined:*

- *ToR for the Trial project*

- *Status of Trial Project and list of participating organizations (existing monitoring systems and/or providers), operation modes*

- *Short list of stations to be used in Trial Project, providing 1X coverage (to provide collecting all measurement data from all satellites of all GNSS)*

- *Requirements for receivers and related equipment*

- *Short list of monitored parameters for Trial Project and calculation methods for them*

- *Organizational procedures (reference data validation for parameters calculations, measurement data exchange, monitoring results exchange, etc.)*

*An example of IGMA - IGS joint Trial project as a reference for making further definition:*

- *IGS is well placed to establish a Trial Project for IGMA*
- *Invite participation from existing non-IGS analysis groups, networks and data centres,*
- *Develop benchmarking between Groups and generate analysis products*
- *Cross sharing between existing IGS functional streams and IGMA activities benefit both.*

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **11/05/2015**

**Issue Title:** **Updated Work Plan Nomenclature for Working Group A**

**Background/Brief Description of the Issue:**
The original ICG work plan from UN General Assembly Document A/AC.105/879 - 29 December 2006 - *Meeting of the International Committee on Global Navigation Satellite Systems, Vienna, 1 and 2 November 2006* assigned five actions to the Working Group on Compatibility and Interoperability (WG-A).

**Discussion/Analyses:**
One of the five original WG-A actions has been completed, two are being actively pursued, one remains critically important as an area of future work, and one is no longer considered essential to pursuing compatibility and interoperability among all GNSS.

The revised work plan for WG-A maintains a focus on compatibility and interoperability and adds additional areas of work consistent with the work plan of the Providers Forum.

**Recommendation of Committee Action:**
*The ICG should adopt the attached work plan for WG-A.*

**Updated Work Plan of the International Committee on Global Navigation Satellite Systems**

**WORKING GROUP ON SYSTEMS, SIGNALS, AND SERVICES**
**Leads: United States, Russia**

## PREAMBLE

1. Global and regional system providers agree that GNSS has become an essential international positioning, navigation, and timing infrastructure operating in a manner that benefits users worldwide.

2. GNSS has become a key component of critical infrastructure in many countries and the world's economy relies more and more on the services that it enables.

3. To provide reliable global navigation service and meet the user needs, the Committee, Providers Forum, and Working Group seek ways to generate recommendations for how to coordinate system development and provide reliability, compatibility, and interoperability of their systems and services , for peaceful purposes, for users worldwide.

4. Activity of WG-A follows the principles of compatibility and interoperability and the definitions were adopted at the first Providers Forum meeting held in Bangalore, India, September 2007. The Third Providers Forum meeting, held in Pasadena, CA, USA, December, 2008, updated these principles and their definition, as attached.

5. Global and regional system providers agree that at a minimum, all GNSS signals must be compatible. To the maximum extent possible, open signals and services should also be interoperable, in order to maximize benefit to all GNSS users. Each individual Provider has also agreed that they will strive to publish and disseminate all signal and system information necessary to allow manufacturers to design and develop GNSS receivers on a non-discriminatory basis.

6. Since compatibility and interoperability are highly dependent on the establishment of standards for service provision and user equipment, the Committee and associated Providers Forum will consider guidelines and standards developed by existing standard-setting bodies applicable to GNSS service provision and use, such as the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the International Telecommunication Union (ITU) and potentially, the International Organization for Standardization (ISO).

## TASKS AND SCOPE OF WORK

7. In order to assist the Providers Forum in accomplishing its objectives, as described in the Terms of Reference, and in order to further the work of the committee focused on compatibility, interoperability, and provision of open service through a system of global, and regional navigation satellite systems, the Systems, Signals, and Services Working Group, coled by the United States of America and the Russian Federation, will pursue the activities described below.

### Compatibility and Spectrum Protection

8. The principle of compatibility and its definition was adopted at the first Providers Forum meeting held in Bangalore, India, in September 2007. The Third Providers Forum meeting, held in Pasadena, CA, USA, in December, 2008, updated this principle and its definition.

9. The Providers Forum has also agreed to pursue the protection of radionavigation satellite service (RNSS) spectrum through appropriate domestic and international regulation.

10. Considering the principle of compatibility and its definition, and the importance of RNSS spectrum protection, the working group, through a subgroup co-chaired by Japan and the European Union will:

a. Seek common understanding on appropriate methods to determine compatibility among all GNSS;

b. In particular, review existing ITU regulations and recommendations related to the avoidance of harmful interference to GNSS; and,

c. If necessary, propose new questions or studies for ITU consideration, through appropriate mechanisms, to further protect all GNSS from harmful interference, and to define methodology used between GNSS providers to ensure compatibility;

d. Develop educational material on sources of interference to GNSS as recommended by the Committee at its 8th meeting, and assist the working group and ICG Secretariat in training and educating governments of user community member nations on RNSS spectrum protection and management, consistent with ITU regulations and recommendations.

11. The Sub-group will develop a strategy for ICG to support mechanisms to detect and mitigate sources of electromagnetic interference, taking features of GNSS signals and existing regulatory mechanisms into consideration. This should lead to increased efforts worldwide to implement coordinated interference detection and mitigation capabilities at the national level. Specifically, the Sub-group will:

a. Develop standards for interference reports submitted to GNSS Civil Service National Centers and establish routine communications among the centers;

b. Recommend standards for IDM capabilities to be implemented by national governments and industry;

c. Facilitate information exchange among system providers on positioning, navigation, and timing capabilities to complement GNSS.

12. If necessary, the sub-group will establish ad hoc task forces to implement concrete tasks and reach objectives in schedule.

**Interoperability and Service Standards**

13. As with the principle of compatibility, the principle of interoperability and its definition was adopted at the first Providers Forum meeting and updated at the third meeting. Consistent with this principle and its definition, the working group, through a subgroup co-chaired by the United States and China, will consider the perspective of various user applications and equipment manufacturers, and will:

a. Continue efforts to interact with industry experts and user community representatives in order to solicit input on improving the overall open service provided by global and regional navigation satellite systems in a manner that allows for effective multi-GNSS use at the user level;

b. Maintain a focus on the open service signal development and broadcast plans of the system providers; and,

c. In cooperation with [Working Group D], consider the role of system time and geodetic reference frames in enabling interoperable multi-GNSS service.

14. Consistent with the principle of transparency in the provision of open services, each individual Provider will strive to publish and disseminate all signal and system information necessary to allow manufacturers to design and develop GNSS receivers. The Subgroup will develop a template to promote common terminology and definitions in individual GNSS Open Service Signal Specifications as published in Interface Standards and Interface Control Documents. The Subgroup

will also develop a template that each individual GNSS provider may consider using in their publication of signal and system information, the policies of provision, and the minimum levels of performance offered for open services used on the Earth and in outer space (Open Service Performance Standards).

15. The Providers Forum has agreed to consider the development and discussion of proposals to widely monitor the performance of their open signals and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability.

16. The Working Group, through the Interoperability and Service Standards Subgroup, will support this activity by translating open service performance standards into parameters for multi-GNSS monitoring. Recommendations on the necessary monitoring infrastructure and organizational approaches may be made to Providers and international organizations in coordination with other ICG working groups as necessary and appropriate.

17. When requested by a provider or providers, the Subgroup will assist in exchanging information with ICG participants to help resolve GNSS open service anomalies that impact users. The Subgroup will also facilitate cooperation and information exchanges between providers and scientific organizations that engage in open service signal quality monitoring.

18. If necessary, the sub-group will establish ad hoc task forces to implement concrete tasks and reach objectives in schedule.

**System-of-System Operations**

19. As requested by the Providers Forum, the Working Group will investigate methods to ensure orbital de-confliction among constellations in medium Earth orbit (MEO) and appropriate application of United Nations Orbital Debris Mitigation guidelines to this regime implemented through national practices. In this regard, the working group will coordinate with the Inter-Agency Space Debris Coordination Committee.

20. Overall open service performance provided by the system of global and regional navigation satellite systems may also be improved through coordination of constellation configurations and replenishment of satellites in specific orbital locations. The Working Group will assist providers in this area as desired and appropriate.

21. The Working Group will investigate the overall GNSS open service volume in order to consider improvement in terms of accuracy, integrity, availability, reliability and service coverage.

**METHOD OF WORK**

22. If necessary, the working group will establish ad hoc task forces to implement concrete tasks and reach objectives in schedule.

23. The working group will conduct at least one meeting each year between the previous and next meeting of the ICG in order to develop draft conclusions and recommendations for Committee consideration.

24. This work plan will be reviewed on an annual basis and revised as necessary in order to address important issues that require the attention and focus of the system providers.

9th Meeting of ICG, Prague, Czech Republic, 10 - 14 November 2014

**Recommendation 9A.2.1 for ICG Decision**

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|---|---|
| **Prepared by:** | **Working Group A** |
| **Date of Submission:** | **13 November 2014 (Original submission in November 2012 and revised in November 2013)** |
| **Issue Title:** | **International Mobile Telecommunications (IMT)-GNSS Compatibility** |

**Background/Brief Description of the Issue:**

It is already recognized that compatibility is one of the key elements to ensure interoperability between RNSS systems. In parallel it is also important to minimize non-RNSS emissions entering into RNSS spectrum so that the benefits of interoperability are not negated by reduced performance due to interference.

Because international spectrum issues are under the responsibility of the International Telecommunication Union (ITU), it is essential to keep track of activities at the ITU that could impact RNSS spectrum. In particular, when new allocations are being considered for inclusion in the Radio Regulations, it should be ensured that these do not have the potential to cause harmful interference into RNSS.

**Discussion/Analyses:**

At the 2012 intersessional meeting of WG-A, the Compatibility Subgroup agreed to keep monitoring the ITU activities for new spectrum for IMT (WRC-15 agenda item 1.1) to avoid potential interference into RNSS.

The Sub-group also agreed on continuing to watch the 700 MHz mobile service channel plan in Europe, which is related to WRC-15 agenda item 1.2, and recognized the importance of the activities to prevent potential harmonic interference into RNSS.

The Subgroup Chairs will also modify the subgroup ToR to address the investigation of unlike service interference to GNSS (RNSS) and propose text for the WG-A work plan to also address this area of work.

WG-A will investigate specific IMT spectrum utilization plans (ITU-R M.1036-4) within relevant Administration's and regional groups and investigate whether interference mitigation methods already exist within the telecommunications industry.

**Recommendation:**

- *ICG members are encouraged to actively participate in the ITU-R and regional WRC-15 preparatory work on new IMT spectrum allocations to ensure that proposals do not impact existing and future GNSS operations.*

- *The ICG members are recommended, when considering candidate bands for IMT below 3 GHz, to encourage their administrations to ensure the protection of RDSS/RNSS from the unwanted emissions from those candidate bands, including adjacent band interference, spurious interference and harmonic interference, as a result may require the implementation of more stringent limits for IMT unwanted emissions levels in RDSS/RNSS bands.*

- *Members may also consider forming links with other satellite groups already defending satellite spectrum.*

**Recommendation 9A.3.1 for ICG Decision**

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| **Prepared by:** | **Working Group A** |
| **Date of submission:** | **13 November 2014** |
| **Issue Title:** | **Evaluation and development of Interference Detection and Mitigation (IDM) capabilities** |

**Background/Brief Description of the Issue:**
Between 2012 and 2014, the ICG Working Group A sponsored three workshops on GNSS Interference Detection and Mitigation (IDM), offering industry and government agencies an opportunity to provide information on systems that are being developed for the purpose of GNSS interference detection, localization and characterization. Some of these systems are being developed for use by governments for enforcement purposes and some are being developed by industry in anticipation of commercial value. Several of these systems have progressed to the point of being fully operational, and at the July 2014 IDM Workshop, discussion focused on bringing these systems to the attention of ICG and UN Member States.

**Discussion/Analyses:**
As current and emerging GNSS systems provide increased worldwide economic benefit and improved operational efficiencies, it becomes more important that GNSS Providers work together to protect their users from unwanted interference. Several ICG Member States and GNSS companies have initiated projects to build capabilities to detect and geo-locate jammer devices in real time. Characterization of the interfering signals is a feature of some of these systems, for purposes of historical records and forensics. Example systems known to the ICG include:

- The U.S. government developed Patriot Watch system
- The Chronos-developed UK government SENTINAL system
- The ITT/Exelis geo-location capability
- The EU funded DETECTOR project
- Grid-based interference detection systems
- Crowd-Source based interference detection techniques

• Note: additional capabilities may exist that should be considered.

ICG and UN Member States need to be aware of the threat to GNSS signals from unwanted interference, and better understand the existing and emerging capabilities available for them to consider in countering these threats.

**Recommendation:**
*The ICG recommends that GNSS providers and GNSS user community member states evaluate existing and emerging interference detection, localization, and characterization capabilities and consider developing, testing and implementing these or similar capabilities in their nations or regions of the world.*

**Recommendation 9A.3.2 for ICG Decision**

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| **Prepared by:** | **Working Group A** |
| **Date of Submission:** | **13 November 2014** |
| **Issue Title:** | **Crowd sourcing interference detection and localization techniques** |

**Background/Brief Description of the Issue:**
GNSS is vital for many elements of the world's critical infrastructure. Because GNSS signals from space are very weak, jamming, intentional or unintentional, is a threat to potential for GNSS to best serve humanity. To minimize this threat, jammers must be quickly located and shut down.

Crowd-sourcing techniques have the potential to be a cost effective method for interference detection and geo-localization. To further pursue this method, it is necessary to work with industry groups to determine if standards for crowd sourcing interference detection and localization techniques should be developed and cost-effectively implemented by mobile telecommunication service providers.

**Discussion/Analyses:**
At the third ICG Working Group A (WG-A) Workshop on Interference Detection and Mitigation (IDM), a presentation was given which highlighted the capability of using crowd-sourcing techniques for interference detection and geo-location of jammer devices. Crowd sourcing techniques enabled by the proliferation and density of mobile phones may be a viable solution but would require cooperation of mobile phone makers, chip suppliers, wireless provider companies, and the federal communications regulators. Interference detection could be built into GNSS chipsets in new mobile phones, and wireless providers would collect interference reports from millions of users. These reports would be anonymous, to protect individual privacy, and the mobile providers would forward interference reports to local authorities for mitigation enforcement at the local level.

**Recommendation:**
*System providers and user community member states are encouraged to work with industry groups to determine if standards for crowd sourcing interference detection and localization techniques should be developed and cost-effectively implemented by mobile telecom service providers.*

**Recommendation 9A.3.3 for ICG Decision**

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| **Prepared by:** | **Working Group A** |
| **Date of Submission:** | **13 November 2014** |
| **Issue Title:** | **United Nations workshops on RNSS spectrum protection and IDM for member nations in the GNSS user community** |

**Background/Brief Description of the Issue:**
As more and more nations of the world become dependent on GNSS, it is important to inform and educate administrations on the threat of unwanted interference, and the impact it can have on reliable use of these signals. Under the auspices of the United Nations, workshops can be organized and conducted by UNOOSA in cooperation with the ITU to educate decision makers about this issue.

**Discussion/Analyses:**
For several years, UNOOSA has been conducting GNSS workshops for the purpose of increasing knowledge of the benefits and efficiencies available through the use of GNSS. Unwanted interference from natural, unintentional and criminal sources can have a detrimental effect on the use of these signals, and therefore it is critical that administrations of nations who use and rely on GNSS are educated on these risks and the threats. Distinguishing the difference between sources of interference presents a challenge to user communities. Interference detection, localization and characterization capabilities are being developed by governments and commercial companies for consideration. Additionally, Member States should be encouraged to align laws regarding import, export, manufacture, and use of jammer devices, with those of other countries. One way to help accomplish this is by bringing together experts to educate and discuss solutions through United Nations Workshops on Interference Detection and Mitigation (IDM). These workshops would be organized and conducted by UNOOSA in coordination with the ICG IDM Task Force and in cooperation with the ITU.

**Recommendation:**
*The ICG Executive Secretariat, in coordination with the IDM taskforce, should organize United Nations workshops on RNSS spectrum protection and IDM for governments of user community member nations in order to protect the worldwide utility and benefits of GNSS.*

- *A proposal focused on educating UN member state administrations regarding RNSS spectrum management approaches and IDM capabilities will be developed for consideration by the ICG;*

- *Participating member state administration representatives will be encouraged to Provide information as to whether it is legal within their country to: manufacture, sell domestically, export, import, purchase, own, or use GNSS jammers.*

**Joint Recommendation 9A.4.1 for ICG Decision**

**Prepared by:** **Working Groups A, B and D**

**Date of Submission:** **13 November 2014**

**Issue Title:** **ICG Open Service Monitoring Information Portal**

**Background/Brief Description of the Issue:**

1. Currently GNSS monitoring activities are conducted by each Provider through its own service/analysis center with different information services.

   − These centers may be associated under the ICG umbrella

   − Information about each center may be available on the ICG portal

2. Both existing and prospective system's centers may provide raw data, products, and information about the service of GNSS OS monitoring, free of charge.

3. To archive the goal of international recognition of monitoring and assessment results, these centers should use a unified list of characteristics to be monitored: with unified definitions; unified calculation methods; the technical capability to assure international recognition of the accuracy and other characteristics based on national standards.

**Discussion/Analyses:**

At the present time, GNSS Providers do their own service monitoring through service/analysis centers. As the Providers work to make their systems more interoperable, the users gravitate toward solutions that use signals from multiple GNSS constellations. As a result, there is an increased need to be able to access standardized data produced by the service/analysis centers, for all GNSS signals. Additionally, having this information available at a single location makes it much easier and quicker to access the information that is needed. Multilateral cooperation by all GNSS Providers can enable this kind of service to be offered through the creation of an ICG portal.

**Recommendation:**

*WG-A recommends that existing monitoring service centers for GNSS open services establish a link to a new ICG portal designed by the IGMA Task Force.*

- *This portal will allow GNSS users worldwide to easily find GNSS monitoring information and products by just looking for the ICG webpage.*

- *Eventually, open service monitoring and analysis centers linked to the ICG portal will use an ICG-recommended list of open service parameters to be monitored that are defined and calculated using accepted techniques and procedures based on a consensus among GNSS service providers.*

| System name | System participant name | GNSS being monitored | Internet address |
|---|---|---|---|
| iGMA | IAC | GLONASS<br>GPS<br>GALILEO<br>BeiDou<br>QZSS<br>… | www.glonass-iac.ru |
| | IGS | GLONASS<br>GPS<br>GALILEO<br>BeiDou<br>QZSS<br>… | http://igs.org/components/prods.html |
| | iGMAS | GLONASS<br>GPS<br>GALILEO<br>BeiDou<br>QZSS<br>… | |

| iGMA participant name, Internet address | List of parameters available | Methods of calculation | Technical means of monitoring | International recognition basis for measurement results |
|---|---|---|---|---|
| IAC<br><br>www.glonass-iac.ru | Unified list of parameters, defined under the umbrella of ICG (all or some), links to parameters description | Unified list of calculation methods, defined under the umbrella of ICG (all or some), links to methods description | List of GNSS receivers, SLR stations, etc<br>links to technical means characteristics | Mutual recognition through national standards of Russia (list of them, calibration techniques etc) |

**Joint Recommendation 9A.4.2 for ICG Decision**

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|---|---|
| **Prepared by:** | **Working Groups A, B and D** |
| **Date of Submission:** | **13 November 2014** |
| **Issue Title:** | **International GNSS Monitoring and Assessment (IGMA) Workshop** |

**Background/Brief Description of the Issue:**

4. The ICG Providers' Forum Workplan includes:

a) The Providers Forum has agreed to consider the development and discussion of proposals to widely monitor the performance of their open signals and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability.

b) Working Group A will support this activity by focusing on potential cooperation in the development of the necessary ground infrastructure to monitor signal and service performance for open services, recognizing that the actual implementation of this infrastructure is subject to the budgetary limitations of each system provider, and the completion of provider-to-provider agreements as necessary and appropriate.

5. WG-A established the IGMA Task Force jointly with WG-B and D, and defined its tasks at the ICG-6 meeting in 2011. The updated recommendation 8A 4.1 redefined tasks to be taken by the TF, and includes the TF "Consider organizing a workshop on IGMA parameters, services and methodologies."

**Recommendation:**

- *An IGMA Workshop should be held in 2015 for potential users and service providers in order to discuss the following:*
  - *Goal and purpose*
  - *Parameters to be monitored using the "Matrices" prepared by the TF*
  - *Organizational approach*
  - *Sharing portal*
    - *The workshop will be held in Xi'an China, May 12, 2015 immediately preceding CSNC 2015*
    - *Participation from the following organizations is expected:*
  - *Existing monitoring network operators, service providers*
  - *GNSS Providers*
  - *SBAS Operators*
  - *International network operators*
  - *Commercial service operators*
  - *User community representatives*
- *TF members should prepare the "Matrices", categorizing the parameters to be monitored by the IGMA*

8th Meeting of ICG, Dubai, United Arab Emirates, 9 - 14 November 2013

**Recommendation 8A.2.1 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **13 November 2013**

**Issue Title:** **IMT-GNSS Compatibility (Revision to 7A.2.1)**

**Background/Brief Description of the Issue:**
It is already recognized that compatibility is one of the key elements to ensure interoperability between RNSS systems. In parallel it is also important to minimize non-RNSS emissions entering into RNSS spectrum so that the benefits of interoperability are not negated by reduced performance due to interference.

Because international spectrum issues are under the responsibility of the International Telecommunication Union (ITU), it is essential to keep track of activities at the ITU that could impact RNSS spectrum. In particular, when new allocations are being considered for inclusion in the Radio Regulations, it should be ensured that these do not have the potential to cause harmful interference into RNSS.

**Discussion/Analyses:**
At the 2012 intersessional meeting of WG-A, the Compatibility Subgroup agreed to keep monitoring the ITU activities for new spectrum for IMT (WRC-15 agenda item 1.1) to avoid potential interference into RNSS. At the 2013 intersessional meeting, it was recognized that potential concern on the protection of RNSS spectrum from new IMT allocations still exists, since some of the candidate bands for IMT currently being discussed within ITU Joint Task Group (JTG) 4-5-6-7 may affect the existing RNSS allocations. These include the 1300-1400, 1518-1559, and 1610-1660.5 MHz bands.

The Sub-group also agreed on continuing to watch the 700 MHz mobile service channel plan in Europe, which is related to WRC-15 agenda item 1.2, and recognized the importance of the activities to prevent potential harmonic interference into RNSS.

WG-A will investigate specific IMT spectrum utilization plans (ITU-R M.1036-4) within relevant Administration's and regional groups and investigate whether interference mitigation methods already exist within the telecommunications industry.

**Recommendation of Committee Action:**
*ICG members are encouraged to actively participate in the ITU-R and regional WRC-15 preparatory work on new IMT spectrum allocations (including JTG 4-5-6-7 until August 2014), to ensure that proposals do not impact existing and future GNSS operations. Members may also consider forming links with other satellite groups already defending satellite spectrum.*

**Recommendation 8A.2.2 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **13 November 2013**

**Issue Title:** **Providers Update to Current and Future System**

**Background/Brief Description of the Issue:**
In 2010, the ICG Providers Forum members put together a publication titled "Current and Planned Global and Regional Navigation Satellite Systems and Satellite-based Augmentation Systems" in an effort to provide the user community and receiver-producing industry with a clear and consistent description of the systems. The publication indicates that the information will be updated as necessary to reflect changes to the information.

**Discussion/Analyses:**
At the 2013 Intersessional Meeting of WG-A, the meeting participants agreed that some of the information in the publication has changed, and therefore a recommendation should be developed to update the publication prior to ICG-10 in 2015.

**Recommendation of Committee Action:**
*System Providers should provide updated information regarding global and regional navigation satellite systems and augmentations in time for the publication of a new edition of the Providers Forum's Current and Planned Global and Regional Navigation Satellite Systems and Satellite-Based Augmentation Systems before ICG-10. The updated information should include observed or expected open service performance.*

**Recommendation 8A.3.1 for Committee Decision**

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| **Prepared by:** | **Working Group A** |
| **Date of Submission:** | **13 November 2013** |
| **Issue Title:** | **Education & Outreach Regarding Sources of GNSS Interference (Revision to 7A.3.1)** |

**Background/Brief Description of the Issue:**

Reception of GNSS signals can be affected by a range of different factors and many users of GNSS receivers may not be familiar with how GNSS works or even basic radio principles (like radio signals being blocked by objects). A user's expectations of GNSS reception could play a role in reducing the likelihood that interruption to GNSS reception (when entering a building for example) would cause negative effects. For this reason educating users on what to expect of their GNSS receiver in certain conditions would help promote 'responsible use' of GNSS receivers. This could similarly be extended to other types of users, (professional users for example) to mitigate against interruption to businesses that rely on GNSS reception for key activities.

Recent regulatory proposals by one administration also suggest that it may be worthwhile explaining why reception of low power level GNSS signals is unlike any other radio system and that the spectrum used by GNSS requires particular considerations when making new frequency allocations around the same range.

**Discussion/Analyses:**

At the 2012 Intersessional Meeting of WG-A, members, with the EU as lead, agreed to develop sample educational material on GNSS Interference to present at ICG-7. The involvement of the ITU was also to be pursued.

The second Workshop on Interference Detection and Mitigation in 2013 discussed the role of GNSS on a country's critical infrastructure. At the 2013 Intersessional Meeting of WG-A, the participants reviewed the recommendation 7A.3.1 and agreed that the recommendation requires further work and that the information material should emphasize the importance of GNSS to critical infrastructure.

**Recommendation of Committee Action:**

*The ICG should develop educational material such as a downloadable pamphlet or other web content on sources of interference to GNSS. The material should include an explanation why radio navigation satellite services (RNSS) are different than radio communications services and more vulnerable to interference, and will emphasize the importance of GNSS services to critical public and private sector functions, infrastructure, and economic activity.*

**Recommendation 8A.3.2 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **13 November 2013**

**Issue Title:** **GNSS Interference Detection Reporting Procedures**

**Background/Brief Description of the Issue:**
Receiving reports of GNSS interference is important to system providers and GNSS users alike. The information received from these reports can be used in a variety of ways, from maintaining the integrity of the system to being able to warn users of potential outages. Exchange of this information between states could be a valuable tool for helping to mitigate interference events and could also alert system providers of potential issues.

**Discussion/Analyses:**
At the first Workshop on Interference Detection and Mitigation (IDM) in 2012, the concept of developing a guideline or best practice for GNSS interference reporting was discussed. The participants agreed that this is an important topic and continued the discussion at the second IDM Workshop in 2013. At the 2013 Intersessional Meeting of WG-A, the participants agreed that a smaller group should discuss this in more detail to develop a common set of guidelines to be considered for reporting GNSS interference.

**Recommendation of Committee Action:**
*Working Group A should form a Task Force on GNSS Interference Detection reporting procedures and system development.*

- *Initially, the task force will focus on developing a common set of information to be reported to GNSS civil service centers.*
- *Next, the task force will focus on establishing routine communications among the centers.*
- *Finally the task force will develop guidelines for common capabilities to be considered in the development of future national IDM networks.*

**Recommendation 8A.4.1 for Committee Decision**

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| **Prepared by:** | **IGMA Sub-Group (Working Group A, B and D)** |
| **Date of Submission:** | **12 November 2013** |
| **Issue Title:** | **Update Recommendation on IGMA ICG-7A4.1 for its Further Development** |

**Background/Brief Description of the Issue:**
Considering that:

IGMA was established as a joint ICG sub-group by recommendation of WG-A (see appended recommendation ICG-7 4.1, which includes the IGMA work plan and charter).

ICG approved recommendations from WG-D to endorse MGA (ICG-4, WG-D #5) and IGS MGEX (ICG-6 WG-D #13).

Recognizing the on-going activities of the IGS, MGA/MGMNet, iGMAS, and Russian Monitoring and assessment system, those networks and systems are expanding their monitoring capability to track and monitor multiple constellations.

The Subgroup had three meetings and collected proposals on the parameters set to be monitored by IGMA.

**Discussion/Analyses:**
Due to sub-group discussions and activities over the past year, progress against the approved work plan is evident. Increasing interest by the wider ICG and discussions at ICG-8 indicated updates to recommendation A7 4.1 were necessary. Therefore, the sub-group has agreed to:

- Reaffirm the 2013-2015 work plan of IGMA and distribute to ICG members, associates and observers and other interested groups
- Share study progress on OS PS with WG-A Compatibility Subgroup and iterate investigation on the parameters
- Seek contribution to IGMA activities by the broader ICG community
- Promote closer cooperation of the identified IGMA organizations (IGS, MGA, iGMAS, Russia)
- Study how to disseminate monitoring and assessment results, such as the concept of "Service Net" proposed by China
- Encourage participation in the IGMA plenary and splinter sessions during the IGS 20th Anniversary Symposium, June 22-26, 2014 in Pasadena, CA, USA

**Recommendation of Committee Action:**
*Recommendation 7A.4.1 is proposed to be updated as follows;*

- *Redefine the current IGMA joint sub-group of WG-A, B & D as an ICG Task Force. Their task will be to:*

– *Determine Service Parameters to Monitor - definition and methodology to be coordinated with WG-A Compatibility sub group study*

– *Determine what gaps exist in current and planned monitoring and assessment*

– *Consider organizing a workshop on IGMA parameters, services and methodologies*

– *Recommend what should be monitored by:*

  - *Individual GNSS monitoring/control segments*
  - *Shared sites of 2 or more GNSS through bilateral agreements*
  - *Global monitoring of Multi-GNSS parameters*

– *Propose an Organizational Approach that:*

  - *Coordinates and integrates the related activities for identifying parameters*
  - *Avoids Duplication*
  - *Considers the role of the current/planned IGS and*
  - *Defines the Relationship of the proposed organization to the ICG*

– *Explore methods to disseminate monitoring and assessment results, considering specific proposals from system providers.*

**Recommendation 8A.5.1 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **13 November 2013**

**Issue Title:** **Interoperability Task Force**

**Background/Brief Description of the Issue:**
At the ICG-5 meeting of WG-A, the co-chairs presented a summary report of user community views on interoperability, with the following findings:

- Priorities include common carrier frequencies, common time scale & reference systems, common modulation, and collocation of reference stations
- Service-related assurances viewed as important by almost all respondents
- It is difficult to draw more detailed conclusions -many respondents did not appear to understand the underlying issues
- ICG Principle of Interoperability and its definition seems valid - No substantial changes to definition required
- Benefits of interoperability include better availability, accuracy, and ability to support RAIM
- Interviews probably were needed

As a result of this presentation, the ICG recommended that interested members of WG-A develop a new approach to the continued collection of user and industry views on interoperability. This new approach was carried forward at the WG-A 2012 intersessional meeting, and a recommendation to hold an interoperability workshop was put forth to be attended by key technical experts. This workshop was held in April 2013 in conjunction with the ION Pacific Conference. Industry participants were presented with a series of questions in advance of the workshop, and had an opportunity to explain and expand upon their answers.

**Discussion/Analyses:**
At the 2013 Intersessional Meeting of WG-A, the participants discussed preliminary results of the workshop and agreed that holding these workshops was a successful way for the WG-A members to get feedback about user and industry views on interoperability. The members of WG-A agreed that the results of the workshop and questionnaire should be compiled for further analysis through the formation of a task force consisting of Provider representatives. Each of the Providers should also consider hosting a workshop to get further feedback from industry.

**Recommendation of Committee Action:**
*Consistent with the principle of interoperability and its definition, and the implementation of previous ICG recommendations related to interoperability, Working Group A should form a task force to complete efforts to collect and analyze user community and industry views on interoperability*

- *The task force will analyze the results of the April 2013 interoperability workshop and adjust the questions for industry accordingly, in preparation for additional workshops to be hosted by each system provider*

- *The results of each workshop will be consolidated and analyzed by the Task Force in preparation for the 2014 intersessional meeting of Working Group A and ICG-9.*

7th Meeting of ICG, Beijing, China, 5 - 9 November 2012

**Recommendation 2.1 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **08 November 2012**

**Issue Title:** **IMT-GNSS Compatibility**

**Background/Brief Description of the Issue:**
It is already recognized that compatibility is one of the key elements to ensure interoperability between RNSS systems. In parallel it is also important to minimize non-RNSS emissions entering into RNSS spectrum so that the benefits of interoperability are not negated by reduced performance due to interference.

Because international spectrum issues are under the responsibility of the International Telecommunication Union (ITU), it is essential to keep track of activities at the ITU that could impact RNSS spectrum. In particular, when new allocations are being considered for inclusion in the Radio Regulations, it should be ensured that these do not have the potential to cause harmful interference into RNSS.

**Discussion/Analyses:**
At the 2012 intersessional meeting of WG-A, the Compatibility Subgroup agreed to keep monitoring the ITU activities for new spectrum for IMT (WRC-15 agenda item 1.1) to avoid potential interference into RNSS.

The Sub-group also agreed on continuing to watch the 700 MHz mobile service channel plan in Europe, which is related to WRC-15 agenda item 1.2, and recognized the importance of the activities to prevent potential harmonic interference into RNSS.

The Subgroup Chairs will also modify the subgroup ToR to address the investigation of unlike service interference to GNSS (RNSS) and propose text for the WG-A work plan to also address this area of work.

WG-A will investigate specific IMT spectrum utilization plans (ITU-R M.1036-4) within relevant Administration's and regional groups and investigate whether interference mitigation methods already exist within the telecommunications industry.

**Recommendation of Committee Action:**
*ICG members are encouraged to actively participate in the ITU-R and regional WRC-15 preparatory work on new IMT spectrum allocations to ensure that proposals do not impact existing and future GNSS operations. Members may also consider forming links with other satellite groups already defending satellite spectrum.*

**Recommendation 3.1 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Education and Outreach Regarding Sources of GNSS Interference**

**Background/Brief Description of the Issue:**
Reception of GNSS signals can be affected by a range of different factors and many users of GNSS receivers may not be familiar with how GNSS works or even basic radio principles (like radio signals being blocked by objects). A user's expectations of GNSS reception could play a role in reducing the likelihood that interruption to GNSS reception (when entering a building for example) would cause negative effects. For this reason educating users on what to expect of their GNSS receiver in certain conditions would help promote 'responsible use' of GNSS receivers. This could similarly be extended to other types of users, (professional users for example) to mitigate against interruption to businesses that rely on GNSS reception for key activities.

Recent regulatory proposals by one administration also suggest that it may be worthwhile explaining why reception of low power level GNSS signals is unlike any other radio system and that the spectrum used by GNSS requires particular considerations when making new frequency allocations around the same range.

**Discussion/Analyses:**
At the 2012 Intersessional Meeting of WG-A, members, with the EU as lead, agreed to develop sample educational material on GNSS Interference to present at ICG-7. The involvement of the ITU was also to be pursued.

**Recommendation of Committee Action:**
*The ICG should develop educational material such as a downloadable pamphlet or other web content on sources of interference to GNSS. The material should include an explanation why radio navigation satellite services (RNSS) are different than radio communications services and more vulnerable to interference.*

**Recommendation 3.2 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Continuation of Workshops on GNSS Spectrum Protection and Interference Detection and Mitigation**

**Background/Brief Description of the Issue:**
At the first IDM workshop, held in Vienna in June 2012, the following conclusions were reached by consensus:

**Sources of interference**

1. The ICG should develop educational material such as a downloadable pamphlet or other web content on sources of interference to GNSS. The material should include an explanation why radio navigation satellite services (RNSS) are different than radio communications services and more vulnerable to interference.

**RNSS Spectrum Protection**

2. The ICG should recommend that its member state participants identify a suitable GNSS monitoring site or operations center to be recognized by the ITU as an official part of its International interference monitoring network.

3. ICG system providers should be reminded to adhere to the existing template for sharing information between service providers and should exchange information related to domestic spectrum management activities applicable to GNSS.

**Current and future information sharing, dissemination, collaboration and standardization**

4. The ICG should compare the existing ITU interference report to the reporting form used by the U.S. and other forms under development in order to develop a guideline or best practice for GNSS interference reporting.

**Concepts and Techniques for Interference Detection**

5. The ICG should consider initiating a process to develop guidelines for mobile GNSS device manufacturers that are interested in contributing interference detection information to national reporting authorities or automated detection networks.

**Continuation of IDM Workshops**

6. System providers and ICG participants should identify experts to participate in the next IDM workshop and reach a consensus on the next meeting date and location.

**Discussion/Analyses:**
At the 2012 Intersesional Meeting of WG-A, members agreed to provide feedback to the Co-Chairs on their ability to attend the proposed workshop and recruit desired expert attendees.

The WG-A Co-Chairs also agreed to request that the ITU-BR representative to the ICG provide the working group with the current list of ITU-recognized interference monitoring network sites. Members of the working group can then compare the existing ITU interference report to the GNSS-specific reporting form used by the U.S., Russia, and China, and other GNSS-specific forms that may be under development. At ICG-7, views were exchanged on whether a standardized form is desirable.

**Recommendation of Committee Action:**

- *The ICG should sponsor additional GNSS Interference Detection & Mitigation (IDM) Workshops*
- *System Providers and ICG participants are encouraged to identify experts to participate in the next workshop, scheduled to occur in Honolulu, Hawaii, immediately preceding the ION Pacific PNT Meeting, April 22-25, 2013*
- *Specific expertise desired includes:*
  - *ITU Radio Bureau officials*
  - *Spectrum Regulators and other appropriate experts from System Providers and Administrations in the Asia-Pacific Region o Representatives of major industrial and transportation sectors (such as mobile telecommunications, automotive electronics, aviation) utilizing GNSS*
  - *IGS and GNSS reference station network developers.*

**Recommendation 4.1 for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group A, Co-chairs of Sub-Group, Working Group D** |
| **Date of Submission:** | **08 November 2012** |
| **Issue Title:** | **International GNSS Monitoring and Assessment (IGMA) Subgroup** |

**Background/Brief Description of the Issue:**
The Providers Forum has agreed to consider the development and discussion of proposals to widely monitor the performance of their open signals and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability. As stated in its work plan, Working Group A will support this activity by focusing on potential cooperation in the development of the necessary ground infrastructure to monitor signal and service performance for open services.
To ensure the service quality, consistent with common open service performance parameters, and realize the ultimate goal of interoperable GNSS open services signals, it is desirable to carry out monitoring and assessment on GNSS open services. An important approach is to determine if international GNSS Monitoring and Assessment requires a single new system, an architecture created by several national systems, or the use of an existing global network system such as the one organized by the International GNSS Service (IGS).

**Discussion/Analyses:**
Several multi-GNSS monitoring network activities are underway:

- China is developing their International GNSS Monitoring and Assessment System (iGMAS) as a contribution to the ICG activity;
    - O Note that China has issued a Call for Participation in their system. ICG components are encouraged to review the CfP and respond: http://en.beidou.gov.cn/
    - o Note that China has prepared a draft version of a document on GNSS Open Service parameters to be monitored, also located at the above website
- Japan has also initiated a project known as Multi-GNSS Demonstration Campaign, which is actively seeking proposals for monitoring sites to host GPS/GLONASS/Galileo/QZSS receivers that have already been procured by JAXA (www.multignss.asia).
- IGS network upgrades currently include multi-GNSS receivers in the framework of the IGS Multi-GNSS Experiment (MGEX). These receivers are being deployed globally and IGS will analyze and produce products for the multi-GNSS constellations, similar to what it is currently accomplishing for GPS and GLONASS. IGS plans should be explored for potential to contribute this ICG task.
- The support and participation of all GNSS providers will be very beneficial for global monitoring and assessment.

To monitor and assess GNSS open services worldwide, a subgroup of WG-A, with participation from WG-B and WG-D was formed as recommended at ICG-6 to develop a proposal to optimize existing and planned capabilities, and identify additional activities necessary for international GNSS Monitoring and Assessment. This subgroup met in July 2012 on the margins of the annual IGS Workshop and the inter-sessional meeting of WG-A.
The ICG-IGMA sub-group meeting in Poland, including WG-A and WG-D members, recognized the need to focus and define the plans of the group. WG-A prepared the recommendation (below), and the

sub-group proposes a two-year work plan to meet the goals and objectives of this recommendation. This work plan is included below.

**Recommendation of Committee Action:**

- *The task of the current IGMA sub-group of WG-A (with B & D participation) should be to:*
  - *Determine Service Parameters to Monitor*
  - *Determine what gaps exist in current monitoring – Recommend what should be monitored by:*
    - *Individual GNSS monitoring/control segments*
    - *Shared sites of 2 or more GNSS through bilateral agreements*
    - *Global monitoring of Multi-GNSS parameters – Propose an Organizational Approach that:*
      - *Avoids Duplication*
      - *Considers the role of the current/planned IGS and*
      - *Defines the Relationship of the proposed organization to the ICG.*

**Recommendation 4.1 for Committee Decision (continues)**

Proposed Work Plan of ICG IGMA, 2013-2015:

*Noting the recommendation and report of WG-A Intercessional Meeting in Poland, the ICG IGMA Sub-Group proposes to:*

- Prepare a charter for subgroup activities for a two-year period until ICG-9. The charter will be based upon a modified ToR draft stemming from discussions at meetings in Vienna, Austria, in December 2011, and in Olsztyn, Poland in July 2012 (see attachment).
- Request each system provider, Working Group B and D, and appropriate Associate Members and Observers, to provide a point of contact for this activity, and to be members of the subgroup.
- Conduct a survey of providers and users, in cooperation with WG-A, WG-B, and WG-D to:
    - define the purpose for monitoring and assessing the parameters,
    - determine what parameters are necessary to be monitored for individual systems and inter-GNSS,
    - define responsibilities for monitoring and assessment,
    - determine what level and methods are needed,
    - prioritize the importance of the parameters to be monitored
- Develop a functional requirements document for ICG GNSS monitoring and assessment.
- Determine what currently exists, based on the functional requirements of individual systems, and what may be available and applicable to multi-GNSS monitoring.
- Identify plans and capabilities of various GNSS monitoring components that may meet any of the functional requirements.
- Determine what needs to be developed; identify potential candidates to develop and implement.
- Develop a schedule for this ICG IGMA sub-group activity by February 2013.
- Report to ICG-9 and include a summary of the findings and potentially, a proposed approach for collective ICG GNSS monitoring and assessment, along with a proposed implementation plan and schedule.
- Provide an interim report at ICG-8 on progress.

**Recommendation 4.1 for Committee Decision (continues)**

**Appendix**

ICG International GNSS Monitoring and Assessment
First Draft of ICG IGMA Charter, 2013-2015
(Working Document)

**Background**

To ensure the service quality and realize the ultimate goal of interoperable GNSS open services signals, it is desirable to carry out monitoring and assessment on GNSS open services. The Providers Forum of ICG-4 has agreed to consider the development and discussion of proposals to widely monitor the performance of their open signals and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability.

To monitor and assess GNSS open services worldwide, the subgroup on International GNSS Monitoring and Assessment was formed at ICG-6 to support activities and develop proposals to optimize existing and planned capabilities, and identify additional necessary activities.

**Objective**

The objective of the subgroup is to actively advance the international GNSS monitoring and assessment by promoting the sharing of the global monitoring resource and carrying forward international cooperation.

**Main tasks**

The subgroup will support related activities by focusing on potential cooperation in the following (including but not limited to):

1. Promote the sharing of existing resources such as data and infrastructure to monitor signal and service performance for open services.
2. Determine parameters to be included.
3. Discuss the standards of monitoring and assessment
4. Discuss the sharing methods of monitoring and assessment resources

**Activities**

The activities shall include but not limited to the following:

1. A work plan will be developed and progress will be reported to the WG-A and ICG plenary (reporting sub-group vs. task group).
2. Subgroup meetings may be held as needed to share the information and experience, to discuss the specific items which GNSS providers and users are concerned with. Persons interested in the topic are welcomed to attend.

**Recommendation 5.1 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Interoperability Workshop**

**Background/Brief Description of the Issue:**
At the ICG-5 meeting of WG-A, the co-chairs presented a summary report of user community views on interoperability, with the following findings:

- *Priorities include common carrier frequencies, common time scale & reference systems, common modulation, and collocation of reference stations*
- *Service-related assurances viewed as important by almost all respondents*
- *It is difficult to draw more detailed conclusions -many respondents did not appear to understand the underlying issues*
- *ICG Principle of Interoperability and its definition seems valid - No substantial changes to definition required*
- *Benefits of interoperability include better availability, accuracy, and ability to support RAIM •*

  *Interviews probably were needed*

As a result of this presentation, the ICG recommended that interested members of WG-A develop a new approach to the continued collection of user and industry views on interoperability. This new approach should include interviews with industry and users and the organization of a large user/industry summit to be attended by key technical experts.

**Discussion/Analyses:**
No follow-on recommendation related to interoperability was made at ICG-6, and the recommended summit has not yet occurred. However, WG-A renewed discussion on the subject at the 2012 intersessional meeting, and completed the recommendation enclosed below. WG-A system provider members agreed to provide the Co-Chairs with a point of contact for developing the agenda and web site material for the proposed Interoperability workshop to be held in conjunction with ION Pacific PNT 2013.

It was also proposed that the identified team would begin developing a draft agenda and other webbased material for consideration by the Committee at ICG-7.

**Recommendation of Committee Action:**
- *Consistent with the principle of interoperability and its definition, and the implementation of previous ICG recommendations related to interoperability, the ICG should conduct an interoperability workshop in conjunction with the ION Pacific PNT meeting, April 22-25, 2013.*
- *The ICG will request inputs from potential participants prior to the workshop through existing web sites related to GNSS information dissemination, conferences, major PNT organizations and events.*
- *The following interoperability subjects may be addressed:*
  - *Potential for a common third open service signal*
  - *Frequency diversity vs. frequency commonality*
  - *DOP improvement with the addition of 2nd, 3rd, 4th, Nth global constellation*

– *System provider time and geodetic reference frame implementation as described by the ICG WG-D templates*

– *Potential opportunities to utilize existing or planned spare capacity in civil/open service or SBAS navigation messages in order to increase multi-GNSS interoperability.*

6th Meeting of ICG, Tokyo, Japan, 5 - 9 September 2011

**Recommendation 2.1 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **8 September 2011**

**Issue Title:** **Continuation of WG-A compatibility subgroup**

**Background/Brief Description of the Issue:**
In June 2010, a Providers-only workshop on compatibility was conducted and a sub-group was formed to investigate organizational models relevant to multilateral coordination of GNSS compatibility. At ICG-5, the Committee recommended to continue the work of the sub-group on organizational models and procedures for multilateral discussions on GNSS compatibility.

**Discussion/Analyses:**
Following ICG-5, the subgroup met twice on, 25 February 2011 in Geneva and on 8 June 2011, in Vienna. During its last meeting, the subgroup developed draft terms of reference (see the annex) and presented them at the ICG WG-A meeting on 9 June 2011. WG-A members agreed on the relevance of those ToR and on the usefulness of continuing the work of the subgroup.

**Recommendation:**
*To continue the activities of the WG-A Compatibility subgroup in accordance with the ToR as attached. The subgroup will assess compatibility issues to support the development of Common Signal Characteristics Reference Assumptions, which are recommended by ICG-5 Recommendation 6. The subgroup will also initiate discussions and collaboration on open service GNSS performance parameters, including definitions and calculation methods, as requested by ICG-6 WG-A recommendation 4.1.*

**Annex**

**Draft Terms of Reference**

**OF THE WG-A COMPATIBILITY SUB-GROUP**

***Noting:***

*a) the importance of cooperation related to civil satellite-based PNT and value-added services;*

*b) The unique and irreplaceable role of bilateral coordination under ITU procedures;*

*c) The increasing importance of multilateral information exchange among GNSS systems;*

***Considering:***

*a) that at ICG-5, WG-A recommended the creation of a subgroup to investigate multilateral discussions for GNSS compatibility.*

*b) that at ICG-6, the committee endorsed a recommendation from WG-A to continue studying the various issues of compatibility that are of concern to all parties;*

*c) that the terms of reference should be reviewed at least annually to determine if the subgroup should continue to exist, and if so, to maintain current relevance;*

***Deciding:***

a) that English will be the official language for the conduct of its meetings and its documentation;

b) that the two Co-Chairs are appointed by Working Group A [for a period of one year], to organize the work to be conducted during meetings and to guide the discussions during meetings;

c) that the sub group shall only work on the compatibility issues that are agreed to by WG-A;

***The WG-A Compatibility Subgroup will****:*

1) work on the compatibility issues as approved by WG-A and define work plans for the corresponding issues;

2) express its agreed results in the form of findings, reports, or whatever form may be appropriate for the case;

3) provide proposals of compatibility issues to WG-A, for discussion and decisions.

**Recommendation 3.1 for Committee Decision**

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| **Prepared by:** | **ICG Working Group A** |
| **Date of Submission:** | **8 September 2011** |
| **Issue Title:** | **Proposed workshop on GNSS Spectrum Protection and Interference Detection and Mitigation for ICG Providers Forum Member Consideration** |

**Background/Brief Description of the Issue:**
ICG Terms of Reference work plan includes the means to: "establish, as mutually agreed and on an ad hoc basis, working groups to investigate specific areas of interest, cooperation and coordination." Also, the work plan of the Providers Forum contains the provision to consider GNSS Interference detection and mitigation. This proposal sets forth the description of a workshop focused on spectrum protection and interference detection and mitigation for GNSS.

**Discussion/Analyses:**
As current and emerging GNSS systems become more and more useful for world-wide economic benefit and efficiencies in operations, it is becoming more important for Providers to work together to protect users of these GNSS signals from harmful interference. A Proposed Agenda for the workshop has been developed based on experience and concerns related to GNSS IDM. The issues to be discussed include regulatory, policy, operational and technical aspects. Specifically, the proposed agenda suggests discussion of the following subjects: RNSS Spectrum Protection Overview; Sources of interference; Update from current Providers; Current and future information sharing, dissemination, collaboration and standardization; Case Studies, Workshop views and recommendations. One of the desired outcomes of this workshop will be to address the next steps for collaboration on IDM, especially on possible technical concepts for interference detection and monitoring and the forecast and observation of harmful space weather effects. This may include establishing additional workshops and/or case studies to examine in more detail some additional aspects of IDM, to include: joint GNSS IDM monitoring, communication and exchange of information, possible development of (recommended) standards for interference detection devices, development of a mechanism for interference source monitoring and mitigation within the ICG, and the exchange of information related to space weather forecasting.

**Recommendation:**
*It is recommended that ICG conduct a two day workshop, with another half-day to finalize recommendations, focusing on GNSS Spectrum Protection, Interference Detection and Mitigation, and international cooperation. The location of the proposed workshop, to be conducted no earlier than March 2012, is to be determined. It is also recommended that follow-up meetings, workshops, and/or case studies, and potential establishment of a platform for international technical cooperation, may be discussed and agreed upon as a result of this initial workshop.*

**Recommendation 4.1 for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group A** |
| **Date of Submission:** | **8 September 2011** |
| **Issue Title:** | **Consensus on Open Service GNSS performance parameters, including Definitions and Calculation Methods** |

**Background/Brief Description of the Issue:**
According to the current work plan, the working group will develop a template that individual GNSS providers may consider using in their publication of signal and system information, the policies of provision, and the minimum levels of performance offered for open services. Before a template for open service performance can be developed, the goal is to reach consensus on a minimum set of parameters common to all GNSS open services.

Moreover, each system has its own definitions and calculation methods for the performance parameters, which may be different from each other. It is recommended that the definitions and calculation methods of the performance parameters be clarified and discussed in order to facilitate the subsequent work on the template.

**Discussion/Analyses:**

- Parameters of each Performance Document (PD) will address the Open Service (OS) provided by each provider.

- The definitions and calculation methods of open service GNSS performance parameters should be provided by each system provider and discussed by all interested participants in order to achieve a common understanding The OS PD values may change over time – as determined by the GNSS provider.

- Providers may choose to define additional parameters for their respective open services or for additional services they intend to provide.

**Recommendation:**
*The Compatibility sub-group of WG-A, with participation from all interested system providers will initiate the necessary discussions and collaboration, including the issue of definitions and calculation methods of the performance parameters. Names of participants should be provided to the WG-A sub-group Chairs as soon as possible.*

**Recommendation 4.2 for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **8 September 2011**

**Issue Title:** **International GNSS Monitoring and Assessment**

**Background/Brief Description of the Issue:**
The Providers Forum has agreed to consider the development and discussion of proposals to widely monitor the performance of their open signals and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability. As stated in its work plan, Working Group A will support this activity by focusing on potential cooperation in the development of the necessary ground infrastructure to monitor signal and service performance for open services.

To ensure the service quality, consistent with common open service performance parameters, and realize the ultimate goal of interoperable GNSS open services signals, it is desirable to carry out monitoring and assessment on GNSS open services. An important approach is to determine if international GNSS Monitoring and Assessment requires a single new system, an architecture created by several national systems or through the use of an existing global network such as the one utilized by the International GNSS Service (IGS).

**Discussion/Analyses:**
Several multi-GNSS monitoring network activities are underway. For example, Preliminary experience includes BeiDou monitoring and assessment, the long-term successful operation of IGS, and the achievements in GNSS signal monitoring and assessment made by Stanford University, DLR, Information Analysis Center of Roscosmos, and others.

China is developing the International GNSS Monitoring and Assessment System (iGMAS).

Japan has also initiated a project known as Multi-GNSS Demonstration Campaign, which is actively seeking proposals for monitoring sites to host GPS/GLONASS/Galileo/QZSS receivers that have already been procured by JAXA.

Future plans for IGS network upgrades to include multi-GNSS receivers should also be investigated, and the support and participation of all GNSS providers will be very beneficial for global monitoring and assessment.

**Recommendation:**
*To monitor and assess GNSS open services worldwide, a subgroup of WG-A, with participation from WG-B and WG-D should be formed to develop a proposal to optimize existing and planned capabilities, and identify additional activities necessary for international GNSS Monitoring and Assessment.*

5th Meeting of ICG, Turin, Italy, 18 - 22 October 2010

**Recommendation #1 for Committee Decision**

**Date of Submission:** **October 21, 2010**

**Issue Title:** **Spectrum Protection – Interference Detection and Mitigation**

**Background/Brief Description of the Issue:**
Proposals were made to focus on the following topics related to interference detection and mitigation:

- Preventing the availability of unlawful interference devices (jammers) in the open market
- Identification of national and international regulations on spectrum protection, their possible inconsistency and necessary improvement
- Detecting and neutralizing interference sources at the national level and the identification of possible international cooperation

The potential for a future workshop was also discussed.

**Discussion/Analyses:**
Consensus on each topic mentioned above was not achieved. However, WG-A did reach consensus on the recommendation shown below.

**Recommendation of Committee Action:**
- *Interested members of WG-A should focus on proposals to address interference detection and mitigation and draft a study plan for consideration by the ICG*
- *ICG participants are asked to provide points of contact for this activity to the WG-A cochairs as soon as possible, recognising the multidisciplinary nature of the task.*

**Recommendation #2 for Committee Decision**

**Date of Submission:** **October 21, 2010**

**Issue Title:** **User Community Views on Interoperability**

**Background/Brief Description of the Issue:**
The WG-A co-chairs presented a summary report of user community views on interoperability, with the following findings:

ICG Principle of Interoperability and its definition seems valid - No substantial changes to definition required.

- Benefits of interoperability include better availability, accuracy, and ability to support Receiver Autonomous Integrity Monitoring (RAIM)
- Priorities include common carrier frequencies, common time scale & reference systems, common modulation, and collocation of reference stations
- Service-related assurances viewed as important by almost all respondents
- It is difficult to draw more detailed conclusions -many respondents did not appear to understand the underlying issues
- Interviews probably were need

**Discussion/Analyses:**
Each provider should now indicate if the questionnaire results could now affect their:
Existing or new signal designs; System documentation; Interface and Performance Standards; System commitments; Constellation health, sustainment policy, notifications to users; treatment of unhealthy satellites, etc.

If not, the effort should be ended. If so, the interested Providers should re-shape the survey and its process for maximum benefit. To enable this, the questionnaire responses will be made available to Providers.

**Recommendation of Committee Action:**
- *Interested members of WG-A will develop a new approach to continued collection of user and industry views on interoperability.*
- *Potential specific topics to include in new questionnaire:*
  - *Value of a common third open service signal*
  - *Importance of DOP improvement with the addition of 2nd, 3rd, 4th, Nth global constellation*
- *Plan for conducting interviews in association with the questionnaires.*
- *Consider organizing a large user/industry summit to be attended by key technical experts.*

**Recommendation #3 for Committee Decision**

**Date of Submission:** **October 21, 2010**

**Issue Title:** **Time and Geodesy Aspects of Interoperability**

**Background/Brief Description of the Issue:**
System time and geodetic reference system aspects of GNSS interoperability were identified as priority needs by respondents to the WG-A questionnaires.

**Discussion/Analyses:**
WG-A conducted a joint session with WG-D where representatives of WG-D made presentations focused on GNSS reference system and timing issues.

**Recommendation of Committee Action:**
• *Continue to investigate system time and geodetic reference frame aspects of interoperability within the WG-D task forces on time and geodesy.*

- *First task is the completion of time and geodetic reference frame templates by all system providers*
- *Other specific methods to potentially improve interoperability could be addressed afterwards*

    - *Inclusion of multi-constellation, multi-frequency tracking in the IGS network*
    - *Monitor and disseminate offsets between each system time.*

**Recommendation #4 for Committee Decision**

**Date of Submission:** **October 21, 2010**

**Issue Title:** **Participation in the Multi-GNSS Demonstration Campaign**

**Background/Brief Description of the Issue:**
A Multi-GNSS Demonstration Campaign is being sponsored by the Government of Japan with support or endorsements from many organizations, including the ICG The purpose is to test and experiment with multi-system receivers and demonstrate the benefits of interoperability between systems. Based on a presentation by Mr. Satoshi Kogure of JAXA, WG-A discussed the need to encourage participation in this campaign by companies and other interested parties.

**Discussion/Analyses:**
In the discussion it was generally agreed that this could be of benefit, but that it should not be a formal ICG requirement that each provider is expected to participate.

**Recommendation of Committee Action:**
Interested ICG participants are encouraged to interact with receiver manufacturers and encourage participation in the Asia-Oceania Multi-GNSS Demonstration Campaign as:

- *An opportunity to test and experiment with multi-system receivers and demonstrate the benefits of interoperability*
- *Also an opportunity to develop potential new GNSS applications enabled by multiple systems*
- *Industry, users, and system providers should all benefit*

**Recommendation #5 for Committee Decision**

**Date of Submission:** **October 21, 2010**

**Issue Title:** **Multilateral Discussions on GNSS Compatibility**

**Background/Brief Description of the Issue:**
In June 2010, a Providers-only workshop on compatibility was conducted and a sub-group was formed to investigate organizational models relevant to multilateral coordination of GNSS compatibility. The workshop participants also confirmed the acceptability of the current ICG Principle of Compatibility and its definition without change.

**Discussion/Analyses:**
The findings of the sub-group were presented to WG-A on 19 October 2010. After the presentation it was proposed that some of the terminology be changed, such as the use of the word "discussions" rather than "coordination". After the discussion the WG-A agreed to the following recommendation:

**Recommendation of Committee Action:**
*Continue the Work of the Sub-group on Organizational Models and Procedures for Multilateral* ***Discussions*** *on GNSS Compatibility*

- *Define the needs and the scope of multilateral discussions on GNSS compatibility*
- *Recommend continued study of appropriate organizational models*
  - *Assess applicability to GNSS*
  - *Select the most relevant models and the appropriate role of the ICG*

**Recommendation #6 for Committee Decision**

**Date of Submission:** **October 21, 2010**

**Issue Title:** **Adoption of common signal characteristics reference assumptions**

**Background/Brief Description of the Issue:**
The GNSS community is interested in knowing the characteristics of signals from each provider. In order to make this information most useful, a set of common reference assumption would be desirable. In response to this the US delegation made a presentation suggesting ways to achieve common assumptions, regarding link budgets and maximum received power, as a step toward additional common conventions and assumptions.

**Discussion/Analyses:**
Because of the detailed information presented, it was decided to continue this discussion in future meetings, as per the following recommendation:

Specific maximum received power conventions discussed included:
- Transmit power equal to or greater than that needed to meet minimum received power commitments
- Conventional loss due to free space propagation
- 0 dB atmospheric loss
- 0 dBic lossless reference receive antenna
- Transmit antenna gain versus angle off nadir, as a mean value over azimuth cuts and satellites*
- Mean orbital radius for circular orbits and perigee for elliptical orbits*

On these last two points, specifically, the need for further study before reaching an agreement was emphasized

**Recommendation of Committee Action:**
*Prepare for discussions on adoption of common reference assumptions with the following priority actions:*
- *Common conventions for specified maximum received power*, as a step toward additional common conventions and assumptions*
- *Convention for link budgets to any point on the earth's surface, when used to define maximum received power*
- *Definition of transmit antenna gain model*

**The maximum received power is the largest of the received powers over all points on the earth's surface.*

4th Meeting of ICG, Saint-Petersburg, Russian Federation, 14 - 18 September 2009

**Attachment I**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **09/17/09**

**Issue Title:** **Updated Work Plan for Working Group A**

**Background/Brief Description of the Issue:**
The original ICG work plan from UN General Assembly Document A/AC.105/879 - 29 December 2006 - *Meeting of the International Committee on Global Navigation Satellite Systems, Vienna, 1 and 2 November 2006* assigned five actions to the Working Group on Compatibility and Interoperability (WG-A).

**Discussion/Analyses:**
One of the five original WG-A actions has been completed, two are being actively pursued, one remains critically important as an area of future work, and one is no longer considered essential to pursuing compatibility and interoperability among all GNSS.

The revised work plan for WG-A maintains a focus on compatibility and interoperability and adds additional areas of work consistent with the work plan of the Providers Forum.

**Recommendation of Committee Action:**
*The ICG should adopt the attached work plan for WG-A.*

**Appendix**

## Updated Work Plan of the International Committee on Global Navigation Satellite Systems Working Group -A

**WORKING GROUP A – Compatibility and Interoperability [Leads, the United States of America and the Russian Federation]**

Global and regional system providers agree that at a minimum, all GNSS signals must be compatible. To the maximum extent possible, open signals and services should also be interoperable, in order to maximize benefit to all GNSS users.

Since compatibility and interoperability are highly dependent on the establishment of standards for service provision and user equipment, the ICG and associated Providers Forum will consider guidelines and standards developed by existing standard-setting bodies applicable to GNSS service provision and use, such as the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the International Telecommunication Union (ITU) and potentially, the International Organization for Standardization (ISO).

In order to assist the Providers Forum in accomplishing its objectives, as described in the Terms of Reference, and in order to further the work of the committee focused on compatibility and interoperability, Working Group A, co-led by the United States of America and the Russian Federation, will pursue the activities described below.:

**Compatibility and Interoperability**
The principles of compatibility and interoperability and their definition were adopted at the first Providers Forum meeting held in Bangalore, India, September 2007. (United Nations Document A/AC.105/901). The Third Providers Forum meeting, held in Pasadena, CA, USA, December, 2008, updated these principles and their definition, as attached.

Considering the principle of compatibility and its definition, the working group will:

- In particular, review existing ITU regulations and recommendations related to the avoidance of harmful interference;
- Seek common understanding on appropriate methods to determine compatibility among all GNSS; and,
- If necessary, propose new questions or studies for ITU consideration, through appropriate mechanisms, to further protect the noise floor impacting all GNSS, and to define methodology used between GNSS providers to ensure compatibility.

Consistent with the principle of interoperability and its definition, the working group will consider the perspective of various user applications and equipment manufacturers, and will:

a) continue efforts to survey industry and user community experts and may require sponsoring and participating in workshops and meetings designed to solicit GNSS user input. It may also require elaboration of an approach for quantitative interoperability evaluation;

b) support measures to promote the interoperability of regional ground-based DGNSS in cooperation with Working Group D.

The Working Group will assist Providers in drafting individual reports on their respective planned or operating systems and the policies and procedures that govern their service provision, consistent with the Providers Forum template for information sharing.

a) The reports will be consolidated and maintained by the ICG Secretariat on behalf of the Providers, and updates will be provided at least annually in preparation for each major meeting of the ICG;

b) The reports will emphasize each Providers current and planned efforts to ensure compatibility and interoperability among the global, regional, and augmentation system components of the global system of navigation satellite systems.

**Open Service Information Sharing**

Consistent with the principle of transparency in the provision of open services, each individual Provider will strive to publish and disseminate all signal and system information necessary to allow manufacturers to design and develop GNSS receivers on a non-discriminatory basis. The Working Group will develop a template to promote common terminology and definitions in individual GNSS Open Service Signal Specifications.

The Working Group will also develop a template that each individual GNSS provider may consider using in their publication of signal and system information, the policies of provision, and the minimum levels of performance offered for open services.

As requested by a provider or providers, the working group will assist in exchanging information with ICG participants important to resolving GNSS open service anomalies that impact users.

**Service Performance Monitoring**

The Providers Forum has agreed to consider the development and discussion of proposals to widely monitor the performance of their open signals and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability.

Working Group A will support this activity by focusing on potential cooperation in the development of the necessary ground infrastructure to monitor signal and service performance for open services, recognizing that the actual implementation of this infrastructure is subject to the budgetary limitations of each system provider, and the completion of provider-to-provider agreements as necessary and appropriate.

**Spectrum Protection - Interference Detection, and Mitigation**

The Providers Forum has agreed to pursue the protection of radionavigation satellite service (RNSS) spectrum through appropriate domestic and international regulation. When necessary and appropriate, the Working Group will facilitate Provider discussions on their individual views and actions related to RNSS spectrum issues and agenda items under consideration by the ITU and its Working Parties.

The Working Group will develop a strategy for ICG support of mechanisms to detect and mitigate sources of electromagnetic interference, taking existing regulatory mechanisms into consideration. This could lead to concrete proposals for detecting interference.

This work plan will be reviewed on an annual basis and revised as necessary in order to address important issues that require the attention and focus of the system providers.

**Attachment II**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **09/17/09**

**Issue Title:** **User Community Input on GNSS Interoperability**

**Background/Brief Description of the Issue:**
At ICG-3, the following WG-A recommendation was adopted:

WG-A should convene at least two interim meetings with system providers and industry before ICG-4 to:

- continue collecting user/manufacturer perspectives on interoperability;
- evaluate various levels, concepts, and dimensions of interoperability as described by the presenters to the working group at ICG-3.

**Discussion/Analyses:**
2 meetings were held this year, one in Munich and one in Vienna.

Munich:

- Provided industry and user representatives an opportunity to express their view on the interoperability issue and provide feedback to the working group based on a review of presentations and final documents from ICG-3;
- 35+ participants from system providers, industry, and the user community;
- Perspectives on interoperability presented from the following sectors: mobile phones; timing and high precision for professional and scientific applications; transportation;
- Presentations and discussions resulted in a Summary Record that will inform the working group report to the ICG on interoperability;
- To be combined with additional inputs and the results of the interoperability Questionnaires.

Vienna:

- 25 participants from system providers and industry/user community;
- Working Group received system updates from providers and presentations on GNSS Applications;
- Available results of interoperability questionnaires were discussed;
- Revisions to questionnaire discussed and approved;
- Co-chairs discussed preparation of a WG-A report to ICG-4 to include recommendations and an updated work plan closely aligned with the Providers Forum work plan.

**Recommendation of Committee Action:**
*WG-A recommends the ICG endorse its efforts to continue the process of surveying industry and user community experts regarding GNSS interoperability through a revised questionnaire (Attached) and additional workshops. WG-A will:*

- *Re-engage with respondents to questionnaire and ask for revised answers to updated questions;*
- *Continue to disseminate updated questionnaires;*
- *First proposed post-ICG-4 meeting is an Interoperability workshop to be held in conjunction with IGNSS 2009, Queensland, Australia, December 2009. At a minimum, the agenda will include:*
    - *A discussion of the following specific signal and system characteristics important to interoperability:*
        - *Common/diverse carrier frequencies;*
        - *Common [power Spectral density][modulation][signal power spectra];*
        - *Common maximum power levels, based on the same link budget assumptions;*
        - *Common standards for geodesy and time references;*
    - *A joint discussion with Working Group D to consider the time and geodesy aspects of GNSS and the proposed definition of ground-based DGNSS interoperability*
    - *A discussion of the Multi-GNSS campaign proposed by the Government of Japan*

**Appendix**


**ICG WORKING GROUP ON COMPATIBILITY & INTEROPERABILITY**
**Global and Regional Navigation Satellite Systems and Satellite-based Augmentations**

**INDUSTRY AND USER COMMUNITY QUESTIONNAIRE**

NAME:_____

AFFILIATION:_____

APPLICATION SECTOR(S) YOU REPRESENT OR DESIGN/MANUFACTURE EQUIPMENT FOR:
_____

Dear Respondent:

The ICG working group on compatibility and interoperability invites you to provide us with answers to each item in this questionnaire to the best of your ability. The intent is to obtain worldwide input from industry, academic institutions, and other representatives of the GNSS user community with technical expertise regarding characteristics of GNSS signals which, from your perspective, aid or hinder the combined use of these signals in applications for which you are responsible or for which you supply equipment or services.

Before beginning the questionnaire, please refer to briefings which describe current and planned GNSS signals from GPS (U.S.), GLONASS (Russia), Galileo (Europe), Compass (China), QZSS (Japan), and IRNSS (India). These are available at the following web site:
http://www.unoosa.org/oosa/SAP/gnss/icg/pf/03/pres.html

The ICG Providers Forum, comprised of the six system providers mentioned above, has developed the following working definition of GNSS interoperability:

***Interoperability*** refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system

1. Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity.
2. Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured.
3. Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical.
4. Any additional solutions to improve interoperability are encouraged.

Please consider this definition in your answers or if your definition of GNSS interoperability is different from this one, please provide this definition below:

**QUESTIONS**

Some of the questions below ask you to grade certain signal characteristics as to their importance in overall interoperability considerations for a particular type of application. We understand there may be different answers for different products or applications, and there will be the opportunity for different answers for each type of product or application. Please feel free to explain your answers in as much detail as you would like, by typing in additional text in the blank rows below each bullet.

1. On a scale of one to five, with five being most important and one being least important, please score each performance characteristic below in terms of its importance as a potential benefit of using signals from two or more global and/or regional navigation satellite systems for your area of GNSS application.

| | |
|---|---|
| 1. Improved accuracy | 1 2 3 4 5 |
| | |
| 2. Improved availability | 1 2 3 4 5 |
| | |
| 3. Quicker time to first fix | 1 2 3 4 5 |
| | |
| 4. Better in-door signal tracking | 1 2 3 4 5 |
| | |
| 5. Greater protection against intentional or unintentional radio frequency interference, and/or spoofing | 1 2 3 4 5 |

2. Are there any other characteristics that should be considered a benefit of using two or more GNSS?

3. On a scale of minus five to plus five, with negative five representing the greatest performance detriment and positive five representing the greatest performance benefit, please quantify the detriment/benefit of each characteristic below on increasing the performance of multi-system receivers vs. single system receivers:

| | |
|---|---|
| 1. common carrier frequencies | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 2. uncommon carrier frequency bands (frequency diversity) | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |

| | |
|---|---|
| 3. Spectral separation within the same frequency band* * *Spectral separation refers to different modulations on the same center frequency such as a BPSK 1 and a BOC signal centered on 1575.42 MHz or two signals in the same band like 960-1215 MHz but on two different center frequencies, regardless of the services that the separated signals provide.* | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 4. Uncommon signal differentiation (CDMA vs. FDMA) | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 5. Common signal power spectra | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 6. Common signal modulation types | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 7. Common data message rate | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 8. Common message format | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 9. Common system performance metrics (equivalency of single system accuracy (URE), availability, etc.) | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 10. Coincident reference systems | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 11. Coincident system times | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |

4. When considering the use of multiple GNSS, with five being most important and one being not very important, please rank the importance of the following service related considerations:

| | |
|---|---|
| The provision of service assurances such as a commitment to maintain constellation performance | 1 2 3 4 5 |
| | |
| Publication of a service performance standard or specification | 1 2 3 4 5 |
| | |
| The issuance of notices when service may degrade due to maintenance or outage | 1 2 3 4 5 |
| | |

5. On a scale of minus five to plus five, with negative five representing the greatest detrimental impact and positive five representing the greatest beneficial impact, please quantify the impact of each characteristic below on the cost, power consumption, and size/weight of multi-system receivers vs. single system receivers:

| | |
|---|---|
| 13. Common carrier frequencies | |
| 14. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 15. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 16. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 17. Uncommon carrier frequency bands (frequency diversity) | |
| 18. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 19. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 20. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 21. Spectral separation within the same frequency band*<br>** Spectral separation refers to different modulations on the same center frequency such as a BPSK 1 and a BOC signal centered on 1575.42 MHz or two signals in the same band like 960-1215 MHz but on two different center frequencies, regardless of the services that the separated signals provide.* | |
| 22. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 23. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 24. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 25. Uncommon signal differentiation (CDMA vs. FDMA) | |
| 26. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 27. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 28. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 29. Common signal power spectra (Power Spectral Density) | |
| 30. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 31. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 32. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |

| | |
|---|---|
| 33. Common signal modulation types | |
| 34. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 35. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 36. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 37. Common data message rate | |
| 38. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 39. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 40. Size/Weight | -1 -2 -3 -4 -5 0<br>1 2 3 4 5 |
| | |
| 41. Common message format | |
| 42. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 43. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 44. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 45. Common system performance metrics (equivalency of single system accuracy, availability, etc.) | |
| 46. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 47. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 48. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 49. Coincident reference systems | |
| 50. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 51. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 52. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |
| 53. Coincident system times | |
| 54. Cost | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 55. Power consumption | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| 56. Size/Weight | -1 -2 -3 -4 -5<br>0 1 2 3 4 5 |
| | |

6. Would each of these characteristics also impact the cost of associated differential systems, and or the cost of data processing?

7. Are there any other criteria that should be considered a potential cost of using signals from more than one GNSS?

8. Are there any other signal parameters that should be considered?

9. On a scale of minus five to plus five, with negative five representing the greatest detrimental impact and positive five representing the greatest beneficial impact, evaluate the impact that small carrier frequency shifts (up to 200 - 250 KHz for signals in common frequency bands) for signals from an additional GNSS would have on the complexity of a multi-system receiver, and quality of signal processing and performance.

| | | | | | |
|---|---|---|---|---|---|
| | -1 | -2 | -3 | -4 | -5 |
| 0 | 1. | 2. | 3. | 4. | 5. |

10. Is there a limit to how many satellites-in-view from multiple GNSS constellations your application can use, beyond which there is no benefit or even a detriment to your areas of GNSS application?

11. On a scale of one to five, with five being most important and one being least important, please evaluate whether collaboration between system providers and integration of one or more GNSS at the space segment or ground control segment level would be beneficial to user-level interoperability.

| | | | | | |
|---|---|---|---|---|---|
| 0 | 1. | 2. | 3. | 4. | 5. |

**Annex**

## Providers Forum Working Principles of Compatibility and Interoperability and their Further Definition

Global and regional system providers agreed that at a minimum, all GNSS signals and services must be compatible. To the maximum extent possible, open signals and services should also be interoperable, in order to maximize benefit to all GNSS users. For many applications, common carrier frequencies are essential to interoperability, and commonality of other signal characteristics is desirable. In some cases, carrier frequency diversity may be preferable to improve performance. The Providers Forum will continue to investigate the benefits of carrier frequency commonality and diversity, as well as compatibility and interoperability, as these latter terms are defined below.

***Interoperability*** refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system:

1. Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity.

2. Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured.

3. Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical.

4. Any additional solutions to improve interoperability are encouraged.

***Compatibility*** refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service:

5. The International Telecommunication Union (ITU) provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals.

6. Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among providers concerned will establish the framework for determining a mutually-acceptable solution.

7. Any additional solutions to improve compatibility should be encouraged.

**Attachment III**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **09/17/09**

**Issue Title:** **Multi-GNSS Demonstration Campaign**

**Background/Brief Description of the Issue:**
During WG-A, Satoshi Korgure, JAXA, presented a preliminary concept for a multi-GNSS demonstration campaign

- It is expected to contribute to the ICG activity defining interoperability among GNSS systems.
- The presentation explained that Japan invites:
  Other GNSS providers to participate and contribute in the campaign;
  Collaboration with IGS and related organizations; and
  WG-A Participation in the campaign

**Discussion/Analyses:**
Working Group A agreed that the proposed campaign would be beneficial to ICG efforts focused on promotion of interoperability among multiple GNSS.

**Recommendation of Committee Action:**
*WG-A recommends that the ICG endorse the implementation of the proposed multi-GNSS demonstration campaign and encourages participation by all Providers.*

**Attachment IV**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **09/17/09**

**Issue Title:** **Planned WG-A Meetings prior to ICG-5**

**Background/Brief Description of the Issue:**
Consistent with the revised work plan of WG-A, the group will convene at least two meetings and/or workshops prior to ICG-5.

**Discussion/Analyses:**
The first proposed meeting would occur on the margins of the iGNSS 2009 Symposium, Queensland, Australia, 30 November – 3 December 2009, as described in WG-A recommendation 2.

The second Working Group A meeting would involve system providers and would be focused on the subject of compatibility among GNSS consistent with the revised work plan. As required, the Providers will also review and discuss the ICG Providers Forum principle and definition of compatibility.

**Recommendation of Committee Action:**
*WG-A recommends that the Committee endorse its proposal to hold at least two meetings in preparation for ICG-5 as described above.*

**Attachment V**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **09/17/09**

**Issue Title:** **Principle of Transparency for Open Services**

**Background/Brief Description of the Issue:**
The United States proposed a new ICG Principle of Transparency in the provision of GNSS open services for addition to the ICG Terms of Reference.

**Discussion/Analyses:**
The working group reached consensus on adding this new principle to the summary report of ICG-4, rather than the terms of reference.

**Recommendation of Committee Action:**
*WG-A recommends that the following language be included in the Report of the Fourth Meeting of the ICG:*

*The ICG adopted the Principle of Transparency, that every GNSS provider should publish documentation that describes the signal and system information, the policies of provision and the minimum levels of performance offered for its open services.*

3rd Meeting of ICG, Pasadena, USA, 8 - 12 December 2008

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **12/11/08**

**Issue Title:** **Interim Meetings/workshops focused on Interoperability**

**Background/Brief Description of the Issue:**
New Action 4 (ICG-2). The Russian Federation, the United States, India, and FIG to form a subgroup to develop an agenda for an exchange of views on interoperability between system providers and representatives for various user applications, to include industry -- Session may occur during regional GNSS workshops being planned by the ICG Secretariat (UN OOSA).

Status: An Agenda was developed for the ICG Experts Meeting in Montreal and presenters discussed interoperability in detail from the perspective of industry. Further meetings should be organized and conducted.

**Discussion/Analyses:**
At ICG-3, Working Group A received additional inputs from presenters regarding various views on interoperability. In support of Action 4, and in light of the discussions at ICG-3, further viewpoints from users and manufacturers with expertise in all areas of GNSS applications should be presented to the working group in cooperation with the Providers Forum prior to ICG-4.

**Recommendation of Committee Action:**
*WG-A should convene at least two interim meetings with system providers and industry before ICG-4 to continue collecting user/manufacturer perspectives on interoperability, including evaluation of various levels, concepts, and dimensions of interoperability.*

*The Working Group Co-chairs propose conducting the first interim WG-A meeting/workshop on March 2-3, 2009 in Munich, Germany, immediately preceding the Munich Satellite Navigation Summit scheduled for March 3-5, 2009.*

**Recommendation for Committee Decision**

**Prepared by:** **Working Group A**

**Date of Submission:** **12/11/08**

**Issue Title:** **Providers Working Principles of Compatibility and Interoperability**

**Background/Brief Description of the Issue:**
Wording changes proposed by various members of WG-A both at ICG-2, in Bangalore, and this meeting were discussed at length, leading to changes to the Principles of Compatibility and Interoperability and their definition included in the Conclusions of the First Providers Forum Meeting (A/AC.105/901).

**Discussion/Analyses:**
Working Group A recommends that the consensus language for the Principles be included in the Providers Forum work plan as working text subject to future modification.

**Recommendation of Committee Action:**
*Global and regional system providers agreed that at a minimum, all GNSS signals and services must be compatible. To the maximum extent possible, open signals and services should also be interoperable, in order to maximize benefit to all GNSS users. For many applications, common carrier frequencies are essential to interoperability, and commonality of other signal characteristics is desirable. In some cases, carrier frequency diversity may be preferable to improve performance. The Providers Forum will continue to investigate the benefits of carrier frequency commonality and diversity, as well as compatibility and interoperability, as these latter terms are defined below.*

***Interoperability*** *refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system.*

(i) *Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity;*

(ii) *Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured;*

(iii) *Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical;*

(iv) *Any additional solutions to improve interoperability are encouraged.*

***Compatibility*** *refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service.*

(i) *The International Telecommunication Union (ITU) provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of*

*detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals;*

(ii) *Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among providers concerned will establish the framework for determining a mutually-acceptable solution;*

(iii) *Any additional solutions to improve compatibility should be encouraged.*

2nd Meeting of ICG, Bangalore, India, 5 - 7 September 2007

**Appendix II**

**Proposed Recommendation**

The International Committee on Global Navigation Satellite Systems (ICG),

*Considering*

- the international value of having many GNSS operational with a composite contribution of several tens of satellites;

- the desirability of using all systems interchangeably;

- the use by GPS of references very close to UTC and International Terrestrial Reference Frame (ITRF);

- the GLONASS efforts to approach UTC and ITRF;

- the Galileo design referring to UTC and ITRF;

- that other important satellite navigation systems (Compass, IRNSS, QZSS, various SBAS) are now being designed and developed.

*Recommends*

- *that the reference times (modulo 1 s) of satellite navigation systems be synchronized as closely as possible to UTC;*

- *that the reference frames for these systems be in conformity with the ITRF;*

- *that these systems broadcast, in addition to their own System Time (ST):*

  - *the time difference between ST and a real-time realization of UTC;*
  - *a prediction of the time differences between ST and UTC.*

## WORKING GROUP B: ENHANCEMENT OF GNSS PERFORMANCE, NEW SERVICES AND CAPABILITIES

**Recommendation 1 for Committee Decision**

| | |
|---|---|
| **Prepared by**: | **Working Group B (WG-B), Space Use Subgroup (SUSG) (Working Group, or individual Members or Associate Members)** |
| **Date of Submission:** | **October 10, 2024** |
| **Issue Title:** | **New Working Group Establishment: Working Group L (Lunar Positioning, Navigation, and Timing (PNT)) (WG-L)** |

**Background/Brief Description of the Issue:**

The International Committee on Global Navigation Satellite Systems (ICG) Working Group B Space Use Subgroup Work Plan 4 (WP-4) was formed in 2021 to understand how the GNSS Space Service Volume could be used in concert with future Lunar PNT systems to support lunar operations. Since that time, through active execution of its work plan, WP-4 has gained significant insight into the scope, breadth, and depth of such PNT systems and use cases that are under development, as well as the meaningful role Global Navigation Satellite Systems (GNSS) will serve in lunar PNT, particularly for vehicles in transit between the Earth and Moon. After the successful organization of multiple ICG joint working group sessions on lunar PNT, WG-B recognizes the need for ongoing coordination within the ICG in a dedicated centralized working group.

**Discussion/Analyses:**

Dedicated PNT systems in lunar orbit, on the lunar surface, and elsewhere in cislunar space are under active development by organizations from multiple nations with planned deployment before the end of this decade. Such systems (referred to as lunar PNT systems) may provide services to users in cislunar space, including in lunar orbit, on the lunar surface, orbiting the Earth-Moon Lagrange points, and in transit between the Earth and Moon.

Lessons learned from GNSS coordination within the ICG clearly show the vital need for compatibility, interoperability and signal availability among PNT systems and services. To support this coordination among lunar PNT systems and with GNSS, and to allow continued focus of existing ICG working groups on their existing work plans, it is recommended that a new ICG Working Group be established, which will have the autonomy to propose changes to its name, scope, and work plan, as necessary, in line with the ICG Terms of Reference. This recommendation represents a specific action from the more general recommendation approved at the 16$^{th}$ Annual Meeting of the ICG (ICG-16) (ICG/REC/2022) entitled “Coordination of GNSS and Lunar PNT systems for lunar operations.”

**Recommendation of Committee Action:**

*WG-B recommends that the ICG establishes Working GroupL (Lunar PNT) as a new working group within the ICG at the earliest date with the attached initial workplan for WG-L reference.*

**Recommendation 2 for Committee Decision**

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|---|---|
| **Prepared by**: | **Working Group B, Space Use Subgroup (SUSG)**<br>**(Working Group, or individual Members or Associate Members)** |
| **Date of Submission:** | **October 10, 2024** |
| **Issue Title:** | **Participation in the Joint International Committee on Global Navigation Satellite Systems (ICG) - Interagency Operations Advisory Group (IOAG) Multilateral Cislunar Positioning, Navigation, and Timing (PNT) Workshop** |

**Background/Brief Description of the Issue:**

At the 17th Annual Meeting of the ICG (ICG-17) in 2023, a recommendation on the organization of a joint ICG-IOAG Multilateral Cislunar PNT workshop to be performed in the late 2024/early 2025 timeframe was adopted.
Since that time, a joint ICG-IOAG organization committee has been established and is proceeding in preparations for this workshop, including objective, scope, date, venue, and agenda. The workshop is planned to be held at the Vienna International Centre (VIC) on 11 –13 February 2025. The workshop will be primarily in-person, with a webinar option with moderated questions. A website with details is available at:
https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/b/CislunarPNT2025.html.

The goal of the workshop is to provide an open international coordination forum for lunar PNT service providers, including Global Navigation Satellite Systems (GNSS) providers, to foster interoperable, compatible, and available lunar PNT systems of the future.

The objectives are to:

1. Outline the scope, depth, use cases, and status of lunar PNT systems being developed.
2. Identify lessons learned from the GNSS community that are applicable to lunar PNT service providers and users.
3. Foster advancement in interoperability, compatibility, and availability between lunar PNT systems, including GNSS.
4. Propose recommendations that may be taken up by the lunar PNT community.

This inaugural Joint ICG-IOAG Multilateral Cislunar PNT Workshop seeks to provide an open international coordination forum to foster interoperable, compatible, and available lunar PNT systems of the future. Its focus is on the lunar PNT systems and services planned and under development, spectrum compatibility, lunar reference systems and time systems, aspects and models for international governance, lessons learned from the Earth-based GNSS community, and driving needs from the user segment.

Therefore, the participants from the GNSS community are highly encouraged to attend in order to promote compatibility, interoperability, and availability for lunar PNT systems.

**Discussion/Analyses:**

Numerous lunar PNT systems are currently under development, with initial operational capabilities (IOCs) as early as the late 2020s. This includes China's Queqiao, Europe's Moonlight Lunar Communications and Navigation Services (LCNS), Japan's Lunar Navigation Satellite System (LNSS), and the United States' Lunar Communications Relay and Navigation Systems (LCRNS). Additionally, India, Italy, and the Republic of Korea have announced contributions to lunar PNT services.

This workshop is timely as Lunar PNT systems are quickly emerging and coordination on the topics of spectrum, signals, lunar time standards and lunar reference frames is critical to ensure compatibility, interoperability and signal availability for both Lunar PNT and GNSS. This workshop intends to provide an international coordination forum for all lunar PNT systems and services.

**Recommendation of Committee Action:**

*The ICG encourages the participation of the GNSS community in the Joint ICG-IOAG Multilateral Cislunar PNT Workshop to be held at the Vienna International Centre on 11–13 February 2025. Lessons learned from the GNSS community will be needed to ensure compatibility and interoperability between GNSS and Lunar PNT systems and services. Coordination on the topics of lunar spectrum management, common lunar reference frames, and lunar time systems are essential and participation from the ICG Working Groups S and D for these aspects is highly recommended. This recommendation follows the recommendation approved at the ICG-17 (ICG/REC/2023) entitled "Joint ICG-IOAG organization of multilateral workshop on cislunar PNT."*

**Recommendation 3 for Committee Decision**

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|---|---|
| **Prepared by**: | **Working Group B**<br>**(Working Group, or individual Members or Associate Members)** |
| **Date of Submission:** | **10 October 2024** |
| **Issue Title:** | **The workshop on ionospheric impacts on Global Navigation Satellite Systems (GNSS) and international collaboration to meet current and future solar activity period challenges** |

**Background/Brief Description of the Issue:**

The ionosphere is one of the key factors affecting the performance of all navigation satellite systems. Currently, the 25$^{th}$ solar activity cycle is approaching its peak years around 2024-2025. During this period, the occurrence and intensity of ionospheric anomalies such as scintillation, disturbances, and storms will increase significantly. The influence of the ionosphere is the same for all navigation satellite systems and ionospheric anomalies have a significant global impact.

**Discussion/Analyses:**

During the 25th solar activity cycle, the ionosphere will significantly affect the performance of GNSS services, with an anticipated continuous increase in the coming years. Monitoring of the GNSS performance is a fundamental activity within the International Committee on GNSS (ICG). Given that the ionosphere exerts global impacts on different countries, collaborative efforts among worldwide countries are needed to monitor the global ionospheric impacts and potentially provide alerts. However, the progress about an interoperable and compatible way for maintaining and improving the performance of GNSS standard and precise positioning during current and future solar activity peak period are limited.

It is necessary to hold a dedicated workshop as the starting point of the sharing of knowledge and strategies as well as the international cooperation on the mitigation of ionospheric impacts across the globe. New monitoring and alert services on the ionospheric impacts on GNSS are expected to mitigate the effects of ionosphere during the period of high solar activity.

**Recommendation of Committee Action:**

*ICG encourages international GNSS and ionospheric space weather communities including ICG members to work together by conducting a workshop aimed at discussing the ionospheric impacts on GNSS and joint actions to be undertaken to mitigate the ionospheric impacts on GNSS during current and future solar activity period through international collaborations.*

**Recommendation for Committee Decision**

**Prepared by**: **Working Group B, Space Use Subgroup (SUSG)**

**Date of Submission:** **September 15, 2023**

**Issue Title:** **Joint ICG-IOAG organization of multilateral workshop on cislunar PNT**

**Background/Brief Description of the Issue:**
China, Europe, India, Japan and the USA plan to deploy cislunar infrastructure to provide realtime Positioning, Navigation and Timing (PNT) services for missions on the lunar surface, in lunar orbits, and within the Earth-Moon L2 Lagrange point. According to tentative timelines outlined in presentations and papers, initial operational capabilities (IOCs) of some of these PNT services are being planned for around 2028. With these initial system developments underway, it is critically important for these systems to be interoperable, compatible and available to maximize their utility for lunar space users.

LunaNet represents an international framework for the standardization of lunar PNT, communications and other services. The LunaNet framework is being documented in a standardization document called the LunaNet Interoperability Specification (LNIS).

At the recent Interagency Operations Advisory Group (IOAG) IOP-5 meeting, held June 20th-22nd, 2023, the IOP adopted a plan for the IOAG and ICG to jointly organize a multilateral forum for the coordination of cislunar PNT systems. The next step is for the ICG to adopt this multilateral coordination plan via this recommendation.

**Discussion/Analyses:**
Some elements of various lunar PNT systems architectures have been discussed in the following international coordination groups: the ICG, the IOAG, CCSDS, the International Space Exploration Coordination Group (ISECG) and the Space Frequency Coordination Group (SFCG). But a full understanding of cislunar PNT development plans, specifications, planned reference frames and timing architectures, across international space agencies and commercial entities, is currently not known. To maximize interoperability, compatibility and availability of lunar PNT signals, a multilateral communication of cislunar PNT plans and developments—early and often—is crucial. Leveraging the outstanding GNSS coordination performed by the ICG, a similar international effort, through workshops and international delegates meetings, should be performed for Lunar PNT. This multilateral cislunar PNT coordination should be co-led by the ICG and the IOAG. To kickoff this coordination effort, a proposed ICG-IOAG multilateral workshop, called the multilateral cislunar PNT workshop, should be held in the late 2024/early 2025 timeframe. This workshop aims to encourage multinational participation, not only from LunaNet service providers, but also from other countries working on their respective lunar PNT systems. Therefore, this workshop will provide the first-ever multilateral discussion and coordination venue on lunar PNT domains.

**Recommendation of Committee Action:**
*The ICG encourages the organization of a joint ICG-IOAG multilateral cislunar PNT workshop to be performed in the late 2024/early 2025 timeframe. The workshop shall: (1) serve as a mechanism to better understand the scope and depth of lunar PNT systems being developed, (2) propose recommendations that may be taken up by lunar PNT developers, and (3) facilitate refinement of interoperable, compatible, and available lunar PNT systems of the future. The workshop co-leaders*

*shall also seek the collaboration of other international bodies such as the ISECG, CCSDS, and SFCG to strengthen the international coordination and standardization of lunar PNT systems. This recommendation represents a specific action from the more general recommendation approved at ICG-16 (ICG/REC/2022), entitled "Coordination of GNSS and Lunar PNT systems for lunar operations."*

16th Meeting of ICG, Abu Dhabi, United Arab Emirates, 9 - 14 October 2022

**Recommendation for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group B, Space Use Subgroup (SUSG)** |
| **Date of Submission:** | **September 15, 2022** |
| **Issue Title:** | **Coordination of GNSS and Lunar PNT systems for lunar operations** |

**Background/Brief Description of the Issue:**
Positioning, Navigation and Timing (PNT) capabilities are being developed now by various international space agencies and other providers to support operations near and on the surface of the moon. During Earth-Moon transit and for portions of lunar operations, lunar PNT will be coupled with Earth-based GNSS to provide on-board PNT solutions. To ensure that these Earth GNSS and lunar PNT systems will be compatible and interoperable with each other and to ensure adequate availability of PNT signals in the lunar environment, GNSS providers and lunar PNT architects need to work together, internationally, and coordinate their developments—emulating the interoperability success of the ICG and GNSS SSV as models.

**Discussion/Analyses:**
To date, twenty nations have signed the Artemis Accords to cooperate in the exploration and use of the Moon and beyond. Also, fourteen nations are coordinating their lunar activities as members of the International Space Exploration Coordination Group (ISECG). Internationally, nations that are GNSS providers are represented in one or both of the above international coordination efforts. Both international efforts agree that the primary, first deep space target for human exploration is the moon. The ISCEG has defined several lunar PNT technology needs that members of the ICG WG-B SUSG are actively tracking and working as part of Work Package 4.

Several space agencies are actively developing PNT services at the vicinity of the Moon including the lunar surface. Under the open LunaNet framework, NASA and ESA have published draft interoperability specification documents. NASA and ESA are developing the Lunar Communications Relay and Navigation Systems (LCRN-S) and Moonlight, respectively, to implement this framework. JAXA is formulating the Lunar Navigation Satellite System (LNSS). And China has announced plans to develop a Lunar Communications and PNT Constellation. Ensuring that all are interoperable, compatible, and available will be essential for successful lunar PNT operations in the future.

During Earth-Lunar transit and for portions of lunar operations, lunar PNT will be coupled with Earth-based GNSS to provide on-board PNT solutions. To ensure that these systems will be compatible and interoperable with each other and to ensure adequate availability of PNT signals, GNSS providers and lunar PNT architects must coordinate their developments. Currently, multilateral organizations, including the IOAG, are studying how they may support and foster this coordination. It is imperative that the ICG engages immediately in these initiatives via the appropriate multilateral liaison roles to ensure interoperability, compatibility, and availability of PNT systems that will be employed from the Earth to the moon.

**Recommendation of Committee Action:**
*The ICG encourages international GNSS providers and lunar PNT developers to work together via the appropriate multilateral fora, such as the IOAG, to ensure the future attainment of an interoperable, compatible, and available PNT system of systems that can support the world's ever-expanding human and robotic space operations around and on the surface of the moon. The collaborative efforts of the ICG, including the GNSS Space Service Volume initiative, should serve as a model for this promising*

*international exploration initiative. The ICG will analyse planned lunar PNT systems and their interactions with GNSS and propose recommendations that may be taken up by GNSS providers and lunar PNT developers.*

**Recommendation for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group B** |
| **Date of Submission:** | **October 12, 2022** |
| **Issue Title:** | **Inclusion and Coordination of Lunar Search and Rescue in Lunar PNT Architecture** |

**Background/Brief Description of the Issue:**
During Earth-Moon transit and for portions of lunar operations, lunar PNT assets and signals will be utilized for transmission of distress alerts and receipt acknowledgement to ensure protection of life on the lunar surface (Lunar Search and Rescue). To ensure that search and rescue is an integral part of PNT service architectures and is developed as an interoperable capability with multiple systems, the intent for integration of SAR should be discussed and documented appropriately among GNSS partners.

**Discussion/Analyses:**
Historically, interoperability among Earth-based search and rescue services has been a focus of both ICG and Cospas-Sarsat discussions of the medium Earth orbit SAR (MEOSAR) system. The MEOSAR system is comprised of several GNSS providers that utilize agreed-upon specifications to ensure interoperability. Currently, several space agencies are independently developing search and rescue capabilities at the vicinity of the Moon, including the lunar surface, as they develop PNT services. Ensuring that search and rescue as a service is included in discussions of interoperability, compatibility and availability will be essential to ensure search and rescue services are maintained consistently among providers intending to offer such services.

**Recommendation of Committee Action:**
*Considering the successful collaboration between international GNSS providers in providing interoperability within the MEOSAR system, and the importance of search and rescue around and on the surface of the moon, the ICG recommends that developers of lunar communication and navigation services consider the integration of search and rescue services, and that they be developed to be interoperable and easily accessible.*

15th Meeting of ICG, Vienna, Austria, 27 September - 1 October 2021

**Recommendation for Committee Decision**

**Prepared by**: **Space Users Subgroup**

**Date of Submission:** **11 December 2019**

**Issue Title:** **Release of GNSS Transmit Antenna Patterns including Side Lobes**

**Background/Brief Description of the Issue:**
The use of GNSS for spacecraft navigation has increased in general over the last decade. In fact, navigation employing GNSS observations for spacecraft in Low Earth Orbit is considered routine. However, the situation is quite different for space missions that intend to employ GNSS in the Space Service Volume (including MEO, GEO, HEO or missions to Moon and beyond). For these space missions, the reception of signals from GNSS transmit antenna side lobes is essential to improve availability and performance. This recommendation extends recommendation #3 from Working Group-B 'Additional Data for Space Service Volume', made on 10 November 2016, which addressed provision of antenna pattern data at least to the extent of the main lobe signal as outlined in the SSV Booklet.

**Discussion/Analyses:**
The joint use of interoperable GNSS signals, especially the signals in the side lobes, will enable and/or improve the on-board navigation of spacecraft in the Space Service Volume. In this context, the knowledge of the full antenna pattern (main lobe and side lobes) from the transmitting antennas of each of the GNSS satellites in the various constellations is essential for missions in MEO, GEO, HEO or to Moon and beyond, to allow mission analysis, mission design as well as for GNSS equipment (receiver and antennas) manufacturers and also for the spacecraft operators for the development of respective operations concepts.

**Recommendation of Committee Action:**

*WG-B recommends that GNSS Service Providers consider releasing the antenna gain patterns or equivalent representative modelling information (including both main lobe and side lobes for each frequency, for open services) for each of the transmit antennas of the GNSS satellites in the respective satellite constellations in order to enable and/or improve the use of GNSS in the SSV. In addition, for future satellite developments, WG-B recommends that GNSS Service Providers consider conducting antenna gain measurements, testing and/or characterization, including both main lobe and side lobes for each open service signal.*

**Recommendation for Committee Decision**

**Prepared by**: **WG-B GNSS SSV Taskforce**

**Date of Submission:** **8 November 2018**

**Issue Title:** **WG-B Space Applications Subgroup**

**Background/Brief Description of the Issue:**
WG-B has an extensive work plan, including many facets such as performance enhancements, ionospheric modeling, new service concepts and augmentations, and the SSV. The MultiGNSS SSV project, and other similar projects, benefit from a highly active and focused team, which otherwise may distract WG-B from its ability to focus on other activities within its work plan.

**Discussion/Analyses:**
The formation of a formal subgroup on Space Applications would allow for independent action by its voluntary membership and leadership. Its focus would be the Multi-GNSS SSV and other aspects specific to the space user community.

**Recommendation of Committee Action:**
*WG-B will create a Space Applications Subgroup, whose scope will include opportunities, issues, and challenges related to space applications of GNSS, as defined by the Subgroup terms of reference. For these purposes, the subgroup will interact with the space user community and the service providers. The terms of reference will be adopted by WG-B and the need for modification will be reviewed annually.*

**Recommendation for Committee Decision**

**Recommendation 1: Search and Rescue**

**Prepared by:** **Working Group B**

**Date of Submission:** **6 December 2017**

**Issue Title:** **Search and Rescue GNSS payload interoperability**

**Background/Brief Description of the Issue:**
The space segment component of the international Search and Rescue program is expanding. This requires continued communication between the GNSS providers to ensure interoperability.

**Discussion/Analyses:**
Information sharing has deepened to better understand the service providers' search and rescue concept of operations using GNSS payloads. Near-term intentions of the newest SAR space segment provider, BDS, was discussed.

**Recommendation of Committee Action:**
*Invite further discussions on the global interoperability of search and rescue payloads on board GNSS constellation spacecraft. This includes national and international coverage concepts as well as return link implementation progress.*

**Recommendation for Committee Decision**

**Recommendation 2:**

**GNSS SSV – Use of GNSS for exploration activities in cis-Lunar space and beyond**

| | |
|---|---|
| **Prepared by:** | **Werner Enderle, Stefan Wallner, Daniel Blonski (ESA), Joel Parker, Frank Bauer (NASA), Hui Yang, Xinuo Chang (CAST, China), Alexey Bolkunov (Roscosmos, Russia)** |
| **Date of Submission:** | **06/12/2017** |
| **Issue Title:** | **GNSS SSV – Use of GNSS for exploration activities in cis-Lunar space and beyond** |

**Background/Brief Description of the Issue:**
During the WG-B GNSS SSV Working Group activities associated with the generation of the GNSS SSV Booklet, it became clear that the use of GNSS signals in support of missions within and beyond cis-Lunar space is possible and could contribute to improved on-board navigation capabilities.

**Discussion/Analyses:**
It is essential to understand the user needs for missions to cis-Lunar space and beyond, and to perform detailed analyses of the GNSS SSV capabilities and potential augmentations related to the support of missions to cis-Lunar space and beyond.

**Recommendation of Committee Action:**
*WG-B will lead and Service providers, Space Agencies and Research Institutions are invited to contribute to investigations/developments related to use of the full potential of the GNSS SSV, also considering the support of exploration activities in cis-Lunar space and beyond.*

**Recommendation 1 for Committee Decision**

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| **Prepared by:** | **Working Group B** |
| **Date of Submission:** | **10 November 2016** |
| **Issue Title:** | **Support to Space Service Volume (SSV) in Future Generation of Satellites** |

**Background/Brief Description of the Issue:**
The importance of establishing an Interoperable GNSS Space Service Volume (SSV) is acknowledged by Space Agencies and Service Providers. Important progress has been made in establishing the interoperable GNSS SSV based on data that was released by the Service Providers.

**Discussion/Analyses:**
Service providers have been actively contributing to the completion of the SSV templates that include the support of the SSV of the different systems. Many GNSS provided data in the SSV template derived from measurement and characterization efforts conducted based on existing satellite designs.

**Recommendation of Committee Action:**
*Service Providers, supported by Space Agencies and Research Institutions, are encouraged to define the necessary steps and to implement them in order to support SSV in future generation of satellites. Service Providers and Space Agencies are invited to report back to WG-B on their progress on a regular basis.*

**Recommendation 2 for Committee Decision**

**Prepared by**: **Working Group B**

**Date of Submission:** **10 November 2016**

**Issue Title:** **GNSS Space User Database**

**Background/Brief Description of the Issue:**
The understanding of user needs is an essential element for any service implementation or service evolution. This in particular also applies to the case of the Space Service Volume as the user needs are highly depending on the specific space mission and the use case of the onboard GNSS receiver.

**Discussion/Analyses:**
The understanding of the user base is critical for the development of the Interoperable GNSS Space Service Volume. An exhaustive identification of space missions embarking a GNSS receiver is essential, in order to ensure a comprehensive view on the mission needs and the use cases of the GNSS receiver.

**Recommendation of Committee Action:**
*Service providers, supported by Space Agencies and Research Institutions, are encouraged to contribute to the existing IOAG database of GNSS space users. Contributions should be reported to WG-B, which should then contribute to the IOAG via the ICG-IOAG liaison.*

*The data included in the database should include the following:*

*Basic details:*
- *Mission name & agency*
- *Actual or planned launch date*
- *Development phase (planned, in development, on-orbit, historical)*
- *Orbit regime (LEO, HEO, GEO, cis-lunar, etc.)*

*GNSS usage:*
- *GNSS constellations used*
- *GNSS signals used*
- *GNSS application (navigation, POD, time, radio occultation, etc.)*
- *Acquisition methods used (traditional, carrier phase)*
- *Solution method (point solution, filtered solution, etc.)*

**Recommendation 3 for Committee Decision**

**Prepared by**: **Working Group B**

**Date of Submission:** **10 November 2016**

**Issue Title:** **Additional Data for Space Service Volume**

**Background/Brief Description of the Issue:**
In order to exploit the Interoperable GNSS Space Service volume for space missions or to develop GNSS space receivers, information from the service providers regarding the power emissions for wide off-boresight angles are essential. Initial information on this aspect is available from every service provider.

**Discussion/Analyses:**
Recognizing the success of WG-B in encouraging all providers to provide SSV service details in templates for their constellations, GNSS space users now have the data necessary to determine if the SSV service is applicable to their needs.

**Recommendation of Committee Action:**
*In order to fully support in-depth mission-specific navigation studies, WG-B invites the providers to consider for the future, to provide the following additional data if available:*

- *GNSS transmit antenna gain patterns for each frequency, measured by antenna panel elevation angle at multiple azimuth cuts, at least to the extent provided in each constellation's SSV template.*

*In the long term, also consider providing the following additional data (see also WG-D Recommendations):*

- *GNSS transmit antenna phase center and group delay patterns for each frequency.*

10th Meeting of ICG, Boulder, Colorado, United States, 1 - 6 November 2015

**Recommendation 1 for Committee Decision**

**Prepared by**: **Working Group B: Enhancement of Performance of GNSS Services**

**Date of Submission:** **04/11/2015**

**Issue Title:** **Working Group-B Workplan Update**

**Background/Brief Description of the Issue:**
The Workplan of Working Group-B was endorsed at ICG-6 in 2011. Since then, important new areas of work were followed up by Working Group-B.

**Discussion/Analyses:**
Working Group-B reviewed its existing workplan taking into consideration the actual work conducted by the group and areas of interest to ICG. Based on this the group recommends an update of the workplan, that also allows to streamline the work and monitor its progress.

**Recommendation of Committee Action:**
*Working Group-B recommends ICG to endorse its updated workplan, which centers around the following tasks:*

1. *Examine the problem of user position integrity and possible novel solutions to it.*
2. *Monitor techniques considered by application developers and external service providers for enhancement of GNSS performance.*
3. *Follow up the implementation of an interoperable GNSS Space Service Volume (SSV) and its evolution.*
4. *Examine the performance of atmospheric models to correct single frequency measurements.*
5. *Establish a dialogue with Space Weather/Remote Sensing community.*

*All tasks shall eventually lead to the identification of recommendations for GNSS Service Providers, in order to enhance the GNSS performance for users, enable new services and capabilities. In addition, the results of Working Group-B shall provide guidance to the GNSS user community to better exploit GNSS services and capabilities.*

*WG-B recommends to update its title to "Working Group on Enhancement of GNSS Performance, New Services and Capabilities" to better reflect its objective and scope of work.*

*While tasks 1, 2 and 4 are maintained from the Working Group-B workplan endorsed in 2011, the tasks 3 and 5 are new elements. As such Working Group-B enlarges its scope.*

**REVISED WORK PLAN**
**WORKING GROUP - Enhancement of GNSS Performance, New Services and Capabilities**

As a unique combination of GNSS service providers and major user groups, the Working Group (WG) of the International Committee on Global Navigation Satellite Systems (ICG) will work to promote and coordinate activities aimed at enhancing Global Navigation Satellite Systems (GNSS) performance, recommending system enhancements that shall eventually lead to New Services and Capabilities at System Level to better serve the different GNSS user communities. Specifically, the following actions will be taken by the Working Group:

**Task 1:** Examine the problem of user position integrity and possible novel solutions to it. Recommend any required system enhancements or actions that contribute or are required for the implementation of novel integrity solutions to Service Providers.

**Task 2:** Monitor on a regular basis the techniques considered by application developers and external service providers for enhancement of GNSS performance in order to recommend any required system enhancements or actions that may support the realization of such techniques to Service Providers.

**Task 3:** Follow up the implementation of an interoperable GNSS Space Service Volume and provide recommendations to Service Providers regarding possible evolution needs arising from users/application developers.

**Task 4:** Examine the performance of atmospheric models to correct single frequency measurements and recommend models for implementation to Service Providers.

**Task 5:** Establish a dialogue with Space Weather/Remote Sensing community in order to identify how GNSS can better support the advancement of Space Weather/Remote Sensing products and vice versa.

In the execution of its tasks, WG-B shall also provide guidance to the GNSS user community to better exploit GNSS services and capabilities.

In addition to its annual Working Group session, at least one interim Working Group session (preferably in conjunction with an ICG Providers' Forum Meeting) will be called for, in order to ensure progress on the different Working Group tasks. Additional interim Working Group sessions may be organized as needed.

The work in relation to Task 2 on the regular monitoring of application developer techniques and related needs is supported by the "Working Group Application Subgroup". The "Working Group Application Subgroup" objectives, tasks and procedures of work are specified in its Terms of Reference.

In the execution of its work, Working Group will coordinate its activities with all other Working Groups of the ICG.

**Recommendation 2 for Committee Decision**

**Prepared by**: **Working Group B: Enhancement of Performance of GNSS Services**

**Date of Submission:** **04/11/2015**

**Issue Title:** **Additional Co-Chair for Working Group**

**Background/Brief Description of the Issue:**
Working Group has important tasks to be carried out that are identified in the updated Workplan of the Group.

**Discussion/Analyses:**
A rising number of aspects shall be covered and addressed by Working Group. The implementation of endorsed ICG Working Group recommendations needs to be monitored. These aspects will lead to an increase of workload for the co-chairs and additional support is considered beneficial in order to ensure a smooth operation of Working Group.

**Recommendation of Committee Action:**
*Working Group recommends to introduce a Third Co-chair in order to ensure a timely and successful follow up of the updated Workplan. A Third Co-chair will also help to ensure to conduct the necessary interim meetings of Working Group. Given the good work of the Working Group Application Subgroup and the active role of China in this Application Subgroup, Working Group recommends to appoint China as a Third Co-Chair of Working Group.*

**Recommendation 3 for Committee Decision**

**Prepared by**: **Working Group B: Enhancement of Performance of GNSS Services**

**Date of Submission:** **04/11/2015**

**Issue Title:** **Utilization of GNSS satellites in Eccentric, Non-Nominal MEO Orbits**

**Background/Brief Description of the Issue:**
Following the launch anomaly in August 2014 of two Galileo satellites, actions were put in place to stabilize the orbit and the satellites. The satellites are now occupying an eccentric orbit, which differs from the nominal orbits of GNSS Medium Earth Orbit (MEO) satellites. The satellites are transmitting Ranging Signals with good quality.

**Discussion/Analyses:**
Satellites in eccentric, non-nominal MEO orbits offer particular opportunities, that can be exploited e.g. for scientific studies of relativity, fast ambiguity fixing for Precise Point Positioning (PPP) users and enhancement of the interoperable GNSS Space Service Volume (SSV).

**Recommendation of Committee Action:**
*ICG participants and scientific organizations are welcome to report to the Working Group on their experience utilizing satellites that are in eccentric, non-nominal MEO orbits in order to build a survey of these satellites for scientific research and Position, Velocity and Time (PVT) applications.*

9th Meeting of ICG, Prague, Czech Republic, 10 - 14 November 2014

**Recommendation for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **13 November 2014**

**Issue Title:** **Nequick Ionospheric Model**

**Background/Brief Description of the Issue:**
Ranging errors induced by ionospheric effects constitute one of the largest error source for a single frequency GNSS user. Ionospheric models are capable to estimate the ionospheric impact on the ranging measurement and compensate for it. Good ionospheric models are important to enhance the ranging accuracy for single frequency GNSS users.

**Discussion/Analyses:**
Results obtained applying the Nequick ionospheric model implemented in Galileo indicates good ionospheric error compensation capability. WG-B members showed interest in this model and encouraged to gain further insight regarding the implementation of the Galileo Nequick model at receiver level such as to allow for comparisons wrt. alternative ionospheric compensation models.

**Recommendation of Committee Action:**
- *To distribute to the Service Providers and Users the document providing the detailed description of the Nequick algorithm implemented in Galileo for the correction of the ionospheric error in single frequency users;*

- *For the Service Providers and interested users participating in the ICG, to assess the performance and usability of a Nequick ionospheric correction algorithm for the single frequency users similar to the one adopted by Galileo in view of its expected good performance compared with other models, i.e. at low latitudes.*

**Recommendation for Committee Decision**

**Prepared by:** **Working Group**

**Date of Submission:** **13 November 2014**

**Issue Title:** **Interoperable GNSS Space Service Volume (SSV) Characterization Outreach**

**Background/Brief Description of the Issue:**
WG-B has followed in the last period the Recommendation to establish an "Interoperable GNSS Space Service Volume". WG-B has addressed this topic at technical level at several Meetings and has identified the advantages of an Interoperable GNSS SSV for the Space User community. So far several GNSS service providers supported this initiative either providing already their SSV characterization or indicating their intention to do so in the near future.

**Discussion/Analyses:**
In order to communicate to the public domain the advantages of an interoperable GNSS SSV and the relevant support of every GNSS service provider, interested members of WG-B have agreed to elaborate a booklet identifying:

- The advantages of an interoperable GNSS SSV for space users.
- The support of every GNSS service provider to an interoperable GNSS SSV based on an agreed comprehensive template.
- An estimation of the capabilities of the identified interoperable GNSS SSV, given the individual SSV characteristics per service provider as input.

This booklet is considered of particular interest for GNSS space-receiver manufacturers. The booklet is meant to characterize the contribution of the different GNSS to an interoperable GNSS SSV for the benefit of the users, but shall not induce commitments as they are handled by the individual GNSS Providers in their respective Performance Commitment Documents.

The booklet shall be worked out by WG-B members representing GPS, GLONASS, BeiDou, Galileo, QZSS, IRNSS and they shall organize the necessary work to have a version for final commenting and approval within WG-B at ICG10 ready.

**Recommendation of Committee Action:**
*GNSS Providers are recommended to support the SSV outreach by making the booklet on "Interoperable GNSS Space Service Volume" available to the public through their relevant websites once the booklet is available.*

8th Meeting of ICG, Dubai, United Arab Emirates, 9 - 14 November 2013

**Recommendation 1 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **12 November 2013**

**Issue Title:** **Specifying and Characterizing an Interoperable GNSS Space Service Volume**

**Background/Brief Description of the Issue:**
WG-B has continued the efforts addressed in Recommendation 6 of ICG-6 entitled "Interoperable GNSS Space Service Volume". Since ICG-6, WG-B has made excellent progress in specifying the SSV and populating respective templates that will characterize the expected qualitative and quantitative characteristics of signals within an interoperable GNSS Space Service Volume. The SSV will open new science and technological opportunities through the use of robust, interoperable GNSS navigational signals in space, enabling missions that save lives, understand our Earth and the universe and provide economic advantages worldwide.

**Discussion/Analyses:**
WG-B has made significant progress in establishing an interoperable GNSS SSV during ICG-8 through significant pre-work, presentations at ICG-8 and additional robust contributions from the administrations of Russia and China. At ICG-8 several administrations presented their SSV signal templates and presented SSV performance expectations. During ICG-8, the WG-B team discussed the importance of common definitions and data needed from the GNSS constellations, in conjunction with the signal template data, to conduct consistent SSV performance analyses. We recommend that WG-B provide an additional template to develop these common definitions and data requirements and gather this data from the appropriate administrations.

**Recommendation of Committee Action:**
*Recognizing the advantages of an interoperable GNSS SSV for the space user community, the ICG is invited to take notice that the WG-B team has taken several actions to compile definitions to support future analyses and gather template data approved by the GNSS system providers. The SSV template data, coupled with the other requested data and definitions, will enable users to analyze GNSS signal availability and navigation performance expectations for space vehicles flying in the SSV.*

*Providers are invited to send all action responses to the WG-B Co-chairs and Interagency Operations Advisory Group (IOAG) ICG representative. Until recommendation on SSV template is approved by ICG, the members agreed to keep this information within ICG forum. WG-B action items include:*

- *SSV Template Completion*
  - *WG-B team works with the service providers to complete and formally submit the SSV templates to WG-B co-chairs prior to the 2nd interim WG meeting.*
  - *Questions and discussion regarding the template will be addressed during a video conference to be held prior to the 1st interim WG meeting.*
  - *WG-B team members shall be prepared to discuss their template inputs at the 1st interim WG meeting.*

- *Maturity of Definition*

  *– WG-B team to develop definitions of the minimal service capability of the GNSS constellations (i.e. satellite orbit, number of satellites and constellation geometry). This will be used in conjunction with template data to perform unified GNSS SSV performance analyses.*

- *Spaceborne GNSS Receivers*

  – *WG-B encourages the development of interoperable multi-frequency space borne GNSS receivers that exploit the use of GNSS signals in space.*

- *Antenna/Electronics Characterization*

*Stable performance of the GNSS space segment over long time periods is crucial for the scientific community. The scientific community recommends:*

– *Minimizing phase and group delay variations of GNSS transmit antennas vs. angle during the design phase.*

– *Measure phase and group delay variations of GNSS transmit antennas vs. angle, and making this information available to the scientific community.*

– *Measure phase center and group delay center for GNSS transmit antennas vs. angle, and making this information available to the scientific community.*

– *Spacecraft electronics: Maintain strict coherence of phase and group delay between signals on the same spacecraft.*

**Recommendation 2 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **13 November 2013**

**Issue Title:** **Harmonization of TTFF Methodology**

**Background/Brief Description of the Issue:**
The Time To First Fix (TTFF) is an essential GNSS signal performance Figure of Merit (FoM) fully transparent to the user. The TTFF is driven by a multiplicity of factors, including the GNSS signal and message structure, user receiver configuration and start condition of the user receiver. As a consequence an unambiguous definition of the TTFF is not commonly established.

**Discussion/Analyses:**
An unambiguous definition of the TTFF FoM is needed in order to assess the performance of the current GNSS and derive conclusions on required performance enhancements driven by the user communities. WG-B discussed on a potential methodology to formalize the TTFF determination, breaking it down into the start conditions cold start, long-off warm start, short-off warm start and hot start. The Working Group also identified the potential need of identifying specific requirements for some classes of receivers (one of them being space receivers). Also, any analytical methodology aiming to assess the impact of different signals and systems into a (multi-system) TTFF should concentrate on the contributions being mainly dependent on signal and system parameters and characteristics, taking reasonable (common) assumptions on technology driven factors (mainly receiver implementation).

**Recommendation of Committee Action:**
*WG-B encourages the service providers and relevant experts to review the proposed TTFF methodology and provide recommendations for its complementation. When consensus on the TTFF definition and the relevant starting conditions has been achieved, the result shall be introduced into the ICG Glossary of Terms.*

*WG-A and WG-B are invited to consider the above in their future activities.*

7th Meeting of ICG, Beijing, China, 5 - 9 November 2012

**Recommendation 1 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Statement of Interest in GNSS Space Service Volume**

**Background/Brief Description of the Issue:**
WG-B has followed in the last year Recommendation 6 of ICG6 entitled "Interoperable GNSS Space Service Volume". WG-B has addressed this topic at a technical level at its interim Meeting in June 2012 in Vienna and has identified the advantages of an Interoperable GNSS SSV for the Space user community.

**Discussion/Analyses:**
In order to progress further towards an interoperable GNSS Space Service volume the contribution of the different system providers is an essential element. Only with their direct involvement in a Space Service Volume definition process it is possible to achieve a harmonization of the qualitative and quantitative characteristics of such an interoperable GNSS Space service volume.

**Recommendation of Committee Action:**
*Recognizing the advantages of an Interoperable GNSS SSV for the Space user community, ICG is invited to take notice that WG-B encourages all system providers to identify their interest in contributing to a future interoperable GNSS space service volume. The qualitative and quantitative specification of such a future, interoperable GNSS space service volume is recommended to be coordinated through the on-going GNSS Space Service Volume initiative within ICG WG-B. This process will need the involvement of the system providers, in order to allow for a high level of interoperability in the Space Service Volume.*

*The committee recommends that a definition of an interoperable GNSS SSV be introduced into the ICG Glossary of Terms.*

**Recommendation 2 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Dual Frequency Multi Constellation RAIM for Maritime Integrity**

**Background/Brief Description of the Issue:**
The deployment of interoperable, dual frequency signals provided by multiple satellite navigation systems opens up new possibilities to provide users with new integrity solutions.

**Discussion/Analyses:**
Initial results presented to WG-B indicate that integrity for Maritime applications could be provided by Dual Frequency Multi Constellation (DFMC) Receiver Autonomous Integrity Monitoring (RAIM). DFMC RAIM might be a solution to provide Maritime integrity (down to coastal and port approach operations) without additional infrastructure investment at system provider side over wide areas, thus including polar regions that are expected to gain in importance in the Maritime Community as well as regions where so far there is no SBAS service available. In order to enhance the robustness of DFMC RAIM the fusion of the GNSS solution with other sensors (e.g. inertial and/or present e-Navigation means) can be considered.

**Recommendation of Committee Action:**
*ICG is invited to take notice that WG-B plans to involve an International Maritime Organization (IMO) representative, in order to propose the consideration of Multi-constellation Dual Frequency classical RAIM solutions to provide integrity to these users allowing for coastal and port approach maritime operations in regions where SBAS service is not provided. Fusion of the GNSS RAIM solution with backup sensors may be recommended to enhance the robustness of the positioning solution.*

**Recommendation 3 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Emergency Warning Service as New Message Broadcast**

**Background/Brief Description of the Issue:**
In relation to WG-B workplan item B6 and in view of WG-B recommendation 3 of ICG6, WG-B addressed in its interim meeting in Vienna possible new message broadcasts to enhance and/or extend the outreach of GNSS services. During that meeting the Emergency Warning Service (EWS) was identified as a most promising candidate that can be enabled through additional message broadcasts within satellite navigation signals.

**Discussion/Analyses:**
At present the definition of new navigation/augmentation signals is ongoing, e.g. the SBAS L5 signal. Potentially available spare data capacity of new signals could be made use of to implement additional services, where an Emergency Warning Service (EWS) and the dissemination of ARAIM related Integrity Support Message (ISM) has attracted the particular interest of ICG WG-B.

**Recommendation of Committee Action:**
*ICG is invited to take notice that WG-B plans to propose to SBAS IWG the consideration of an Emergency Warning Service (EWS) as new message broadcast within the new SBAS L5 signals currently under definition. As the ARAIM concept and the related ISM definition materializes, ISM dissemination through this signal may be also considered in the future and brought to the attention of SBAS IWG.*

**Recommendation 4 for Committee Decision**

**Prepared by:** **Working Group B Application Subgroup**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Application Subgroup meeting in the margin of the Munich Satellite Navigation Summit 2013**

**Background/Brief Description of the Issue:**
The WG-B Application Subgroup was established at ICG6 in order to support Action B4 of the Work Plan of WG-B. The group held its first meeting on "LBS and Mass Market Applications" on 12/13 March, 2012 in Munich, Germany. Several core application areas shall be monitored by this group in the future.

**Discussion/Analyses:**
Until ICG8 WG-B agreed that the WG-B Application Subgroup shall dedicate a particular focus on Personal Navigation and Transportation (road, rail, water) applications. The group will continue to investigate together with users representing the identified applications areas to which extent their application needs are already served today by the different satellite navigation systems and about the enabling techniques, in order to provide them with better service in the future.

**Recommendation of Committee Action:**
*In order to promote the global multi-GNSS applications in the area of Personal Navigation and Transportation (road, rail, water) and to understand on their additional demands, ICG participants are invited to identify appropriate users and/or institutions representing the before mentioned application sectors by end of Dec. 2012. The 2nd Application SG meeting focusing on Personal Navigation and Transportation applications will be held on Feb. 26, 2013 [tbc] in the margin of the Munich Satellite Navigation Summit.*

6th Meeting of ICG, Tokyo, Japan, 5 - 9 September 2011

**ATTACHMENT 2.1**

**WG-B Recommendation 1 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **07/09/2011**

**Issue Title:** **Integrity via ARAIM**

**Background/Brief Description of the Issue:**
Advanced Receiver Autonomous Integrity Monitoring (ARAIM) is attracting interest at various fora as it shows the capability to provide integrity for aviation users suitable to conduct precision approach procedures.

**Discussion/Analyses:**
By the end of this decade there will be multiple global and regional navigation satellite systems all providing dual frequency services allowing thus for the cancellation of the first order Ionospheric error and for an improved user geometry. This sets the basis to consider an extension of the classical, horizontal Receiver Autonomous Integrity Monitoring (RAIM) towards more demanding phases of flight, in particular precision approach procedures requiring vertical guidance. However, the Vertical Protection Levels (VPL) for these procedures are this demanding that new algorithms, assumptions and concepts need to be investigated which are labelled as Advanced RAIM (ARAIM).

**Recommendation of Committee Action:**
*ICG is invited to encourage global and regional satellite navigation service providers and stakeholders interested in integrity to*

- *Include regional systems in the concepts for ARAIM*
- *Clarify the use of augmentation systems for ARAIM*
- *Encourage the further work on broadcast parameters to enable multiconstellation ARAIM*
- *Address certification related issues for ARAIM*

**ATTACHMENT 2.2**

**WG-B Recommendation 2 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **07/09/2011**

**Issue Title:** **Satellite Navigation in Natural Disasters**

**Background/Brief Description of the Issue:**
The management of the consequences of natural disasters (earthquake, floods, storms, etc.) is a considerable challenge, in particular the provision of latest status information on the current situation to the affected citizens.

**Discussion/Analyses:**
In case of natural disasters ground based infrastructure used for information dissemination/communication may be destroyed or may suffer from significant overload making them unavailable. Due to the single way nature of the radio navigation satellite links these links show significant advantages over any ground-based infrastructure or satellite communication system. In particular, these links could allow the dissemination of relevant information precisely to those people affected by the disaster.

**Recommendation of Committee Action:**
*ICG is invited to further discuss the use of satellite navigation in natural disasters. ICG should consider that WG-B proposes to update its work plan addressing the work on Satellite Navigation in Natural Disasters in a dedicated action B6.*

**ATTACHMENT 2.3**

**WG-B Recommendation 3 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **07/09/2011**

**Issue Title:** **Workshop on New Message Broadcasts in New Signals**

**Background/Brief Description of the Issue:**
The definition of the international standard for satellite-based navigation signals/augmentation signals is currently ongoing, in particular the definition of the future SBAS L5 standard.

**Discussion/Analyses:**
Within the definition of new navigation/augmentation signals that are foreseen for international standardization enough spare capacity within the data message should be reserved allowing for future service enhancements.

**Recommendation of Committee Action:**
*ICG is invited to take not that WG-B is considering organizing a cross-working group workshop (system providers/users) including also non-ICG WGs (e.g. SBAS IWG) to identify opportunities for new message broadcasts using existing or planned spare capacity in new signals (e.g. SBAS L5/GLONASS CDMA, ...).*

**ATTACHMENT 2.4**

**WG-B Recommendation 4 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **07/09/2011**

**Issue Title:** **Establishment of a sub-group on 'Applications' in WG-B**

**Background/Brief Description of the Issue:**
Workgroup B covers many aspects of GNSS performance enhancement. Since more and more application-related issues are introduced and discussed in WG-B, there is a necessity to establish a sub-group on 'Applications' for better discussion.

**Discussion/Analyses:**
A sub-group on 'applications' may help both the system providers and the user communities to exchange views on the utilization of GNSS and help to identify potential shortcomings of the current systems, their signals and services. The identification of shortcomings shall foster the identification of potential ways to increase the performance for the future evolution of GNSS. This sub-group will create a convenient channel for user communities to present the status of current GNSS applications and state the requirements and feedbacks. Both users and system providers will benefit from this. The subgroup of WG-B is tasked to support the work identified under Action B4 of the Work Plan of WG-B.

**Recommendation of Committee Action:**
*ICG is invited to take note that WG-B considers the establishment of a WG-B sub-group oriented on 'Application '. This sub-group is tasked to support the work identified under Action B4 of the Work Plan of WG-B, and report its findings on a yearly basis to WG-B. For the first 2 years this sub-group shall be co-chaired by China and Japan.*

**ATTACHMENT 2.5**

**WG-B Recommendation 5 for Committee Decision**

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| **Prepared by:** | **Working Group B** |
| **Date of Submission:** | **07/09/2011** |
| **Issue Title:** | **Meeting of WG-B subgroup on "Applications" during Munich Satellite Navigation Summit** |

**Background/Brief Description of the Issue:**
The concept of having interim meetings on dedicated aspects within WG-B and other WGs of ICG has shown in the past to be very fruitful. The Munich Satellite Navigation Summit with its large number of participants offers the possibility to conduct an interim meeting of WG-B subgroup on Applications.

**Discussion/Analyses:**
An interim meeting shall be organized by the WG-B sub-group on Applications. The meeting shall include topics on LBS, mass market applications etc. It will provide a good opportunity for broad and thorough discussion, as a complement to the annual ICG meetings.

**Recommendation of Committee Action:**
*ICG is invited to take notice that the WG-B subgroup on Applications would like to convene a meeting in the margin of Munich Satellite Navigation Summit on 13 March 2012 (TBC) addressing user communities including at least LBS and mass market applications.*

**ATTACHMENT 2.6**

**WG-B Recommendation 6 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **08/09/2011**

**Issue Title:** **Interoperable GNSS Space Service Volume**

**Background/Brief Description of the Issue:**
The initial introduction of the GPS Space Service Volume (SSV) concept was presented by Dr. Larry Young/NASA/JPL at the ICG-5 as an information paper. The GPS SSV concept was further expanded on by James Miller/NASA at ICG-6 WG B on September 7, 2011.

**Discussion/Analyses:**
An ICG definition of the "space service volume" out to GEO (36,000km), with subsequent related Provider documentation of GNSS characteristics (in the form of ICDs, ISs, etc.,) available to that domain is needed to provide agreed upon levels of service for space application developers and SSV users of signals-in-space. ICG recognition of the SSV domain and identification of the required GNSS performance parameters to support GNSS applications in the SSV domain will facilitate Provider Administrations' documentation of SSV supporting GNSS system performance parameters.

The goal is to provide ICG stakeholders a more comprehensive "GNSS Service Volume" that would also include the Galileo, GLONASS, and Beidou/COMPASS constellations.

**Recommendation of Committee Action:**
*In order to address these issues it is recommended that WG B:*

- *Develop a ICG definition of the "space service volume" out to GEO (36,000km) with identified levels of service,*
- *Develop a template for documenting the Provider GNSS performance parameters necessary to support GNSS applications in the SSV domain, and*
- *Using the above template, survey the Providers and decide on further action as appropriate.*

**ATTACHMENT 2.7**

**WG-B Recommendation 7 for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **08/09/2011**

**Issue Title:** **Standardization for Maritime Applications**

**Background/Brief Description of the Issue:**
Today the standardization procedures for aviation applications and receivers are well established and understood by the GNSS community. For maritime applications and receivers the procedure to be followed is not this clear yet.

**Discussion/Analyses:**
Maritime users will benefit greatly from use of multi GNSS. Analysis should be performed to demonstrate benefits of multi-GNSS constellations to meet the needs of maritime user communities and encourage maritime users to plan for adoption of multi-GNSS use. The International Maritime Organization (IMO) is the organization developing requirements for maritime use of GNSS. Reference IMO documents include A.915(22), A.953(23), NAV 56/12.

**Recommendation of Committee Action:**
*ICG is invited to encourage WG-B to liaise with IMO on how maritime requirements could be achieved by multi-GNSS constellations and to foster the future standardization for maritime users. ICG may take note that WG-B considers to invite IMO for one of its future sessions.*

5th Meeting of ICG, Turin, Italy, 18 - 22 October 2010

**ATTACHMENT 2.1**

**WG-B Recommendation 1 Endorsed by Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **21/10/2010**

**Issue Title:** **WG-B Rec. 1: RFI Mitigation**

**Background/Brief Description of the Issue:**
Implementation of GBAS has detected the existence of "Privacy Jammers" that cause RFI causing the GBAS facility to cease operations.

**Discussion/Analyses:**
Although the "Privacy Jammer" devices are generally illegal to use, they are easy to obtain from sources over the internet.

**Recommendation of Committee Action:**
*ICG-member states are encouraged to take appropriate actions to address this issue including the introduction of barriers to the production and marketing of these devices.*

**ATTACHMENT 2.2**

**WG-B Recommendation 2 Endorsed by Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **21/10/2010**

**Issue Title:** **WG-B Rec. 2: Global Multi-Constellation monitoring network to support integrity**

**Background/Brief Description of the Issue:**
WG-B of ICG had a special meeting on "GNSS User Positioning Integrity" in March 2010 identifying the potential of integrity enhancements based on R&D activities including among others multiconstellation SBAS and ARAIM (Advanced Receiver Autonomous Integrity Monitoring) and/or combinations of these concepts.

Regional SBAS monitoring networks in place today for augmentation of GPS L1 do not provide continuous monitoring of satellites, which would be beneficial for multi-constellation GNSS augmentation with ARAIM.

**Discussion/Analyses:**
A cooperative network of multi-constellation monitor stations could provide global monitoring of all constellations with fewer stations.

Working Group B includes within its work plan the follow up of development on this matter.

**Recommendation of Committee Action:**
*ICG is invited to take note of the potential to establish a cooperative global multi-constellation monitoring network to support ARAIM and encourage WG-B to follow further this matter. ICG is encouraged to recognize that transparency at service provider level is an important element in achieving user positioning integrity based on multi-constellation architectures.*

**ATTACHMENT 2.3**

**WG-B Recommendation 3 Endorsed by Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **21/10/2010**

**Issue Title:** **WG-B Rec. 3: SBAS Interoperability Working Group**

**Background/Brief Description of the Issue:**
The SBAS service providers have established an ad-hoc working group to coordinate program strategies and resolve technical issues relative to SBAS interoperability since the 1990's.

**Discussion/Analyses:**
The IWG is beginning to address many of the technical issues identified by the ICG WG-B relative to multi-constellation dual frequency GNSS augmentation for the future. SBAS IWG has a subgroup addressing ionospheric impacts to GNSS.

**Recommendation of Committee Action:**
*ICG is invited to encourage SBAS service providers to participate on the SBAS IWG to share current status and define future SBAS integrity architectures for dual frequency multiconstellation SBAS.*

**ATTACHMENT 2.4:**

**WG-B Recommendation 4 Endorsed by Committee Decision**

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| **Prepared by:** | **Working Group B** |
| **Date of Submission:** | **21/10/2010** |
| **Issue Title:** | **WG-B Rec. 4: Reduction of Vertical Alert Limit (VAL) by multiconstellation augmentation** |

**Background/Brief Description of the Issue:**
Directions of SBAS evolution include multi-frequency, multi-constellation augmentation. This can be made use of in two directions:

a) Enlargement of today's LPV-200 coverage area
b) Reduction of VAL while maintaining LPV-200 coverage area.

**Discussion/Analyses:**
Simulations have shown that VAL of 12-10 m is possible based on dual constellation dual frequency SBAS augmentation while maintaining dual frequency single constellation LPV-200 coverage zone. Currently much attention is devoted to the benefit of enlarging the coverage area while reduction of VAL would be also of interest.

**Recommendation of Committee Action:**
*ICG is invited to take note of the potential to reduce VAL with the use of multi-constellation dual frequency SBAS and to encourage WG-B to follow further this work.*

**ATTACHMENT 2.5**

**WG-B Recommendation 5 Endorsed by Committee Decision**

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| **Prepared by:** | **Working Group B** |
| **Date of Submission:** | **21/10/2010** |
| **Issue Title:** | **WG-B Rec. 5: Benefit of multi-GNSS for maritime and land applications** |

**Background/Brief Description of the Issue:**
Much of the focus of WG-B has been on the benefits of multi-GNSS constellations for aviation.

**Discussion/Analyses:**
Maritime and land users also will benefit greatly and their requirements may be easier to meet. Analysis should be performed to demonstrate benefits of multi-GNSS constellations to meet the needs of maritime and land user communities and encourage those communities to plan for adoption of multiGNSS use.

**Recommendation of Committee Action:**
*ICG is invited to take note and encourage WG-B to identify an appropriate forum focusing on maritime and/or land navigation (maritime may be easier) and figure out requirements of maritime and land applications and how those requirements could be achieved by multi-GNSS constellations.*

**ATTACHMENT 2.6**

**WG-B Recommendation 6 Endorsed by Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **21/10/2010**

**Issue Title:** **WG-B Rec. 6: Enhancement of GNSS services for Indoor**

**Background/Brief Description of the Issue:**
One possible enhancement of GNSS services is to make it available for in-door applications.

**Discussion/Analyses:**
1. Possibility of improvements in the GNSS receivers like receiver loop bandwidth optimization or by introducing an FEC (Forward Error Correction) scheme such as LDPC/LDPCCC to increase the detection threshold.

2. Possibility of augmenting satellite-based navigation signals with terrestrial signals such as assisted GNSS or PNT information through internet in the perspective of 3GPP, 3GPP2, OMA (standards for personal communication).

**Recommendation of Committee Action:**
*ICG is invited to take note and encourage WG-B to explore the possibility of enhancing the GNSS services for in-door application/navigation, paying attention to the evolution of standards in this area.*

**ATTACHMENT 2.7**

**WG-B Recommendation 7 Endorsed by Committee Decision**

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| **Prepared by:** | **Working Group B** |
| **Date of Submission:** | **21/10/2010** |
| **Issue Title:** | **WG-B Rec. 7: Interim meeting of WG-B during CSNC 2011** |

**Background/Brief Description of the Issue:**
Chinese Satellite Navigation Conference (CSNC) is the largest navigation related conference in China with more than 1000 participants in CSNC 2010. CSNC 2011 will be held in May 2011 in Shanghai together with CPGPS (Chinese Professionals on GPS) and Shanghai Navigation Forum.

**Discussion/Analyses:**
China offers the opportunity to host an interim meeting of WG-B during CSNC 2011.

**Recommendation of Committee Action:**
*ICG is invited to take note that WG-B considers the organization of an interim meeting during CNSC 2011. Topics to be addressed are still under discussion and might include, e.g. RF interference, multipath, integrity, land/maritime users and will be coordinated as part of the preparation.*

**ATTACHMENT 3**

## ICG-5 WG-B Meeting Agenda

**Wednesday, October 20, 09:00 – 13:00**

| | | |
|---|---|---|
| 09:00 – 09:15 | Welcome and adoption of agenda | |
| 09:15 - 11:00 | Discussion of Inputs for WG-B recommendations | |
| 09:15 - 09:35 | • U.S. Augmentation Systems | L. Eldredge<br>*FAA* |
| 09:35 – 09:55 | • Performance Enhancement in Beidou System: Integrity and Accuracy | Xingqun Zhan<br>*Shanghai Jiao Tong University* |
| 09:55 – 10:15 | • Ionospheric Monitoring in China | Dongkai Yang<br>*Beihang University* |
| 10:15 – 10: 35 | • Alternative Ionosphere and Troposphere Compensation | V. Tyubalin<br>*Institute of Space Device Engineering* |
| 10:35 – 10:50 | • Outcomes of WG-B Special Meeting "GNSS User Positioning Integrity" | S.Wallner<br>*ESA* |
| 10:50 – 11:05 | • GNSS In-Door Application | N. Neelakantan<br>*ISRO* |
| 11:10 – 11:30 | Coffee break | |
| 11:30 – 12:00 | WGB workplan Discussion | All |
| 12:00 – 12:30 | Identification of topics for special meetings of WGB until ICG6 and planning of special meetings | All |
| 12:30 – 13:00 | Organization of Preparation of Report of Working Group B to ICG Plenary | All |

4th Meeting of ICG, Saint-Petersburg, Russian Federation, 14 - 18 September 2009

**Attachment I**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **09/17/09**

**Issue Title:** **Endorse WG-B revised workplan**

**Background/Brief Description of the Issue:**
The revision takes into account the progress in the definition of the activities of the ICG and the Providers' Forum. A past action (Ref. action B1 from original workplan) related with the development of a reference document on models and algorithms for ionospheric and tropospheric corrections is considered closed taking into account that significant work on this area has been already done by other bodies outside the ICG.

**Discussion/Analyses:**
Comments received at WG-B incorporated in revision. Period of one month is open for further comments.

Workplan is provided to the working groups co-chairs for comments.

WG-B co-chairs will finalize the workplan and propose to the ICG for endorsement at the earliest opportunity.

**Recommendation of Committee Action:**
*WG-B recommends that ICG endorse the implementation of the revised workplan.*

**Attachment II**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **09/17/09**

**Issue Title:** **Action B1 to be cancelled**

**Background/Brief Description of the Issue:**
Action B1 of the WG-B workplan is proposed to be cancelled.

**Discussion/Analyses:**
To follow-up closely the different initiatives that are being undertaken at international level to characterize the ionosphere during the next period of maximum solar activity (2010 onwards).

**Recommendation of Committee Action:**
*WG-B recommends that the ICG support initiatives with a view to develop further the knowledge of the ionospheric phenomena and its impact on GNSS.*

**Attachment III**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group B**

**Date of Submission:** **09/17/09**

**Issue Title:** **Planned WG-B Workshop**

**Background/Brief Description of the Issue:**
Consistent with the revised work plan of WG-B, the working group will hold the workshops prior to ICG-5.

**Discussion/Analyses:**
The workshop is planned to be held on the margins of the 2010 Munich Satellite Navigation Summit, Munich, Germany, 9 – 11 March 2010, on 8 March 2010.

**Recommendation of Committee Action:**
*WG-B recommends that the ICG endorse its proposal to hold the workshop in preparation for ICG-5.*

3rd Meeting of ICG, Pasadena, USA, 8 - 12 December 2008

**Recommendation for Committee Decision**

**Prepared by:** **Working Group B or individual Members or Associate Members**

**Date of Submission:** **11 December 2008**

**Recommendation of Committee Action:**
*The Working Group recommends to align its further work on models and algorithms for ionospheric and tropospheric corrections for GNSS systems with a paper entitled "Ionospheric effects on GNSS for Aviation Operations" submitted by the International Civil Aviation Organization (ICAO) GNSS Panel.*

2nd Meeting of ICG, Bangalore, India, 5 - 7 September 2007

**Report of the Working Group B: Enhancement of performance of Global Navigation Satellite Systems services**

1. The Working Group B on Enhancement of Performance of GNSS Services held its first meeting on 6 September 2007 and in accordance with the ICG workplan (A/AC.105/879), considered the assigned actions.

2. *The recommendations of the Working Group are summarized as follows:*

- *The Working Group recommended to align its further work on models and algorithms for ionospheric and tropospheric corrections for GNSS systems with a paper titled "Ionospheric effects on GNSS Aviation Operations" submitted by the International Civil Aviation Organization (ICAO) GNSS panel;*

- *The Working Group agreed that the problem of multipath and related mitigation actions affecting both GNSS systems and user receivers, especially for mobile receivers would be addressed by the use of (i) advanced modulation techniques such as, a binary offset carrier (BOC), a multiplexed binary offset carrier (MBOC) and an alternate BOC; (ii) choice of ranging codes; and (iii) choice of centre frequencies vis-à-vis the signals-in-space characteristics of present and planned GNSS;*

- *The Working Group noted that extension of GNSS services for indoor applications is closely linked with terrestrial mobile services technology, modulation schemes such as, frequency modulation (FM), carrier offset frequency division multiplex (COFDM), and evolving technologies for broadband wireless access (BWA) like WiFi and Worldwide Interoperability for Microwave Access (WiMAX), which are getting integrated with 3G/4G techniques for personal computers and mobile phones. It was also noted that usability of GNSS services for indoor applications could be further improved if GNSS systems incorporated modern GNSS signal structures with modulations like BOC and MBOC, and a use of a powerful pilot carrier, which would help to improve tracking and acquisition performance of a receiver. Other technologies like communications, micro-electro-mechanical systems for supporting a GNSS based positioning need to be explored.*

## WORKING GROUP C: INFORMATION DISSEMINATION AND CAPACITY BUILDING

16th Meeting of ICG, Abu Dhabi, United Arab Emirates, 9 - 14 October 2022

15th Meeting of ICG, Vienna, Austria, 27 September - 1 October 2021

**Recommendation for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group C on Information Dissemination and Capacity Building** |
| **Date of Submission:** | **30 September 2021** |
| **Issue Title:** | **Establishment of the Project Team "Space Weather Monitoring using Low-Cost Receiver Systems"** |

**Background/Brief Description of the Issue:**
Space weather refers to conditions in space (the Sun, solar wind, magnetosphere, ionosphere, or thermosphere) that can influence the performance and reliability of space borne and ground-based technological systems. Ionospheric irregularities at equatorial, auroral, and middle latitudes constitute a major category of space weather effects that need to be better characterized and understood.

Field experiences of past several years showed that it was difficult to promote and deploy receiver systems at large scale for space-weather:

- Existing space-weather receivers are expensive
- Antenna costs are additional costs

If low-cost receiver systems, developed using hardware platforms such as Arduino, RaspberryPi, Android device, can be used for space weather monitoring, this may solve several problems related with receiver system cost, large scale deployment, hands-on training, and education activities.

As several research reports show that it is possible, it is necessary to explore to what level it can be used for space weather monitoring using low-cost receiver systems.

**Discussion/Analyses:**
The University of Tokyo has already developed a low-cost receiver system for high-accuracy positioning that gives accuracy of 20 – 70 cm and performances are quite satisfactory. This allowed large-scale deployment. Other low-cost receiver systems may also be available.

Low-cost does not mean only receiver and antenna costs, but also the system as a whole, including low-cost data-logging devices. For example, such as:

- RaspberryPi device, Arduino or other Single Board Computers
- Android Device (Smart-phone or Tablet)

Easy to use and deploy system:

- System for working environment not only in the research centers with people having technical knowledge.

Experience from the International Space Weather Initiative (ISWI) instrument network, trying to develop space weather science in Africa, showed that the network in Africa requires further enhancement. Therefore, low-cost receiver systems would aid developing further a low-cost monitoring network for science using GNSS, shedding light on space weather.

**Recommendation of Committee Action:**
*To establish the project team within the WG-C to implement prototype systems to explore the possibilities of using low-cost receiver systems for space weather monitoring.*

**Recommendation for Committee Decision #1**

| | |
|---|---|
| **Prepared by:** | **Working Group C on Information Dissemination and Capacity** |
| **Date of Submission:** | **8 November 2018** |
| **Issue Title:** | **Strengthening GNSS Education, Training and Capacity Building** |

**Background/Brief Description of the Issue:**
In 2017, at the ICG-12 meeting, Working Group C recommended that further research on the definition of capacity building should be undertaken. The concept of capacity building was subsequently defined as the process by which individuals and organizations obtain, improve and retain the skills, knowledge, tools, equipment and other resources needed to do their jobs competently or to a greater capacity (larger scale, larger audience, larger impact, etc).

**Discussion/Analyses:**
During work group discussions, problems with current capacity building efforts were identified as:
- links between needs and supply are weak;
- training institutions are isolated and communications are limited;
- there is insufficient development of teaching materials;
- alternative methods of capacity building are not adequately recognized and
- limited funds availability.

Elements of GNSS Education capacity building might include the following: -
Teacher team building; - Teaching activities;
- Infrastructure construction;
- Educational environment;
- Information dissemination;
- Funding support.

**Recommendation of Committee Action:**
*To strengthen cooperation with industry, government, academia, and other relevant institutions to improve GNSS education, training and capacity building. This may be accomplished through:*
- *Continued outreach to policy and decision makers;*
- *Supporting the exchange of experts and educational resources;*
- *Increased engagement of women and young professionals.*

12th Meeting of ICG, Kyoto, Japan, 3 - 7 December 2017

**Recommendation for Committee Decision #1**

| | |
|---|---|
| **Prepared by:** | **Working Group C on Information Dissemination and Capacity Building** |
| **Date of Submission:** | **5 December 2017** |
| **Issue Title:** | **Strengthening Education and Training in global navigation satellite systems and information dissemination** |

**Background/Brief Description of the Issue:**
The development of global navigation satellite systems (GNSS) has a major influence in the creation and development of GNSS-related applications and fosters the growing global GNSS market. It is therefore essential to build capacity in the use of GNSS technologies and ensure that there is a prepared workforce for the growing opportunities in the GNSS sector.

**Discussion/Analyses:**
The presentations made by the representatives of Russian Space Systems company, Moscow State University of Geodesy and Cartography, Moscow Timiryazev Agricultural Academy, BeiDou Belt and Road School of Beihang University, Tokyo University of Marine Science and Technology, the University of Tokyo and the Regional Centre for Space Science and Technology Education in Asia and the Pacific (RCSSTEAP - China) affiliated to the United Nations highlighted their capacity building activities in promoting the use of GNSS capabilities through seminars, workshops and training courses particularly in developing nations.

The working group noted the educational resources of the European Space Agency (ESA) on GNSS technologies and applications available on its own wiki-based information source "Navipedia" (www.navipedia.net), which is a duly updated single entry point. So called, "GNSS wiki" is extremely beneficial for the entire GNSS community.

The working group also noted a cooperation with the United Nations Subcommittee on Geodesy and its focus group on Education, Training and Capacity Building, presented by the International Federation of Surveyors (FIG) aiming at assessing the current availability of education, training, and capacity building resources on global geodetic reference frames.

**Recommendation of Committee Action:**
*The working group C recommends that ICG join forces with educational institutions to strengthen and deliver targeted capacity-building and technical advisory activities with the goals of sharing ideas and expertise regarding GNSS technologies and applications, particularly encouraging participation of women and young professionals. Additionally, further research on definition of capacity-building and workforce index should be undertaken.*

*Consistent with this recommendation and in order to avoid duplication of efforts in sharing available educational materials, support for open data-sharing policy and real-time data accessibility should be taken into account.*

**Recommendation 1 for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group C** |
| **Date of Submission:** | **10 November 2016** |
| **Issue Title:** | **Training for Capacity Building and Information dissemination** |

**Background/Brief Description of the Issue:**
GLONASS is the key part of the multi-GNSS, therefore, it is important to advance the GLONASS technology and share the Russian experience with other countries.

The Joint Stock Company "Russian Space Systems" and the Moscow State University of Geodesy and Cartography are working actively to inform users about the GLONASS-GNSS technology and their applications through the training courses/workshops/seminars.

**Discussion/Analyses:**
To highlight an experience of the "Russian Space Systems" Joint Stock Company and the Moscow State University of Geodesy and Cartography and to inform the interested universities, information and education centers about the educational GNSS activities in Russian Federation.

**Recommendation of Committee Action:**
*Working Group C noted the experience of the "Russian Space Systems" company and the Moscow State University of Geodesy and Cartography the training courses on the GLONASS-GNSS technologies and recommends that the ICG Information Centres and other organizations use the educational potential of these entities.*

*Working Group C recognizes the experience of the Timiryazev Academy and the Moscow State University of Geodesy and Cartography in precision agriculture and appreciates the benefit of the monograph "The management of the agricultural enterprise with the appliance of space navigation means (GLONASS) and distance zoned probes of the Earth" to be used in the ICG Information Centres.*

**Recommendation 2 for Committee Decision**

**Prepared by**: **Working Group C**

**Date of Submission:** **10 November 2016**

**Issue Title:** **The International Civil Aviation Organization (ICAO) Global Navigation Satellite Systems (GNSS) Monitoring guidelines for Aviation**

**Background/Brief Description of the Issue:**
During ICAO Navigation System Panel#2 held in December 2015, guidelines for States were approved on GNSS Monitoring for Aviation (GNSS performance verification and data recording). Such guidelines have been reflected on a proposal of amendment to ICAO Annex 10 (SL 16-061) to be effective from November 2018 and on an update of ICAO Doc9849 GNSS Manual to be published in the next months.

ENAV and Telespazio, in the framework of BEYOND project funded by the European Commission under H2020 programme, have investigated and validated some methodologies for calculation of ICAO GNSS parameters.

**Discussion/Analyses:**
ICAO GNSS Monitoring concept for Aviation has been presented explaining the mean of "Performance Assessment", "Data recording" and "Operational Status Monitoring". Concerning the performance assessment, a set of 6 GNSS Key Performance Indicators (KPI) on the range and position domain have been presented. Proposed methodologies and validation steps carried on by Beyond project has been discussed.

**Recommendation of Committee Action:**
*The Working Group C takes note of recent developments in ICAO and proposes:*

- *Disseminate "Aviation GNSS Monitoring concept" among related communities;*
- *Invite nation states to publish and share ICAO KPI reports;*
- *Create synergies among stakeholders; - Coordinate with other ICG Working Groups.*

10th Meeting of ICG, Boulder, Colorado, United States, 1 - 6 November 2015

**Recommendation 199 for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group on Information Dissemination and Capacity Building** |
| **Date of Submission:** | **05 November 2015** |
| **Issue Title:** | **Proposed template for cooperation between existing and developing Provider and GNSS user information centers** |

**Background/Brief Description of the Issue:**
A proposed template for cooperation between Global Navigation Satellite Systems (GNSS) service centers has been presented to the Working Group. Webpages with Provider links have been developed and will be posted on the ICG Information Portal and offered to Providers for posting on their web-sites once it has been completed.

**Discussion/Analyses:**
The ability to quickly answer user inquiries is critical to instilling confidence in the GNSS being used. Problems encountered with equipment and disruption reports need to be quickly referred to subject matter experts and law enforcement authorities for disposition. A template has been developed that attempts to identify the manner in which certain types of questions can be forwarded back and forth between service centers to the benefit of the user, and establish the existing or developing center as the representative for their GNSS.

**Recommendation for Committee Action:**
*The Providers and GNSS user information centres should continue developing and adopting a process for referring inquiries to each other where appropriate.*

**Recommendation 200 for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group on Information Dissemination and Capacity Building** |
| **Date of Submission:** | **05 November 2015** |
| **Issue Title:** | **Increase ICG Member Cooperation and Support in GNSS Education** |

**Background/Brief Description of the Issue:**
This recommendation was based on China's presentation on updated GNSS educational activities at Beihang University.

**Discussion/Analyses:**
Enhanced access by developing countries to training and educational resources is needed in order to build their capacity in the use of GNSS technologies. Develop and distribute educational booklets covering fundamentals of GNSS that could serve as educational resources for the United Nations-affiliated Regional Centres for Space Science and Technology Education and other institutionsin all regions.

In this regard, the work of Beihang University of China and the Moscow State University of Geodesy and Cartography (MIIGAIK) of the Russian Federation was highlighted.

It was also noted that an international exchange program is an enriching experience on many levels. It affects both personal and professional development, stimulates creative ideas, and enhances relationships among the institutions at the national, regional and international levels. Faculty and staff alike will experience firsthand different approaches to education, teaching styles, and research. Therefore, working, teaching or conducting research in different environments presents new and rewarding challenges, in particular for the United Nations affiliated Regional Centres for Space Science and Technology Education.

**Recommendation for Committee Action:**
*In order to support rising demands in the use of space technology, in particular in developing countries, increased cooperation is needed in GNSS knowledge sharing (e.g. textbooks/teaching materials, faculty/students exchange programmes) among ICG members and the United Nations-affiliated Regional Centres for Space Science and Technology Education and other centers of excellence and institutions, such as Beihang University and Moscow State University of Geodesy and Cartography (MIIGAIK).*

ICG/REC/2015

**Recommendation 3 for Committee Decision**

**Prepared by:** **Working Group on Information Dissemination and Capacity Building**

**Date of Submission:** **05 November 2015**

**Issue Title:** **Expand Capacity Building and GNSS outreach activities**

**Background/Brief Description of the Issue:**
In reference to the recommendation "Capacity Building and GNSS outreach activities in SouthEast Asia" (Ninth Meeting of the International Committee on Global Navigation Satellite Systems (ICG-9), Prague, Czech Republic) to expand the action.

**Discussion/Analyses:**
It was highlighted that the work of the Moscow State University on Geodesy and Cartography (MIIGAIK) was developing GLONASS/GNSS education courses, including distance learning education programmes. Therefore, these courses, provided through a distance-learning degree programme, could be a good resource for effectively teaching diverse levels of trainees of all disciplines at the United Nations-affiliated Regional Centres for Space Science and Technology Education.

**Recommendation for Committee Action:**
*The Office for Outer Space Affairs, in cooperation with the ICG members and the United Nations-affiliated Regional Centres for Space Science and Technology Education and other centers of excellence and institutions, should organize workshops/technical seminars in the field of GNSS and its applications in all regions.*

*It was noted that courses prepared by the Moscow State University on Geodesy and Cartography (MIIGAIK) could be provided through a distance-learning degree programme to the United Nations-affiliated Regional Centres for Space Science and Technology Education. In addition, a faculty/student exchange programme could be established with MIIGAIK of the Russian Federation and Beihang University of China.*

**Recommendation 4 for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group on Information Dissemination and Capacity Building** |
| **Date of Submission:** | **05 November 2015** |
| **Issue Title:** | **Consideration of the value of National Positioning Navigation and Timing (PNT) Advisory Committees** |

**Background/Brief Description of the Issue:**
This recommendation is based on a United States proposal by Dr. Brad Parkinson in the Ninth Meeting of the International Committee on Global Navigation Satellite Systems (ICG-9), 2014, Prague, Czech Republic and briefing made by the United States representative in the Working Group C.

**Discussion/Analyses:**
Space-based positioning, navigation and timing (PNT) capabilities are truly a global utility that positively affect the daily lives of many people around the globe.

The United States National Space-Based PNT Advisory Board provides independent advice to the United States government on Global Positioning Systems (GPS)-related policy, planning, program management, and funding profiles in relation to the current state of national and international satellite navigation services. The PNT Advisory Board provides advice, as directed by the United States government's PNT Executive Committee (EXCOM), on the United States. PNT policy, planning, program management, and funding profiles in relation to the current state of national and international space-based PNT services. This advice consists of assessments and recommendations to facilitate the accomplishment of the goals and objectives of the United States. PNT Policy on behalf of the PNT EXCOM. The PNT Advisory Board evaluates national and international needs for changes in space-based PNT capabilities, assesses possible trade-offs among options, and provides independent advice and recommendations on requirements and program needs. These evaluations are considered in recommending a national PNT strategy and in development of annual updates to a United States PNT Policy 5-Year Plan. Board members are selected subject-matter experts within a variety of GPS user communities.

**Recommendation for Committee Action:**
*It is proposed that ICG member countries consider the value of National and Regional PNT Advisory Committees and share their findings at ICG meetings when available.*

9th Meeting of ICG, Prague, Czech Republic, 10 - 14 November 2014

**Recommendation for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group C** |
| **Date of Submission:** | **13 November 2014** |
| **Issue Title:** | **Capacity Building and GNSS outreach activities in South East Asia** |

**Background/Brief Description of the Issue:**

The Collaboration Centre for Research and Development on Satellite Navigation Technology in South East Asia (NAVIS) Centre was set up by the Hanoi University of Science and Technology, Istituto Superiore Mario Boella (ISMB), Politecnico di Torino and Universitat Politècnica de Catalunya with the support of the European Commission and the European GNSS Agency (GSA) with the aim to strengthen the dissemination activities on GNSS and its applications, in particular, in South East Asia.

**Discussion/Analyses:**

In the last three years, the NAVIS Centre has successfully enlarged its links and activities in South East Asia by conducting joint research activities, participating to governmental committee and organizing workshops, also in cooperation with Multi-GNSS Asia (MGA) and other organizations from South East Asia, Europe, Australia and Japan. Working Group C recognizes the successful setup of the NAVIS Centre and its participation in the MGA initiative.

**Recommendation of Committee Action:**

*ICG Working Group C recommends that the Office for Outer Space Affairs in cooperation with the ICG membership, and the educational centres and organizations, such as the NAVIS Centre and* GEospatial and Space Technology consortium for Innovative Social Services *(GESTISS), and international initiatives, such as MGA and its members, organize workshops and technical seminars in the field of GNSS and its applications in South East Asia region. The participation of BeiDou/GNSS Application Demonstration and Experience Campaign (BADEC) is also encouraged.*

**Recommendation for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group C** |
| **Date of Submission** | **13 November 2014** |
| **Issue Title:** | **Outreach material and contribution to the UN-affiliated regional centres for science and technology acting as information centres for the ICG** |

**Background/Brief Description of the Issue:**

Different efforts have been made by organizations in the Working Group to promote education in GNSS and outreach activities. The presentations made by the members of the Working Group highlighted the possibility for cooperation on different levels within the different institutions.

Within the framework of the Working Group C of ICG, negotiations with the regional centres are on-going in order to utilize them as "hubs" for training and information dissemination on global applications of GNSS and their benefits for humanity. ICG Information Centres aim to foster a more structured approach to information exchange in order to fulfil the reciprocal expectations of a network between ICG and regional centres. By using the existing infrastructure of the regional centres, ICG (more specifically GNSS service providers) may save significant effort and resources by taking advantage of the operational regional centres for information dissemination. The regional centres can then expand their range of training programmes and services and thus open new opportunities to connect to other GNSS providers (or future providers).

**Discussion/Analyses:**

Discussions built upon Action C2 of the Revised Workplan for Working Group C, and in particular, the distance learning programmes, web-based courses and tutorials, interactive programmes for middle/high schools, multimedia software and demonstration data sets to enrich the training and research programmes recommended as part of the workplan. The work of the Moscow State University of Geodesy and Cartography (MIIGAIK), Tokyo University of Marine Science & Technology (TUMSAT), and Beihang University was highlighted. Members also discussed how industry could contribute to educational programmes.

**Recommendation of Committee Action:**

*Working Group C recommends that providers disseminate educational material to the UN-affiliated regional centres for science and technology acting as ICG information centres. This will be done through the ICG Executive Secretariat. Active provider participation in the regional centres and their work is encouraged. The Working Group also encourages industry involvement in the activities of the regional centres.*

**Recommendation for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group C** |
| **Date of Submission:** | **13 November 2014** |
| **Issue Title** | **Proposed template for cooperation between existing or developing Provider and GNSS user information centers for ICG Member Consideration** |

**Background/Brief Description of the Issue:**

Past work of the ICG Provider's Forum and working Group A seeks to improve cooperation and information sharing between GNSS Providers' user service centers. The European GNSS Service Center and the U.S. Coast Guard NAVCEN (the GPS civil user service center) have been working together since the beginning of the year to develop a procedure to jointly administer inquiries that come into the centers from users. Additionally, NAVCEN and the BeiDou Test and Assessment Research Center (TARC) have been engaged in discussions of the same sort.

**Discussion/Analyses:**

The ability to quickly answer user inquiries is critical to instilling confidence in the GNSS being used. Problems encountered with equipment and disruption reports need to be quickly referred to subject matter experts and law enforcement authorities for disposition. A template has been developed that attempts to identify the manner in which certain types of questions can be forwarded back and forth between service centers to the benefit of the user, and establish the existing or developing center as the representative for their GNSS system. Web page templates were proposed for each GNSS with links and contact information for all use information centers.

**Recommendation of Committee Action:**

*To improve cooperation between existing and developing provider user information centres, Working Group C recommends that all the Provider and GNSS user information centres consider development and adoption of a process for referring inquiries to each other where appropriate.*

8th Meeting of ICG, Dubai, United Arab Emirates, 9 - 14 November 2013

**Recommendation 208 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **13 November 2013**

**Issue Title:** **ICG Website Design and Content**

**Background/Brief Description of the Issue:**

- A follow up on the Working Groups workplan actions C7 and C8 on the revision of the ICG Information Portal.
- A well-constructed proposal to change the ICG website was made by the US delegation at the ICG meetings in 2011 and in 2012.

**Discussion/Analyses:**

The Office for Outer Space Affairs, as the ICG Executive Secretariat introduced a coherent and comprehensive plan to increase the quality and relevance of the ICG website. The underlying approach of the web strategy was about how to plan and manage data/information and knowledge sharing that support communications and ICG goals.

ICG website must be structured in a way that it can be easily searched and presented online. This will be used to raise awareness and understanding of ICG's challenges and achievements.

**Recommendation of Committee Action:**

*Changes to be made to the website content structure along already accepted the website standards of the Office for Outer Space Affairs.*

**Recommendation 2 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **13 November 2013**

**Issue Title:** **Collaborative Portal for Workgroups**

**Background/Brief Description of the Issue:**
The need to create a web-based forum for the working groups use that could include advance/draft meeting materials. This will allow working groups to better communicate and coordinate organization of meetings and regular discussions.

**Discussion/Analyses:**
The Working Group noted the limitations of the ICG Executive Secretariat and restrictions to set such a portal especially in terms of cost and time to implement.

It was understood that it would be mutually beneficial if such a portal could be set up by one of the members who would volunteer hosting space and time to create a portal. The Working Group took note of the Forum hosted by the International Telecommunication Union (ITU) that was set up to assist the ICG Working Group A Subgroup members to exchange information and working documents.

**Recommendation of Committee Action:**
*Working group agreed to find a solution for collaborative online workspace that will allow to facilitate documents distribution and files sharing. It was highlighted that if such a website was set up, the link will be included in the ICG website.*

**Recommendation 3 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **13 November 2013**

**Issue Title:** **Collaboration on Education and Information Dissemination**

**Background/Brief Description of the Issue:**
Different efforts have been made by organizations in the Working Group to promote education in GNSS and outreach activities.

**Discussion/Analyses:**
The presentations made by the members of the Working Group highlighted the possibility for cooperation on different levels within the different institutions.

The Beihang University proposal for collaborating with the United Nations-affiliated Regional Centres was discussed by the working group; with a conclusion that there should be a stepped approach for collaboration and a GNSS education program should be set as a future plan.

**Recommendation of Committee Action:**
*The working group recommended that the United Nations-affiliated Regional Centers, the Beihang University of China, the Moscow State University of Geodesy and Cartography of the Russian Federation, the Geospatial and Space Technology Consortium for Innovative Social Services (GESTISS) of Japan and other GNSS centers of excellence to work together where possible in order to promote better outreach activities, knowledge sharing and to learn from each other's experience in terms of information dissemination.*

**Recommendation 4 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **13 November 2013**

**Issue Title:** **Information Dissemination between GNSS Users and Providers**

**Background/Brief Description of the Issue:**
The issue was raised during the Seventh Meeting of the ICG, in 2012 by the US delegation for better information dissemination from GNSS systems to governments, scientific, commercial and other users.

**Discussion/Analyses:**
The U.S. Global Positioning System Service Interface Committee was presented as a successful model for information dissemination to users.

The Working Group agreed that this is a successful example for information dissemination and can be used as a baseline for developing a method/guidelines through the Working Group.

**Recommendation of Committee Action:**
*The Civil Global Positioning Systems Service Interface Committee to be used as a successful example for dissemination of information between GNSS users and providers.*

7th Meeting of ICG, Beijing, China, 5 - 9 November 2012

**Recommendation 1 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **08 November 2012**

**Issue Title:** **ICG Website**

**Background/Brief Description of the Issue:**
The current ICG Website is maintained by UNOOSA. At the 6th meeting of ICG, responding to the ICG secretariat request for input, USA gave a presentation on ICG website revision. At the 7th meeting of ICG, USA again gave the presentation on ICG website revision, and China made the presentation on ICG information service system to the Providers' Forum. The Providers' Forum referred both of the presentations to WG-C for further consideration. WG-C considered the topic of possible revision of the ICG Website and the two presentations referred to it by the Providers' Forum.

**Discussion/Analyses:**
Discussion of the issue led the group to agree on the following two points:
1. The specific elements and features desired of the ICG Website need to be identified by the ICG/PF and documented.
2. The implementation of ICG Website revision may be possible through various mechanisms, some examples of which are: (NOTE: other mechanisms are possible)
    a. UNOOSA revises and continues the hosting of the current ICG Website
    b. UNOOSA revises, and continues the hosting of, the current ICG Website to the degree possible. Links to external website(s) will be added to the ICG Website. The external website(s) would provide the desired ICG Website elements and features that could not be provided by UNOOSA.
    c. An ICG Member accepts the responsibility of hosting the ICG Website including the maintenance and revision.

Also, the group agreed to prepare a Recommendation for Committee Decision providing the proposed Workplan modification for addressing the issue of revising the content and format of the ICG Website.

**Recommendation of Committee Action:**
1. *The ICG invites its participants to review the ICG Website and provide, to the next meeting(s) of WG-C, specific details on how the content and format should be revised.*
2. *The ICG invites its participants and the ICG Executive Secretariat to consider and provide proposals for the revision and hosting of the ICG Website.*
3. *The WG-C Workplan is to be modified to incorporate the following new action: ICG Website*

    *• Document the desired elements and features of the ICG Website as provided by ICG/PF participants. Produce a Report that is sufficiently detailed for the purpose of being used by a website designer to revise the ICG Website.*

*Document the proposals for the revision and hosting of the ICG Website. Produce a Recommendation for Committee Decision detailing which of the options provided is considered to be the most suitable for adoption by the ICG.*

**Recommendation 2 for Committee Decision**

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| **Prepared by:** | **Working Group C (Proposed by the representative of China)** |
| **Date of Submission:** | **08 November 2012** |
| **Issue Title:** | **Proposal on the International Centre for GNSS Science, Technology and Education at Beihang University, as ICG Information Centre** |

**Background/Brief Description of the Issue:**
The United Nations International Meeting on the Applications of GNSS held on 12-16 December 2011 in Vienna (A/AC.105/1019) recommended that the United Nations should lead, with the active support of China and relevant scientific organizations, an international effort to establish an **International Centre for GNSS Science, Technology and Education** in an existing national educational and research institution. **Beihang University** (http://www.buaa.edu.cn ), Beijing, China, has offered to host such a centre.

**Discussion/Analyses:**
In the past year, Beihang University actively started the construction of the center. With the support of China Satellite Navigation Office and the university, the Beidou international communication and training center was inaugurated on August 24, 2012. Summer school on GNSS frontier technology was held, and the Master degree program on GNSS has begun with 20 participants from 7 countries. Beihang University has established a partnership with Asia Pacific Space Cooperation Organization (APSCO) and is pursuing the cooperation with the UN –affiliated Regional Centers for Space Science and Technology Education located in Morocco, Nigeria, India, Mexico/Brazil and Jordan. A GNSS Information Service System for education and research purposes is proposed.

**Recommendation of Committee Action:**
*Recognize International Centre for GNSS Science, Technology and Education as an ICG information Centre.*

**Recommendation 3 for Committee Decision**

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| **Prepared by:** | **Working Group C (Proposed by the representative of USA)** |
| **Date of Submission:** | **08 November 2012** |
| **Issue Title:** | **Amend the WGC workplan to reflect responsibility for information dissemination activities** |

**Background/Brief Description of the Issue:**
The U.S. proposes that the ICG consider adding a new topic heading "Information Dissemination" and an action item numbered C6 under "Information Dissemination" to the ICG Working Group-C (WG-C) Workplan. Currently, the Workplan does not contain either of these.

**Discussion/Analyses:**
WG-C has responsibility for information sharing and dissemination. The workplan for WG-C currently does not contain wording to explain that portion of the working group's designation. An integral part of, and challenge for GNSS systems is developing methods to quickly and efficiently distribute available system information to public, governmental, scientific, and commercial users of GNSS. In a future multi-GNSS world, methods to distribute this information will have to be coordinated among provider systems to facilitate common use by users. The ICG members, from governmental, scientific and educational backgrounds, are particularly suited to identifying ways to distribute information, including the development of web-presence materials to document and publicize the related activities.

**Recommendation of Committee Action:**
*The recommendation of ICG WG-C is to add topic heading "Information Dissemination" and the associated action item to the WG-C Workplan as follows:*

***Information Dissemination***
*Action C6 (new): Identify recommended methods to quickly and efficiently distribute information available from GNSS systems to the public, governmental, scientific, and commercial users of GNSS, including web-presence materials to document and publicize the related activities.*

**Recommendation 4 for Committee Decision**

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| **Prepared by:** | **Working Group C (proposed by the representative of European Space Agency)** |
| **Date of Submission:** | **08 November 2012** |
| **Issue Title:** | **Participation to Navipedia** |

**Background/Brief Description of the Issue:**
The current GNSS international scenario is very dynamic, including the modernization of the legacy GPS and GLONASS as well as the emergence of new satellite navigation systems including Galileo in Europe and COMPASS in China, but also Satellite Based Augmentation and Regional satellite systems. The field of satellite navigation is progressing at such a rapid pace that it is difficult to keep track of the latest evolutions, satellite launches, technologies or even systems and signals. Furthermore, books on GNSS are rapidly outdated and incorrect information can be found scattered over the internet.

**Discussion/Analyses:**
In order to overcome the issues listed above the European Space Agency has launched Navipedia aiming at having a GNSS educational portal (or wiki) to support the transfer of GNSS know-how to the public, providing a common, complete and trustable compilation of reference updated knowledge in GNSS. Navipedia is freely accessible on the internet via www.navipedia.org and is conceived as a collaborative GNSS encyclopedia with the objective to foster the transfer of knowledge in the field of GNSS. Navipeia adopts the concept of Media-wiki products where anyone can comment, propose modification to an existing articles, suggest a new topic or submit a draft article.

**Recommendation of Committee Action:**
*ICG WG-C invites all ICG participants to contribute to Navipedia and support therewith education in the area of navigation.*

6th Meeting of ICG, Tokyo, Japan, 5 - 9 September 2011

**ATTACHMENT 2**

**WG-C Recommendation 1 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **8 September 2011**

**Issue Title:** **Education and training programmes on GNSS**

**Background/Brief Description of the Issue:**
A lack of graduate and undergraduate education in GNSS fundamental techniques; a new action item "Education and training programmes on GNSS" to be added into the WG workplan.

**Discussion/Analyses:**
To meet effectively work market demands for high-level technicians endowed with a broad vision of the state-of-the-art navigation/localization, new programmes are needed, including: (i) distance learning programmes and web-based education curriculum; (ii) multimedia softwares and, (iii) demonstration data sets in order to enrich the training and research programmes.

Cooperation with industries should also be taken into consideration.

**Recommendation of Committee Action:**
*To add a new action to the workplan of the working group on "Education and training programmes on GNSS"*

*Build upon the existing educational programmes and support the creation of new under and post graduates programmes in both developing and developed countries, including distance learning programmes, web-based courses and tutorials, interactive programmes for middle/high schools, multimedia softwares and demonstration data sets to enrich the training and research programmes. Further consideration should be given to onsite "hands-on/off" training programmes. Support the establishment of International Centres for GNSS Science, Technology Development and Education based on the existing national educational and research institutions.*

**WG-C Recommendation 2 for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **8 September 2011**

**Issue Title:** **Education curriculum on GNSS**

**Background/Brief Description of the Issue:**
The ad hoc group of experts drew up a GNSS education curriculum for introduction at the regional centres for space science and technology education affiliated to the United Nations. The ICG membership is invited to improve the course content.

**Discussion/Analyses:**
The WG meeting considered that the additional review of the curriculum by (i) the Providers' Forum members could enrich the depth and content of the curriculum taking into account the current status of the current and planned systems and their policies; (ii) the ICG associate members representing international and regional organizations/associations dealing with GNSS services and applications could improve the content of the education curriculum, in particular the part related to the practical exercises (laboratory experiments, field visits, project work), and (iii) Space Weather-related topics should also be added taking into account growing interest in better understanding solar-terrestrial interactions, particularly patterns and trends in space weather and the space weather impact on GNSS-based applications.

**Recommendation of Committee Action:**
*Support of the ICG membership in further development (possible improvement) of the current content of the GNSS education curriculum to address the following topics: (i) Current status of planned or operating systems and policies and procedures that govern their service provision; (ii) GNSS services and applications; (iii) Atmospheric phenomena related to space weather and climate change.*

5th Meeting of ICG, Turin, Italy, 18 - 22 October 2010

**Attachment I**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **21 October 2010**

**Issue Title:** **Development of a GNSS Education Curriculum**

**Background/Brief Description of the Issue:**
Support education and training programmes related to satellite navigation for purposes of building capacity in developing countries through the regional centres for space science and technology education affiliated to the United Nations.

**Discussion/Analyses:**
- e-learning based mode of knowledge transfer (Politecnico di Torino, Roscosmos – Russian Education Center);
- expand ICG Info Portal's education focused page (NASA, SGAC, "GLONASS/GNSS Forum" Association, China);
- launch of a pilot cooperation project between the Russian Education Center and the UN-affiliated Regional Centres;
- issues related to the development of the GNSS curriculum (existing university courses and trainings, course lengths, modules, on-line materials, different students backgrounds).

**Recommendation of Committee Action:**
- *Support the development of a GNSS Education Curriculum to be implemented by ICG Information Centres based on the UN - Affiliated Regional Centres for space science and technology education.*

- *Support further development of the ICG Information Portal to be utilized for the programme on GNSS Applications.*

4th Meeting of ICG, Saint-Petersburg, Russian Federation, 14 - 18 September 2009

**Attachment I**

**Recommendation for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **09/17/09**

**Issue Title:** **Updated Work Plan for Working Group C**

**Background/Brief Description of the Issue:**
The workplan consists of the following 4 actions: (1) training for capacity building in developing countries; (2) promoting the use of GNSS technologies as tools for scientific applications; (3) international space weather initiative; (4) regional workshops on the applications of GNSS.

**Discussion/Analyses:**
The revised workplan for WG-C maintains a focus on providing support for education and training in satellite navigation and location-based services for purposes of building capacity in developing nations through the regional centres for space science and technology education affiliated to the United Nations and organizing the workshops and special sessions on the use of GNSS technologies as tools for scientific applications.

**Recommendation of Committee Action:**
*The ICG should adopt the work plan for WG-C and consider outreaching to the nations to promote their space segments.*

3rd Meeting of ICG, Pasadena, USA, 8 - 12 December 2008

**Recommendation for Committee Decision**

**Prepared by:** **Working Group C**

**Date of Submission:** **11 December 2008**

**Issue Title:** **ICG Information Centres**

**Background/Brief Description of the Issue:**
Based on resolutions of the United Nations General Assembly, Regional Centres for Space Science and Technology Education were established in India, Morocco, Nigeria, Brazil and Mexico. Simultaneously, education curricula were developed for the core disciplines of remote sensing, satellite communications, satellite meteorology, and space and atmospheric science. These centres agreed to act as information centres of the International Committee on Global Navigation Satellite Systems (ICG).

**Discussion/Analyses:**
The working group discussed the draft concept paper (objectives and scope, procedure, first approach, mechanisms of information transfer, benefits for providers forum and regional centres) for the regional centres for space science and technology education to become information centres for the international committee on global navigation satellite systems.

**Recommendation of Committee Action:**
*The working group C recommends that the ICG plenary affirm the Regional Centres act as the ICG information centres on the basis of the final version of the concept paper.*

2nd Meeting of ICG, Bangalore, India, 5 - 7 September 2007

**Report of the Working Group C: Information dissemination**

1. The Working Group C on Information Dissemination held its first meeting on 6 September 2007 under the chairmanship of the Office for Outer Space Affairs.

2. In accordance with the workplan (A/AC.105/879), the Working Group considered the assigned actions.

3. The Working Group heard the following presentations:

- "The United Nations and Global Navigation Satellite Systems: Global in Space and Time" by S. Gadimova (Office for Outer Space Affairs);

- "International Heliophysical Year" by H. Haubold (Office for Outer Space Affairs);

- "Centre for Space Science and Technology Education in the Asia and Pacific region", K. Bandyopadhyay (India);

- "Master Program in Navigation and Related Applications in Torino", L. Lo Presti (Italy);

- "Information Dissemination", M. Shmulevich (Russian Federation).

4. The Working Group noted that such presentations provided complementary content for deliberations of the Working Group, in particular timely and useful information on the activities carried out under the thematic area of GNSS of the Office for Outer Space Affairs.

5. The Working Group noted with appreciation that the Office for Outer Space Affairs was maintaining an ICG Information Portal as part of the website of the Office for Outer Space Affairs (www.unoosa.org/oosa/en/SAP/gnss/icg.html).

6. The Working Group agreed that the Committee members should be requested to provide regular updates on GNSS-related events, information on on-line available educational courses, text books and other sources of educational materials to be uploaded to the ICG information portal.

*7. In the course of the discussions, the Working Group made the following recommendations:*

- *The Committee should support the long and short-term training and education on GNSS at the regional centres for space science and technology education, affiliated to the United Nations.*

- *The Committee should provide support for the development of a curriculum on GNSS as a course discipline for the regional centres;*

- *The Committee should accept as final the draft ICG brochure and the ICG logo as prepared by the Office for Outer Space Affairs.*

## WORKING GROUP D: REFERENCE FRAMES, TIMING AND APPLICATIONS

**Recommendation for Committee Decision**

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| **Prepared by**: | **the "Applications of Global Navigation Satellite Systems (GNSS) For Disaster Risk Reduction" Task Force of Working Group D (WG-D).** |
| **Date of Submission:** | **Friday the 11th of October 2024.** |
| **Issue Title:** | **Publication of a Policy Brief on the Uses of GNSS for Disaster Risk Reduction** |

**Background/Brief Description of the Issue:**

The "Applications of GNSS for Disaster Risk Reduction" Task Force (hereafter DRR TF), operates under the umbrella of Working Groups D and B. Its mission is to explore how GNSS technology can enhance disaster risk reduction (DRR) strategies and bolster natural hazard early warning systems (NHEWS). At the heart of this endeavour is the concept that GNSS-based techniques provide a cost-effective means to comprehensively monitor the surface-atmosphere system, offering a novel approach to tracking natural hazards. Currently, the Task Force's focuses primarily on four GNSS-based techniques: Precise Point Positioning (GNSS-PPP), Reflectometry (GNSS-R), Radio Occultation (GNSS-RO), and ground-based Total Electron Content (GNSS-TEC). These techniques have broad applications, spanning for instance earthquakes, tsunamis, floods, and solar storms. Established at the 16th Annual Meeting of the International Committee on GNSS (ICG-16) in October 2022 following WG-D Recommendation #26, the DRR TF has now achieved two years of gathering and organizing expertise in the field.

**Discussion/Analyses:**

Through its exchanges with experts, stakeholders, and policymakers worldwide, as well as through its co-chairs' own academic research efforts, the DRR TF has identified outreach as a critical factor in promoting the use of GNSS for Disaster Risk Reduction. Despite the clear advantages GNSS-based techniques offer to enhance early warning systems, there is hesitancy among current systems to fully integrate these augmentations due to concerns about robustness and reliability.

While the role of GNSS in geodesy is well recognized, its broader applications in natural hazard monitoring remain largely unfamiliar to stakeholders and policymakers. This gap in awareness is further highlighted by findings from the United Nations Global Geodetic Centre of Excellence[1], which revealed that the Global Geodetic Supply Chain receives far less funding than its geodetic benefits alone justify. Considering the additional benefits GNSS could offer in Disaster Risk Reduction, there is a strong case for more extensive outreach and advocacy in this area.

Recognizing this need, the DRR TF, with inputs from external experts, has drafted a concise policy brief. This document aims to clearly articulate the benefits of GNSS in DRR, with the goal of enhancing the perception and uptake of GNSS technology among stakeholders and policymakers. By doing so, the DRR TF hopes to foster greater integration of GNSS into disaster risk reduction strategies worldwide.

**Recommendation of Committee Action:**

[1] United Nations Global Geodetic Centre of Excellence "Hidden Risk" Report - Version 1.1 - 20 June 2024 (https://ggim.un.org/UNGGCE/documents/20240620-Hidden_Risk_Report.pdf)

*The International Committee on GNSS to publish the Policy Brief on the Uses of GNSS for Disaster Risk Reduction prepared by WG-D's "Applications of GNSS for Disaster Risk Reduction" Task Force and external experts (provided as attachment).*

**Recommendation for Committee Decision**

**Prepared by:** **Working Groups B, S, and D**

**Date of Submission:** **19 October 2023**

**Issue Title:** **On the use of the broadcast prediction of UTC to determine the offsets between GNSS times for non-space-based users**

**Background/Brief Description of the Issue:**
Multi-GNSS is more and more used in a variety of applications. Multi-GNSS users need to know the timing offsets between the individual GNSS, also called inter-system timing biases.

In ICG 2017, a discussion was raised on the possibility to use a pivot time scale as reference to estimate the different GNSS time offsets, so that each GNSS would need to broadcast only one parameter. In recent years, the use of the prediction of UTC already broadcast by the GNSS as this pivot has proved to be a viable solution, without the need to create a new time scale. On this topic the Consultative Committee for Time and Frequency of the BIPM issued a Recommendation in 2021 "On the use of existing time scales to generate GNSS inter-system information" recommending to avoid the proliferation of unnecessary time scales.

**Discussion/Analyses:**
The inter-system time biases can be determined by three different approaches:

- determination at user level when a sufficient number of GNSS satellites are in view
- use of direct broadcast information (GNSS-to-GNSS time offset) when available
- use of the prediction of UTC (called $bUTC_{GNSS}$) that each GNSS currently broadcasts through the message (GNSStime - $bUTC_{GNSS}$) as a pivot to determine related inter-system time biases

Even if the $bUTC_{GNSS}$ is not the same for the different GNSS (different UTC(k) are used by the GNSS as intermediate references), they are sufficiently close to one another for that purpose. Recent studies have confirmed that with the current differences between the $bUTC_{GNSS}$ broadcast by the different GNSS, the resulting error on the inter-system time bias has no significant impact on positioning and timing in situations where non-space-based mass-market receivers cannot determine the inter-system bias directly from the measurements.

The prediction of UTC broadcast by the GNSS is expected to improve in the future, which will improve GNSS interoperability and time dissemination accuracy.

The feasibility/performance of the three approaches depend on many factors such as the number of GNSS satellites in view, the noise level of the receiver and the accuracy of the broadcast messages.

Continuous effort in monitoring and validating all GNSS-to-GNSS time offset is to be pursued also promoting the collaboration among the different involved groups.

The needs of space users may lead to different conclusions that may require revisiting this recommendation.

**Recommendation of Committee Action:**

*1. In the case a common pivot method is chosen to provide the user with GNSS inter-system time biases, multi-GNSS receiver manufacturers consider the benefit of using the common pivot* $bUTC_{GNSS}$ *contained in the GNSS navigation message. This approach comes in addition to the two other existing methods (estimation at user level or use of broadcast GNSS-to-GNSS time offset). For mass-market non-space-based users, this eliminates the need to create an ad hoc time scale as a common pivot.*

*2. GNSS providers continue their efforts to improve the prediction of UTC broadcast in the navigation message with the help of time laboratories, with the aim to improve their time dissemination service.*

**Recommendation for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **19 October 2023**

**Issue Title:** **Development of GNSS-based techniques for applications related to disaster risk reduction and natural hazards monitoring**

**Background/Brief Description of the Issue:**
The "Applications of GNSS for Disaster Risk Reduction" Task Force (hereafter DRR TF), operates under the umbrella of Working Groups (WGs) D and B. Its mission is to explore how GNSS technology can enhance disaster risk reduction (DRR) strategies and bolster natural hazard early warning systems (NHEWS). At the heart of this endeavour is the concept that GNSS-based techniques provide a cost-effective means to comprehensively monitor the surface-atmosphere system, offering a novel approach to tracking natural hazards. Currently, the TF's focuses primarily on four GNSSbased techniques: Precise Point Positioning (GNSS-PPP), Reflectometry (GNSS-R), Radio Occultation (GNSS-RO), and ground-based Total Electron Content (GNSS-TEC). These techniques have broad applications, spanning for instance earthquakes, tsunamis, floods, and solar storms. Established at ICG-16 in October 2022 following WG-D Recommendation #26, the DRR TF has dedicated a full year to gathering and organising expertise in the field up to the time of this recommendation.

**Discussion/Analyses:**
The DRR TF has explored the GNSS-based techniques and their potential and current applications to DRR and NHEWS. Over the past year, the TF has convened seven times, gathering diverse worldwide expertise from Australia, Chile, China, France, Germany, Italy, Japan, New Zealand, Spain, and the United States of America. The DRR TF has found the following points to be relevant to the discussion.

- A single ground GNSS station is sufficient to obtain GNSS-PPP, GNSS-TEC, and interferometric GNSS-R data which would be critically useful to DRR and NHEWS.
- GNSS-PPP remains the conventional approach for early warning systems, with ongoing efforts to strengthen it and explore innovative methods.
- GNSS-TEC is a relatively new development from the past two decades but shows promising results (*e.g.*, the GUARDIAN system developed by JPL; Martire *et al.*, 2023).
- GNSS-R and GNSS-RO represent cutting-edge research areas, holding significant potential but requiring further development for operational use (*e.g.*, the gnssrefl software by Larson *et al.*).
- Earthquakes remain the primary and most-developed target for GNSS-based NHEWS, followed closely by tsunamis.
- Efforts are underway to study space weather effects, such as solar storms, mainly motivated by the desire to monitor the perturbations such effects induce on positioning and navigation (such as the European JRC's Ionospheric Prediction Service).
- There are ongoing but more limited, non-operational research studies on using GNSS to monitor volcanic eruptions, wildfires, floods, storms, and sea-level rise.
- The topics of data assimilation, data fusion for various types of datasets (*e.g.*, seismo-geodetic enhancements; Golriz *et al.*, 2023), and crowd-sourcing GNSS data (*e.g.*, cellphones) were deemed to be particularly valuable in the short-term.

Not related to GNSS, satellite imagery was found important to assess Disaster Risk Reduction potential, especially by and for island nations in the Pacific.

**Recommendation of Committee Action:**
*It was recommended by ICG that:*

*1. The DRR TF should (a) demonstrate the deployment of a multi- GNSS station in an area of sparse coverage; and (b) define a step-by-step guide for future such deployments, including critical details such as (but not limited to) the administrative and technical requirements, the cost and timing estimates, and the potential sources of funding to which one could apply.*

*2. The ICG should encourage the development of open-source, freely available, and readily- and easily-usable software. In addition, the ICG should encourage the publication of open-access, real-time, high-rate, accurate, and precise multi-GNSS data and products.*

*3. The science community should pursue the development of data assimilation, data fusion for various types of datasets, and crowd-sourcing GNSS data to their full, synergistic potential.*

**Recommendation for Committee Decision**

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| **Prepared by:** | **Working Group D, in cooperation with Working Group B** |
| **Date of Submission:** | **14 October 2022** |
| **Issue Title:** | **Creation of a WG-D Task Force, "Applications of GNSS for Disaster Risk Reduction"** |

**Background/Brief Description of the Issue:**
Background: GNSS-based techniques are extremely useful in monitoring natural hazards and disasters. Traditional GNSS techniques, already well-established, allow the live monitoring of ground motion. Recently developed, GNSS-based remote sensing (ionospheric monitoring) enables a much wider coverage of disasters through the atmospheric waves they induce; this is particularly useful to cover oceans, and therefore for tsunami early warning.
Need: There is a growing need to coordinate GNSS-based efforts for disaster risk reduction. This has been acknowledged by multiple organisations already (see, *e.g.*, IUGG's GeoRisk commission created in 2000, and IUGG's 2015 Resolution IV which sparked the creation of IUGG's IAG's GGOS Geohazards Focus Group). This is also in alignment with the United Nations Sustainable Development Goals and Sendai Framework for Disaster Risk Reduction.

**Discussion/Analyses**
Multiple ICG Members, Associate Members, and Observers already provide efforts towards disaster risk reduction. Some tools are already operational to this effect. To this day, there exists no recommendations or focus groups to develop GNSS-based disaster risk reduction within ICG. IGS and NASA JPL presented a use case at ICG-16, demonstrating an operational GNSS-based ionospheric monitoring software; this would serve as an initial use case, and other members are encouraged to contribute additional use cases to this Task Force. More generally, this Task Force would centre on novel applications of GNSS data and infrastructure to support sustainable development and disaster risk reduction. WG-B fully supports this recommendation.

**Recommendation of Committee Action:**
- *WG-D recommends the creation of a new Task Force, "Applications of GNSS for Disaster Risk Reduction"; the Task Force will coordinate efforts on using GNSS for disaster risk reduction.*
- *WG-D recommends this Task Force be hosted by WG-D, co-chaired by one or more members of WG-D, and co-chaired by one or more members of WG-B.*

**Recommendation for Committee Decision#21-B**

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| **Prepared by:** | **Working Group D** |
| **Date of Submission:** | **06 December 2017** |
| **Issue Title:** | **On the monitoring of offsets between GNSS times (revision of Recommendation #21-A)** |

**Background/Brief Description of the Issue:**
Offsets between GNSS times are important information for GNSS users. Monitoring of the offsets between GNSS times and provision of consistent broadcast information are essential to improve interoperability and combined navigation using multiple GNSS.

**Discussion/Analyses:**
Information of the differences between the GNSS times is the basis of interoperability and combined application of the various GNSS systems. Every GNSS system has its own time system and they are different. The time offsets between different GNSS could be measured continuously by GNSS timing receivers, could be obtained by direct time comparison link or computed from a common reference. The monitoring and broadcast of GNSS time offsets are technically possible and will benefit GNSS providers and users.

The time offset between GPS and Galileo (GGTO) is being monitored and is currently broadcast in Galileo navigation message. GLONASS also broadcasts its offset to GPS time. The time offset parameters of BDT relative to the other three GNSS times have been designed in BeiDou navigation messages and the relevant experiments of monitoring and prediction have been implemented.

In order to improve the monitoring of offsets between GNSS times, the different GNSS should work for reaching consistency in the procedures for monitoring and broadcasting the GNSS time offsets.

**Recommendation of Committee Action:**
*1. GNSS Providers should consider monitoring of offsets between GNSS times and implement the broadcast of this information in the navigation messages.*

*2. GNSS Providers are encouraged to undertake studies on possible approaches for giving information on the offsets between GNSS times.*

*3. In order to improve consistency of offsets between GNSS times broadcast by the various systems, GNSS Providers should discuss on the adoption of the same or similar models.*

*4. In order to promote GNSS compatibility and interoperability, GNSS providers and time relevant organizations, including the BIPM, actively develop methods to monitor the offsets between GNSS times, share the monitoring data and relevant research results and actively collaborate with the relevant experts in WG D and S.*

**Recommendation for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **6 December 2017**

**Issue Title:** **Guidelines on Selection and Prioritizing Laser Ranging to GNSS Satellites by the International Laser Ranging Service (ILRS)**

**Background/Brief Description of the Issue:**
The International Laser Ranging Service (ILRS) coordinates a global network of approximately 40 laser tracking stations.

Laser tracking provides a very accurate means of determining satellite orbits, including of the GNSS satellites fitted with laser retroreflectors.

The ILRS supports a variety of satellite missions, with the highest priority being for the ITRF and Earth remote sensing. Currently the ILRS tracks all GNSS satellites in an uncoordinated fashion.

**Discussion/Analyses:**
The ILRS is close to being overloaded and will be unable to track all future GNSS satellites. Satellite laser ranging is the best independent means of evaluating the precise GNSS satellite orbits derived by GNSS System Providers, and other researchers and third parties.

It is vital that this valuable service continues to be provided, so that GNSS orbits with centimeter-level accuracy can be assured with progressive refinements in orbit models and analyses.

The ILRS seeks advice on how to select and prioritize the GNSS satellites that should be tracked.

**Recommendation of Committee Action:**
*That ICG work with the ILRS to develop guidelines on how to select and prioritize GNSS satellite laser tracking to ensure the best utilization of the ILRS resources.*

**Recommendation for Committee Decision (WG-D#16-B)**

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| **Prepared by:** | **Working Group D** |
| **Date of Submission:** | **10 November 2016 (REVISED 12 November 2012)** |
| **Issue Title:** | **Information on the works related to the proposed redefinition of UTC (revision of Recommendation 16 (2012), revised as 16-1 in 2013)** |

**Background/Brief Description of the Issue:**

Considering that:

- the navigation systems have unique timing and geodetic references for operational necessity. Interoperability of the GNSS requires interrelationship of the timing and geodetic references to reduce ambiguities for users with regard to the interpretation of navigation and timing solutions,
- discussion on redefinition of UTC started in 2000 at the ITU-R, SG7 Science Services WP7A Time Signals and Frequency Standard Emissions,
- during 2000-2010 WP7A studied the issue, considered different options, organized an open meeting (Torino, 2003), and worked on a proposal for an amended ITU recommendation,
- in 2010 the Draft Revision of Recommendation ITU-R TF.460-6 (new proposed version) was submitted by ITU-R WP7A to ITU-R SG7; while considering this issue at SG7 no consensus on the Draft Revision of Recommendation ITU-R TF.460-6 was achieved,
- the SG7 sent the Draft Revision of Recommendation ITU-R TF.460-6 to the Radiocommunication Assembly 2012 (RA -12) for « final decision »,
- at RA-12 after several statements of Administrations and Sector members supporting different views the Chairman stated that there are almost even balance between those administrations that are in favour of the draft revision of the Recommendation, those that are opposing it, and a third group of administrations who indicated that as they had not participated actively at SG7 and WP7A meetings, more information is required to enable them to form an opinion,
- as a result RA-12 decided to address this issue in the RA-12 Report for World Radiocommunication Conference 2012 (WRC-12) to develop a new WRC-15 Agenda item.
- WRC-12 started a new study question on WRC-15 Agenda item 1.14 in accordance with Resolution 653 (WRC-12) and put back the Draft Revision of Recommendation ITU-R TF.460-6 to SG7-WP7A for a final decision at WRC-15,
- WRC-12 Resolution 653 on the feasibility of a continuous UTC involves the BIPM, CCTF, CGPM, IAU, IUGG, URSI, ICAO, IMO, WMO, ISO, and invites to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of UTC or some other method, and take appropriate action, taking into account ITU-R studies,
- WRC-15 recognized the roles of the BIPM and ITU concerning time scales definition and maintenance and their dissemination, invited the various organizations to cooperate for developing studies on the present and potential future reference time scales and submit contributions to WRC-23 and decided than until WRC-23 Rec.

460-6 will continue to apply.

**Recommendation of Committee Action:**

*It is recommended that the ICG monitors the ongoing development of the proposed redefinition of UTC and that reports be presented until a decision is made at WRC-23.*

**Recommendation for Committee Decision (WG-D#20-A)**

| | |
|---|---|
| **Prepared by:** | **Working Group D** |
| **Date of Submission:** | **10 November 2016 (REVISED 12 November 2013)** |
| **Issue Title:** | **BIPM publication of [*UTC – GNSS times*] and [*UTC – UTC (k)*$_{GNSS}$] (revision of Recommendation 20 adopted in 2013)** |

**Background/Brief Description of the Issue:**

Considering that

- Coordinated Universal Time UTC is the sole international reference time scale,
- That GNSS times are constraint to keep within specified offsets from UTC(k),
- That GNSS broadcast a prediction of UTC(k) namely ***UTC (k)***$_{GNSS}$.

Noting that

- the BIPM has been publishing in its monthly *Circular T* for over 25 years daily values of [*UTC – GNSS times*] and more recently also of [*UTC – UTC (k)*$_{GNSS}$],
- This information is useful to users of GNSS services, but also to GNSS systems to assess the quality and interoperability of their systems.

**Discussion/Analyses:**

The monitoring of the values of [*UTC – GNSS times*] and [*UTC – UTC (k)*$_{GNSS}$] serves to a better coordination of the various GNSS and to provide a better time service to users.

The procedure for calculation of these values is provided in the explanatory supplement of *BIPM Circular T*.

**Recommendation of Committee Action:**

*The ICG WG-D recommends that the BIPM continues the regular provision of the values of [UTC – GNSS times] and [UTC – UTC (k)*$_{GNSS}$*] and extends them to other GNSS, in particular Galileo and BeiDou.*

**Recommendation for Committee Decision (#21-A)**

| | |
|---|---|
| **Prepared by:** | **Working Group D** |
| **Date of Submission:** | **10 November 2016 (REVISED 13 November 2013)** |
| **Issue Title:** | **On the monitoring of offsets between GNSS times (revision of Recommendation 21 adopted in 2013)** |

**Background/Brief Description of the Issue:**
Offsets between GNSS times are important information for GNSS users. Monitoring of the offsets between GNSS times and provision of consistent broadcast information are essential to improve interoperability and combined navigation using multiple GNSS.

**Discussion/Analyses:**
Information of the differences between the GNSS times is the basis of interoperability and combined application of the various GNSS systems. Every GNSS system has its own time system and they are different. The time offsets between different GNSS could be measured continuously by GNSS timing receivers, could be obtained by direct time comparison link or computed from a common reference. The monitoring and broadcast of GNSS time offsets are technically possible and will benefit GNSS providers and users.

The time offset between GPS and Galileo (GGTO) is currently being monitored and is planned to be broadcast in their navigation messages. The time offset parameters of BDT relative to the other three GNSS times have been designed in BeiDou navigation messages and the relevant experiments of monitoring and prediction have been implemented.

In order to improve the monitoring of offsets between GNSS times, the different GNSS should work for reaching consistency in the procedures for monitoring and broadcasting the GNSS time offsets.

**Recommendation of Committee Action:**
*1. GNSS Providers should consider monitoring of offsets between GNSS times and implement the broadcast of this information in the navigation messages.*
*2. GNSS Providers are encouraged to undertake studies on possible approaches for giving information on the offsets between GNSS times.*
*3. In order to improve consistency of offsets between GNSS times broadcast by the various systems, GNSS Providers should discuss on the adoption of the same or similar models.*
*4. In order to promote GNSS compatibility and interoperability, GNSS time relevant organizations actively develop methods to monitor the offsets between GNSS times and share the monitoring data and relevant research results.*

10th Meeting of ICG, Boulder, Colorado, United States, 1 - 6 November 2015

9th Meeting of ICG, Prague, Czech Republic, 10 - 14 November 2014

**Recommendation for Committee Decision (WG-D # 22)**

**Prepared by:** **Working Group D**

**Date of Submission:** **13 November 2014**

**Issue Title:** **ICG support for the UN General Assembly Resolution on the Global Geodetic Reference Frame**

**Background/Brief Description of the Issue:**
Considering

- The importance of geodesy and the global geodetic reference frame for scientific and societal applications;
- The important contribution of GNSS to location-based services in general and to the International Terrestrial Reference Frame in particular;
- The ICG mission and vision.

**Discussion/Analyses:**
The Committee of Experts of the United Nation Global Geospatial Information Management (UN-GGIM) has established a Working Group on the Global Geodetic Reference Frame (GGRF), tasked to draft (1) a text of a UN General Assembly Resolution, (2) an associated Concept Note, (3) Terms of Reference of the WG, and (4) establish a geodetic roadmap. At its 4$^{th}$ session held in New York in August 2014, the UN-GGIM Committee of Experts has adopted the draft text of the resolution prepared by the WG on GGRF and submitted it to ECOSOC for further referral to the General Assembly of the United Nation for adoption.

**Recommendation of Committee Action:**
*The ICG WG-D recommends that the ICG Providers' Forum consider supporting the approval by the UN-GGIM Committee of Experts of the draft resolution on Global Geodetic Reference Frame for Sustainable Development and its submission to the UN General Assembly.*

**Recommendation for Committee Decision (WG-D # 23)**

**Prepared by:** **Working Group D**

**Date of Submission:** **13 November 2014**

**Issue Title:** **Improving the accuracy of multi-GNSS orbits determination by the IGS**

**Background/Brief Description of the Issue:**
Considering

- several global navigation satellite systems (GNSS) exist and that each is continuously expanding and improving,
- the importance of improving the ITRF defining parameters for earth science and positioning applications
- the importance of the GNSS contribution to the ITRF from the IGS,
- the importance of the accuracy of the GNSS orbits determined by the IGS and their impact on the IGS products, and subsequently on the ITRF;
- the necessity of improving the orbit dynamics modelling of GNSS satellites by the IGS.

**Discussion/Analyses:**
The knowledge of GNSS satellite structure, geometry, dimensions, among other satellite data is fundamental to improving orbit modelling and accuracy.

**Recommendation of Committee Action:**
*The ICG WG-D recommends that the GNSS Providers consider the possibility of making available the following list (or a sub-set) of satellite data for better orbit dynamics modelling:*

***Primary list**:*

- *Surface geometry and dimensions*
- *Surface optical properties (or material types)*
- *Nominal attitude model*
- *Transmitted power in all signals (and direction if relevant)*
- *Solar panel construction information (thickness, conductivity, power draw)*
- *Position and power output of radiators*
- *Thermal properties of multi-layered insulation*

***More detailed list**:*

- *Structural data/drawings of the satellite, with dimensions (surface only – we don't need the internals)*
- *Optical properties (reflectivity, specularity) of the surface materials*
- *Identification of what is covered in multi-layered insulation (MLI) or 'thermal blankets'*
- *Attitude model of the satellite*
- *Power of all transmitted signals (note we don't need to know anything about function of the signals, only which way they are pointed, and how much power is transmitted)*
- *Construction data of the solar panel (material types, thickness, conductivity, surface properties – reflectivity, specularity, emissivity, power draw from the panel)*

***Other necessary information**:*

- *Centre of mass location*
- *Change of centre of mass over time (manoeuvres)*
- *Location of antenna reference point*
- *Phase centre offset for all frequencies w.r.t. antenna reference point*
- *Phase centre variation as function of azimuth and elevation*
- *Knowledge about the epoch of change of the attitude mode (e.g. for QZSS and BeiDou that switch from Yaw-steering to normal-mode)*
- *Attitude of the satellite as measured/computed on board (i.e. those values used by the attitude control system)*
- *Differential group delays between the different signals (on board of the satellite): can be measured pre-launch*

8th Meeting of ICG, Dubai, United Arab Emirates, 9 - 14 November 2013

**Recommendation 16-A for Committee Decision**

| | |
|---|---|
| **Prepared by:** | **Working Group D** |
| **Date of submission:** | **12 November 2013** |
| **Issue Title:** | **Information on the works related to the proposed redefinition of UTC (revision of Recommendation 16 (2012)** |

**Background/Brief Description of the Issue:**

Considering that:

- the navigation systems have unique timing and geodetic references for operational necessity. Interoperability of the GNSS requires interrelationship of the timing and geodetic references to reduce ambiguities for users with regard to the interpretation of navigation and timing solutions.
- discussion on redefinition of UTC started in 2000 at the ITU-R, SG7 Science Services WP7A Time Signals and Frequency Standard Emissions,
- during 2000-2010 WP7A studied the issue, considered different options, organized an open meeting (Torino, 2003), and worked on a proposal for an amended ITU recommendation,
- in 2010 the Draft Revision of Recommendation ITU-R TF.460-6 (new proposed version) was submitted by ITU-R WP7A to ITU-R SG7; while considering this issue at SG7 no consensus on the Draft Revision of Recommendation ITU-R TF.460-6 was achieved,
- the SG7 sent the Draft Revision of Recommendation ITU-R TF.460-6 to the Radiocommunication Assembly 2012 (RA -12) for « final decision »,
- at RA-12 after several statements of Administrations and Sector members supporting different views the Chairman stated that there are almost even balance between those administrations that are in favour of the draft revision of the Recommendation, those that are opposing it, and a third group of administrations who indicated that as they had not participated actively at SG7 and WP7A meetings, more information is required to enable them to form an opinion,
- as a result RA-12 decided to address this issue in the RA-12 Report for World Radiocommunication Conference 2012 (WRC-12) to develop a new WRC-15 Agenda item.
- WRC-12 started a new study question on WRC-15 Agenda item 1.14 in accordance with Resolution 653 (WRC-12) and put back the Draft Revision of Recommendation ITU-R TF.460-6 to SG7-WP7A for a final decision at WRC-15,
- WRC-12 Resolution 653 on the feasibility of a continuous UTC involves the BIPM, CCTF, CGPM, IAU, IUGG, URSI, ICAO, IMO, WMO, ISO, and invites to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of UTC or some other method, and take appropriate action, taking into account ITU-R studies.

**Recommendation of Committee Action:**

- *It is recommended that the ICG monitors the ongoing development of the proposed redefinition of UTC and that reports be presented until a decision is made at WRC-15.*

**Recommendation 18 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of submission:** **12 November 2013**

**Issue Title:** **Assessment of the alignments of GNSS associated reference frames to the ITRF**

**Background/Brief Description of the Issue:**

Considering

- The alignment of CGS2012 for Beidou, JGS2010 for QZSS, PZ-90.11 for GLONASS and WGS84(G1674) for GPS, the GTRF13v02 for Galileo to the latest realization of the International Terrestrial Reference System in the form of ITRF2008,
- The IGS effort in conducting MGEX project and in making publicly available all data collected at MGEX sites, including broadcast orbits and clocks.

**Discussion/Analyses:**

The users of different GNSS broadcast orbits contained in the corresponding navigation messages need consistent and precise point positioning results expressed in a reference frame that is pre-aligned to the ITRF.

**Recommendation of Committee Action:**

*The ICG WG-D recommends that interested groups to determine multiple sets of coordinates for MGEX or/and other stations where multi-GNSS receivers are operated, using individual sets of GNSS broadcast ephemeris, evaluate their consistency and provide feedback to the IGS multi-GNSS experiment.*

**Recommendation 19 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of submission:** **12 November 2013**

**Issue Title:** **Official provision of a rapid UTC (UTCr) by the BIPM**

**Background/Brief Description of the Issue:**
In November 2012 the ICG recognized that a rapid computation of UTC at the BIPM was an important service benefiting interoperability of navigation systems.

Considering that:

- after a successful pilot experiment started in January 2012, UTCr has attained the expected stability and accuracy,
- at the issue of the validation process, UTCr become an official BIPM product in July 2013, and is regularly published on the BIPM website every Wednesday at 18 h UTC at latest,
- the weekly provision of the offsets between local realizations UTC(k) in national institutes with respect to UTCr enhances the traceability of these local realizations to the ultimate reference UTC,
- the UTC(k) serving for synchronizing the GNSS times to UTC participate to the weekly UTCr solution, and that predictions of these UTC(k) are broadcast by GNSS,
- users of GNSS get a better synchronization of GNSS times to UTC, through improved UTC and UTC(k) predictions.

**Discussion/Analyses:**
N/A

**Recommendation of Committee Action:**
*WG-D recommends that GNSS Providers consider the use of UTCr for*

- *getting a better synchronization of GNSS times to UTC,*
- *improving the quality of the predictions of UTC(k) broadcast by GNSS, and further recommends studying the possibility of using UTCr as a common time reference for interrelationship between GNSS times.*

**Recommendation 20 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of submission:** **12 November 2013**

**Issue Title:** **BIPM publication of [*UTC – GNSS times*] and [*UTC – UTC (k)*$_{GNSS}$]**

**Background/Brief Description of the Issue:**
Considering that

- Coordinated Universal Time UTC is the sole international reference time scale,
- That GNSS times are constraint to keep within specified offsets from UTC(k),
- That GNSS broadcast a prediction of UTC(k) namely *UTC (k)*$_{GNSS}$.

Noting that

- the BIPM has been publishing in its monthly Circular T for over 25 years daily values of [*UTC – GNSS times*] and more recently also of [*UTC – UTC (k)*$_{GNSS}$]
- This information is useful to users of GNSS services, but also to GNSS systems to assess the quality and interoperability of their systems.

**Discussion/Analyses:**
The monitoring of the values of [*UTC – GNSS times*] and [*UTC – UTC (k)*$_{GNSS}$] serves to a better coordination of the various GNSS and to provide a better time service to users.

The procedure for calculation of these values is provided in Section 5 of BIPM Circular T, available at http://www.bipm.org/jsp/en/TimeFtp.jsp?TypePub=publication.

**Recommendation of Committee Action:**
*The ICG WG-D recommends that the BIPM continues the regular provision of the values of [UTC – GNSS times] and [UTC – UTC (k)*$_{GNSS}$*] and extends them to other GNSS, in particular Galileo and BeiDou.*

**Recommendation 21 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of submission:** **13 November 2013**

**Issue Title:** **On the monitoring of offsets between GNSS times**

**Background/Brief Description of the Issue:**
Offsets between GNSS times are important information for GNSS users. Monitoring of the offsets between GNSS times and provision of consistent broadcast information are essential to improve interoperability and combined navigation using multiple GNSS.

**Discussion/Analyses:**
Information of the differences between the GNSS times is the basis of interoperability and combined application of the various GNSS systems. Every GNSS system has its own time system and they are different. The time offsets between different GNSS could be measured continuously by GNSS timing receivers, could be obtained by direct time comparison link or computed from a common reference. The monitoring and broadcast of GNSS time offsets are technically possible and will benefit GNSS providers and users.

The time offset between GPS and Galileo (GGTO) is currently being monitored and is planned to be broadcast in their navigation messages. The time offset parameters of BDT relative to the other three GNSS times have been designed in BeiDou navigation messages and the relevant experiments of monitoring and prediction have been implemented.

In order to improve the monitoring of offsets between GNSS times, the different GNSS should work for reaching consistency in the procedures for monitoring and broadcasting the GNSS time offsets.

**Recommendation of Committee Action:**
1. *GNSS Providers should consider monitoring of offsets between GNSS times and implement the broadcast of this information in the navigation messages.*

2. *GNSS Providers are encouraged to undertake studies on possible approaches for giving information on the offsets between GNSS times.*

3. *In order to improve consistency of offsets between GNSS times broadcast by the various systems, GNSS Providers should discuss on the adoption of the same or similar models.*

7th Meeting of ICG, Beijing, China, 5 - 9 November 2012

**Recommendation 14 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Interrelationship of the GNSS geodetic references through the International Terrestrial Reference System (ITRS)**

**Background/Brief Description of the Issue:**

Considering

- that several global navigation satellite systems (GNSS) exist and that each is continuously expanding and improving,
- these navigation systems have unique timing and geodetic references for operational necessity. Interoperability of the GNSS requires interrelationship of the timing and geodetic references to reduce ambiguities for users with regard to the interpretation of navigation and timing solutions.
- the existence of the International Terrestrial Reference System (ITRS),
- the adoption of the ITRS by the International Union of Geodesy and Geophysics (IUGG) and by the General Conference on Weights and Measures (CGPM) for geosciences and metrological applications,
- that the adoption of a theoretical reference system would lead to benefits for users regarding interrelationship of navigation and timing solutions and systems interoperability.

It is essential for multi-GNSS positioning users to be able to position precisely their locations in a unique terrestrial reference frame. Given the fact that each GNSS system has its own reference frame, e.g. WGS84 for GPS, PZ-90 for GLONASS, CGCS2000 for COMPASS, GTRF for Galileo, etc., it is desirable, from the user point of view, to relate or align these different frames to the International Terrestrial Reference Frame (ITRF), as a realization of the ITRS

**Discussion/Analyses:**

The individual GNSS reference frames are materialized through the provision/computation of the coordinates using data collected at the ground control stations.

All the current individual GNSS reference frames are aligned to the ITRF.

**Recommendation of Committee Action:**

*The ICG WG-D recommends that the ITRS, as defined by the International Union of Geodesy and Geophysics (IUGG), adopted by the General Conference on Weights and Measures (CGPM) and realized by the International Earth Rotation and Reference Systems Service (IERS), be adopted by the ICG as the theoretical reference system for the alignment of GNSS terrestrial reference frames to the ITRF.*

**Recommendation 15 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Improving the GNSS contribution to the ITRF defining parameters**

**Background/Brief Description of the Issue:**

Considering

- several global navigation satellite systems (GNSS) exist and that each is continuously expanding and improving,
- the existence of thousands of continuously observing GNSS stations,
- the importance of improving the ITRF defining parameters for earth science and positioning applications
- the importance of the GNSS contribution to the ITRF from the IGS,
- the nearly unique role of GNSS in accessing and densifying the ITRF.

But considering also

- that weaknesses affect the GNSS reference frame in origin and scale.

**Discussion/Analyses:**

The GNSS reference frame exhibits weaknesses in origin and scale determination because of high correlations between (1) the reference frame Z-axis and satellite solar radiation pressure parameters and (2) the scale of the reference frame and the satellite antenna phase center offset.

**Recommendation of Committee Action:**

*The ICG WG-D recommends that the GNSS Providers consider (1) calibrating satellite antenna phase center and variations before launch, (2) adding retro-reflectors to GNSS satellites and (3) studying the possibility and utility of adding an accelerometer to new satellites.*

**Recommendation 16 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Information on the works related to the proposed redefinition of UTC**

**Background/Brief Description of the Issue:**
Considering that:

- the navigation systems have unique timing and geodetic references for operational necessity. Interoperability of the GNSS requires interrelationship of the timing and geodetic references to reduce ambiguities for users with regard to the interpretation of navigation and timing solutions,
- discussion on redefinition of UTC started in 2000 at the ITU-R, SG7 Science Services WP7A Time Signals and Frequency Standard Emissions,
- during 2000-2010 WP7A studied the issue, considered different options, organized an open meeting (Torino, 2003), and worked on a proposal for an amended ITU recommendation,
- in 2010 the Draft Recommendation ITU-R TF.460-6 (new proposed version) was submitted by WP7A to SG7; discussion came to a « dead-end » with a 10-year opposition from one administration, plus two more administrations joining this position,
- the SG7 sent the Draft Recommendation to the Radiocommunication Assembly 2012 (January) for « final decision »,
- WRC 2012 put back the recommendation to SG7-WP7A for a final decision at WRC 2015;
- WRC 2012 Resolution 653 on the feasibility of a continuous UTC involves the BIPM, CCTF, CGPM, IAU, IUGG, URSI, ICAO, IMO, WMO, ISO, and invites to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of UTC or some other method, and take appropriate action, taking into account ITU-R studies.

**Recommendation of Committee Action:**
*to inform the Providers and all ICG participants that the redefinition of UTC was not resolved at the WRC-2012 and the decision is deferred until WRC-2015. It is recommended that the ICG monitors the ongoing development of this issue.*

**Recommendation 17 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **08 November 2012**

**Issue Title:** **Declaration on the computation of Rapid UTC (UTCr)**

**Background/Brief Description of the Issue:**
Considering:

- that 10 to 40 days delay as publication of UTC in BIPM Circular T is not adequate for some applications,
- that short term assessment of UTC(k) steering to UTC, is impacting contributing laboratories, and in particular GNSS times steering to UTC(k),
- better determination of GNSS times offsets is essential for interoperability of navigation systems,
- discussions at the ICG in 2010 and 2011,
- discussions with experts in commissions for developing strategies for GNSS times,
- need of a « rapid » product, to give access on a shorter delay to an approximation to UTC, before final validation by Circular T, similar to IERS, IGS rapid products,
- that UTC contributing laboratories have been invited to participate on a voluntary basis to a pilot experiment (daily submission of daily data),
- positive responses of national time laboratories with adequate equipment,
- pilot experiment started on January 2012 computing every Wednesday rapid UTC and publishing it on BIPM website,
- report to the Consultative Committee for Time and Frequency in September 2012,
- pilot experiment will continue until final validation (few months)
- routine production of UTCr should start in 2013,
- UTC as calculated and published today will not be affected, however, it will benefit from UTCr.

**Recommendation of Committee Action:**
*to recognize UTCr as an important service benefiting interoperability of navigation systems, and to thank the BIPM and contributing time laboratories for their efforts and commitment. It further recommends that GNSS providers consider studying the possibility of using UTCr as a common time reference for interrelationship between GNSSs.*

6th Meeting of ICG, Tokyo, Japan, 5 - 9 September 2011

**APPENDIX A**

**WG-D Recommendation 11 for Committee Decision**

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|---|---|
| **Prepared by:** | **Working Group D** |
| **Date of Submission:** | **08/09/2011** |
| **Issue Title:** | **Finalization and Publication of Templates on Geodetic and Timing References** |

**Background/Brief Description of the Issue:**
ICG WG-D notes:

- progress at ICG-6 with submission of the remaining templates on geodetic references and timing prepared by System Providers;
- assessment by Task Force Chairs of the suitability and consistency of these templates, and;
- expresses appreciation to System Providers for providing this information.

**Discussion/Analyses:**
Templates are now complete it is timely and appropriate that these be made available to ICG and the community in general. It is recognized that these may be updated as necessary to reflect system changes.

**Recommendation of Committee Action:**
*ICG WG-D Recommends that, following minor amendments based on discussions at ICG-6, all templates for Geodetic and Timing References be published on the ICG website and that any future updates or improvements to templates also be published as they become available.*

**WG-D Recommendation 12 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **08/09/2011**

**Issue Title:** **Interoperability of geodetic references among the different GNSS systems**

**Background/Brief Description of the Issue:**
It is essential for multi-GNSS positioning users to be able to position precisely their locations in a unique terrestrial reference frame. Given the fact that each GNSS system has its own reference frame, e.g. WGS84 for GPS, PZ-90 for GLONASS, CGCS2000 for COMPASS, GTRF for Galileo, etc., it is desirable, from the user point of view, to relate or align these different frames to the International Terrestrial Reference Frame (ITRF).

**Discussion/Analyses:**
The individual GNSS reference frames are materialized through the provision/computation of the coordinates using data collected at the ground control stations.

The International GNSS Service (IGS) is providing in a weekly basis the coordinates of its global network consisting of more than 300 stations, expressed in the ITRF. Time series of IGS weekly station positions are used in the construction of the ITRF.

Eleven WGS84 control stations operated by the National Geospatial-Intelligence Agency (NGA) are delivering data to IGS. Station positions and velocities of these NGA 11 stations are now available in the latest ITRF solution, namely the ITRF2008. The inclusion of these NGA 11 stations greatly facilitates in an optimal way the alignment of WGS84 to the ITRF.

**Recommendation of Committee Action:**
*The ICG WG-D recommends that as GNSS Ground Control Segments become operational, the interested GNSS providers deliver the data collected at a globally representative subset of their respective monitoring control stations to the IGS on a regular basis to facilitate the alignment of all GNSS reference frames to the ITRF.*

**WG-D Recommendation 13 for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **08/09/2011**

**Issue Title:** **International GNSS Service Multi-GNSS Global Experiment – IGS MGEX**

**Background/Brief Description of the Issue:**
The IGS recently released a Call for Participation (CfP) for the IGS Multi-GNSS Experiment – IGS M-GEX. This CfP focuses on the availability of new additional GNSS signals on the horizon that are globally accessible. The IGS, through this CfP, is preparing for its next evolutionary phase to track, perform signal analysis, collect and analyze global GNSS data from these multi-GNSS constellations though an international tracking network experiment.

The objective is to eventually generate consistent, reliable and robust products for all GNSS available, in a fully interoperable manner, to benefit high-precision users, the scientific community, understanding inter-constellation biases, system monitoring and timing applications. IGS M-GEX will lay the groundwork for strengthening of the International Terrestrial Reference Frame (ITRF) by having contributions from all GNSS. The IGS M-GEX CfP is located at htpp://igs.org (see the 'What's New' box).

It is important to note that the IGS is simultaneously harmonizing the IGS M-GEX in support of the JAXA CfP titled '**Multi-GNSS Demonstration Project for Asia and Oceania'**, endorsed by the ICG-4 in St. Petersburg in 2009.

In addition, the IGS is a component of the Global Geodetic Observing System (GGOS). GGOS recently released a separate CfP that should be of interest to ICG members. GGOS is soliciting proposals for a core network of multi-technique, state-of-the-art geodetic sites (co-located VLBI, SLR, GNSS, DORIS, etc.) to define and improve the Terrestrial Reference Frame and provide essential data for fundamental space geodesy requirements. Please access this companion CfP at htpp://www.ggos.org

**Discussion/Analyses:**
Main objectives of the IGS M-GEX are to:

- Encourage and promote the international utilization of the available GNSS systems to observe, collect and analyze the collection of signals;
- Provide an international framework within the well established organization of IGS to operate an experimental network for multi-GNSS;
- Stipulate that a common format is needed for all experiment data, hence, RINEX 3.01 (or the most current update) will be the agreed upon format;
- Promote engineering analysis of inter-constellation signals as a key focus, as well as classic orbit and position determination based on the new signals, and comparison to current IGS products;
- Present and discuss interim results at the IGS 2012 Workshop in Poland, July 2327, 2012;
- Ultimately explore capabilities of IGS towards monitoring multi-GNSS performance.

And in WG-D discussions in support of Multi-GNSS Asia and IGS M-GEX to:

- Emphasize to receiver manufacturers the importance of implementation of SW for standard format exchange of data (RINEX and Real-time formats);
- Note that this would further the goals of WG-D ICG-5 Recommendation 9.

Experiment Description:

IGS M-GEX will operate February through August 2012. The experiment calls for participating:

- Multi-GNSS Observing Sites
- Multi-GNSS Data Centers
- Multi-GNSS Experiment Analysis Centers and/or Engineering Analysis Centers
- Multi-GNSS Collaborating Organizations and Networks

Detailed information is included in the CfP.

**Recommendation of Committee Action:**

*It is therefore recommended that the ICG support and endorse the IGS Multi-GNSS Global Experiment (IGS M-GEX) and actively encourage participation and/or contributions from:*

- *GNSS providers*
- *Governments, government agencies and international organizations related to GNSS utilization, including National Mapping Agencies (NMOs), timing, navigation, aviation, transportation, GIS, and relevant fields as appropriate in each country*
- *Appropriate UN bodies*
- *International organizations, and particularly ICG Associate Members and Observers*
- *Industries: receiver manufacturer, service providers*
- *Space Agencies*
- *Universities and research institutions*

5th Meeting of ICG, Turin, Italy, 18 - 22 October 2010

**ATTACHMENT 7**

**Recommendation for Committee Decision (WG-D Recommendation #06)**

**Prepared by:** **ICG Working Group D**

**Date of Submission:** **22 October 2010**

**Issue Title:** **Working Group D: New Name and Updated Work Plan**

**Background/Brief Description of the Issue:**
Working Group D proposes a name change and outlines its revised workplan in the Attached document.

**Discussion/Analyses:**
The original name of Working Group D is "Interaction with National and Regional Authorities and Relevant International Organizations", in order to better reflect the activities of the WG, and to facilitate remembering the name, we propose to rename the WG to:

**ICG Working Group D on Reference Frames, Timing and Applications (RFTA)**

After lengthy discussion, the workplan for WG-D is similarly revised and attached.

**Recommendation of Committee Action:**
*It is therefore recommended that the ICG*
a. *Approve and accept the new name, and*
b. *Approve and accept the updated workplan.*

**ATTACHMENT 8**

**Recommendation for Committee Decision (WG-D Recommendation #07)**

**Prepared by:** **ICG Working Group D**

**Date of Submission:** **22 October 2010**

**Issue Title:** **Working Group D: Multi-GNSS Demonstration**

**Background/Brief Description of the Issue:**
The IGS, IAG and FIG are already committed to supporting the Multi-GNSS Demonstration Project in the Asia Oceania region in line with the relevant recommendations at ICG-4. The IGS is now extending that support through a wider Call for Participation in a global Multi-GNSS Demonstration Campaign, which will bring in other relevant international activities.

**Discussion/Analyses:**
The working group notes that the IGS Governing Board decided in June 2010 to prepare a Call for Participation (CfP) in a Multi-GNSS Demonstration Campaign to initiate longer-term preparation to incorporate and utilize other GNSS and regional systems.

This is a similar approach taken by the IGS in 1998 when a CfP was developed for an International GLONASS Experiment (IGEX) that resulted in a phased approach to observing, analyzing and ultimately incorporating GLONASS into the IGS processing streams. This contributed to the decision to change the name of IGS from International GPS Service into the International GNSS Service in 2005. GLONASS and GPS are both routinely handled on a continuous basis with the IGS network and processing streams.

**Recommendation of Committee Action:**
*It is therefore recommended that the ICG*

a. *Note the IGS support for ICG WG-D Recommendation 5 on Multi-GNSS in support of Japan's proposal, and,*

b. *Note that the CfP will extend this to a global Multi-GNSS Demonstration Campaign and that the CfP will be broadly distributed within ICG.*

**ATTACHMENT 9**

**Recommendation for Committee Decision (WG-D Recommendation #08)**

**Prepared by:** **ICG Working Group D**

**Date of Submission:** **22/10/2010**

**Issue Title:** **Adoption of the International Terrestrial Reference System (ITRS) by the General Conference on Weights and Measures (CGPM) in October 2011**

**Background/Brief Description of the Issue:**
The International Terrestrial Reference System (ITRS) has been recommended by the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (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 (GTRF), the China Geodetic System 2000 (CGS'2000), and the regional densifications.

**Discussion/Analyses:**
As previously noted, interoperability of the various GNSS benefit greatly by aligning to a common geodetic and time references.

The ICG is a unique mechanism to recommend that GNSS Service Providers align their Geodetic and Time References to the internationally recognised standards and conventions represented by the ITRS and UTC for the operation of their systems. A key issue for ICG to note is that while UTC has been endorsed by the CGPM in 1975, the ITRS has never been officially recommended for use by any intergovernmental organization.

**Recommendation of Committee Action:**
*Considering*

- *that international geodetic reference is ITRS as realized by ITRF;*
- *that the International Committee for Weights and Measures (CIPM) agreed in October 2009 on the need to support the adoption of the ITRS as the reference for geodetic metrological applications;*
- *that the General Conference on Weights and Measures (CGPM) will vote in October 2011 on a resolution recommending the adoption of the ITRS as the international standard for terrestrial reference frames used for all metrological applications;*
- *that the endorsement by the CGPM will bring the ITRS under the umbrella of the Metre Convention: an international treaty to which all current System Providers and many GNSS user countries are signatories.*

*WG D recommends to the ICG*

*a. Note the above and its implications for the work of the Working Group D Task Forces and the System Providers.*

**ATTACHMENT 10**

**Recommendation for Committee Decision (WG-D Recommendation #09)**

**Prepared by:** **ICG Working Group D**

**Date of Submission:** **22/10/2010**

**Issue Title:** **Radio Technical Commission for Maritime Services**

**Background/Brief Description of the Issue:**
RTCM is considering the establishment of a sub-committee devoted to the definition and extension of the RINEX (Receiver Independent Exchange) format. IGS is a full member of RTCM and is working in the RTCM on GNSS format issues, including real-time formats, and seeking a common, open (non-proprietary) format to be agreed upon by receiver manufacturers as a common interface to users.

**Discussion/Analyses:**
The IGS has been in discussion with JAXA, as the lead organization for the Asian Pacific MultiGNSS campaign, to extend the RINEX format to handle data from QZSS.

Data and exchange formats for multi-GNSS are increasingly complicated and a more unified approach seems prudent.

**Recommendation of Committee Action:**
*Considering*

*WG D recommends to the ICG*

*That all System Providers be aware of these issues and recognize the importance of open descriptions of GNSS signals to ensure proper implementation, into new multi-GNSS receivers, the output of well-defined measurement data, and*

*They are also encouraged to liaise with IGS and RTCM to ensure that future signals from next generation GNSS are supported through unambiguously defined exchange formats (e.g., extensions to RINEX, or common receiver output) and output data streams.*

**ATTACHMENT 11**

**Recommendation for Committee Decision (WG-D Recommendation #10)**

**Prepared by:** **Working Group D**

**Date of Submission:** **21 October 2010**

**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:

- SLR can perform a completely independent Quality Assurance on the computation of the orbits of GNSS satellites;
- 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;
- SLR can help to ensure that the realization of each Geodetic Reference used in a GNSS in order to improve accuracy, reliability and consistency with respect to the International Terrestrial Reference Frame (ITRF).

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

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

**Discussion/Analyses:**
During discussions at ICG5, WG-D reiterated its commitment to the Recommendation to ICG3 in Pasadena to encourage all GNSS System Providers to ensure that all future GNSS satellites carry a suitable retroreflector array.

**Recommendation of Committee Action:**
It is therefore recommended to the ICG and its Providers Forum that:

a. It commends Japan for its deployment of retroreflectors on their recently launched QZSS satellite, and;

b. b. Notes that Japan therefore joins China, Europe, India and Russia among the System Providers now including retroreflectors in their current designs for GNSS satellites.

4th Meeting of ICG, Saint-Petersburg, Russian Federation, 14 - 18 September 2009

**Recommendation for Committee Decision**

**Prepared by:** **Working Group D**

**Date of Submission:** **09/17/09**

**Issue Title:** **Multi-GNSS Demonstration Project for Asia and Oceania**

**Background/Brief Description of the Issue:**

In Asia Oceania region there are three major global systems:

- Global Positioning System (GPS) (24 SVs in nominal constellation, currently 32 SVs);
- GLObal NAvigation Satellite System (GLONASS) (24 SVs).

And in the future:

- COMPASS (10 => 35);
- Galileo (27 + spare 3 = 30 SVs);

Plus three regional satellite PNT systems:

- Quasi-Zenith Satellite System (QZSS) (3);
- Indian Regional Navigation Satellite System (IRNSS) (7).

New modernized global navigation satellite system (GNSS) signals, multi-frequency and multiGNSS signals can be utilized earlier here than in other regions in the world

**Discussion/Analyses:**

Main objectives of the project are to:

- Encourage and promote the introduction and utilization of satellite positioning, navigation and timing services in the Asia and Oceania region through assistance with the integration of GNSS services into their infrastructures;

- Promote new multi-GNSS utilization and applications in the region and feedback needs and requirements related to interoperability from user communities to GNSS providers

- Encourage GNSS provider and users in Asia Oceania region to develop new applications and carry out experiment or demonstration jointly.

Project Description:

The proposed Multi-GNSS observation network has the following features:

- Generate precise orbit and clock offset estimation and prediction, time offset bias among multi-GNSS systems, ionospheric, tropospheric delay, and other beneficial information for experiments

- Provision of multi-frequency, multi-GNSS receivers for the above purposes is being considered by the Japan Aerospace Exploration Agency (JAXA);

- Provides the opportunity to experiment using first QZSS satellite LEX and L1-SAIF signals;
- Requires collaboration with International GNSS Service (IGS) and related organizations, which will also promote the project concept within their communities;
- Requests contributions from other GNSS providers such as provision of receivers and co-locations with monitor stations sites.

**Recommendation of Committee Action:**

*It is therefore recommended that the ICG support and endorse the Multi-GNSS Demonstration Project and actively encourage participation and contributions from:*

- *GNSS providers*
- *International organization, and particularly ICG Associate Members related to GNSS utilization: IGS, the International Federation of Surveyors (FIG), the International Association of Geodesy (IAG);*
- *Government agencies and international organizations related to GNSS utilization in Asia Oceania region: Mapping, Transportation, Geographic Information System (GIS), Tourism, and relevant fields in each country, and United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Asian Development Bank (ADB), etc.;*
- *Industries: Receiver manufacturer, service providers;*
- *Universities and research institutes.*

3rd Meeting of ICG, Pasadena, USA, 8 - 12 December 2008

**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:**
*Considering*

(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.*

2nd Meeting of ICG, Bangalore, India, 5 - 7 September 2007

**Report of the Working Group D: Interaction with national and regional authorities and relevant international organizations**

1. The Working Group D on Interaction with National and Regional Authorities and Relevant International Organizations held its first meeting on 6 September 2007 under the chairmanship of International Association of Geodesy (IAG), International GNSS Service (IGS) and Fédération internationale des géomètres (FIG).

2. In accordance with the workplan (A/AC.105/879), the Working Group considered the following two specific assignments:

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

3. The Working Group noted that the Working Group on Compatibility and Interoperability discussed a similar action, i.e. develop a strategy for support by the ICG of mechanisms to detect and mitigate sources of electro-magnetic interference taking existing regulatory mechanisms into consideration. It was also noted that the results of the Working Group A was close coordination with the Working Group D on this aspect of interference.

4. The Working Group noted that the Working Group A agreed that it was not advisable at present to separate inter-system interference from any other interference to GNSS, whether unintentional, sporadic, casual and so forth. It was noted, that the Working Group A would further propose to the ICG that an Expert Session be planned for a future ICG meeting in order to address interference issues in terms of providing a venue and explore raising awareness of interference issues.

5. It was noted that the ICG could foster the exchange of information for independent assessment of interference of GNSS. Therefore the Working Group agreed to coordinate with the Working Group A on this issue and await the report and proposals of the Working Group A.

6. The Working Group held discussions on site quality and integrity. It was noted that a demonstration of the resources available from IGS in terms of station information, Site Guidelines, Frequently Asked Questions (FAQs), automated change-point analysis applied to the global tracking network (to determine any excursions beyond set levels of various data indicators and raise an alarm notification) should be promoted by the ICG as best practice for GNSS.

7. The Working Group further noted that the guidelines covered a number of different types of GNSS applications. It was generally agreed that one document source would be preferable and that extensions of IGS site guidelines could be considered by the Committee to include additional applications, for example, DGNSS, Real Time Kinematics (RTK).

8. The Working Group noted that the current guidelines were adopted with the IGS community which consists of more than 200 organizations in over 80 countries, discussed with many leading national mapping agencies, approved by the IGS governing board and currently adopted by regional reference frames (African Geodetic Reference Frame (AFREF), EUREF, GAGAN, Geocentric Reference System for the Americas (SIRGAS)).

9. The Working Group also noted that for these regional implementations extensions to the site guidelines for their specific requirements was quite reasonable, and the benefits of adopting a particular set of guidelines permit enhanced global interoperability amongst GNSS users. Therefore the Working Group encouraged the use, review, refinement and extension, as needed, of the IGS site guidelines.

10. The Working Group held discussions on regional reference frames. It was noted that all regional reference frames should be within the context of the International Terrestrial Reference System (ITRF) and its realization.

11. At the meeting of the Working Group, the chairman of the IGS presented a document (see Appendix I) entitled “Proposal to Establish a Working Group on Geodetic References within the International Committee on GNSS” outlining the objective “there is an emerging demand to recognize the International Terrestrial Reference System (ITRS) as the unique preferred system geo-referencing in science and applications”.

12. After considering the presented document, it was noted that the Working Group should not lose sight of the importance of the regional reference frames. It was further noted that these are inseparable, the needed development of the global ITRS and the continental reference frames in order to continually improve both.

13. The view was expressed whether timing should be included in the proposed Working Group since it was a fundamental aspect of the Geocentric Terrestrial Reference System (GTRS).

14. The Working Group agreed that timing should not be included, however the Working Group should harmonize with existing bodies, BIPM, for close cooperation. It was noted that the Working Group A will propose a recommendation on “Coordination of Navigation Satellite Systems Space and Time References” (see Appendix II). The Working Group supported this recommendation.

15. The view was expressed that BIPM works on a legal basis, whereas the ITRS was not recognized on a legal basis, but globally adopted. The Working Group agreed to explore this issue and consider bringing a legal basis to the IRS/ITRF. The importance of having representatives of the service providers in the Working Group was noted.

16. The Working Group agreed to propose to the Committee an establishment of a Working Group on geodetic references.

17. The view was expressed that service providers should include in the information on the reference frame and timing system being used into the “Template for Information Sharing between GNSS Service Providers”.

18. The Working Group proposed that the Committee should recommend the densification of the IGS network particularly in sparse areas, and encourage improved access to GNSS observation data from many existing and planned stations noting the wide benefit to society by having improved access to observational data.

19. The Working Group encouraged the Committee to support the recent IAG recommendations to place retro-reflectors on all GNSS satellites.

**Appendix I**

## Proposal to establish a Working Group on Geodetic References within the International Committee on Global Navigation Satellite Systems

Claude Boucher, as of 8 July 2007

### Context

*Promotion of the International Terrestrial Reference System*

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.

Meanwhile, for various reasons, several communities (for instance civil aviation, hydrography) have formally adopted the World Geodetic System 1984 (WGS84) to play this role.

In fact, there is no real technical problem, but rather an issue of terminology and proper understanding. A major proof of that is the recent agreement signed by the United States and the European Union about GNSS, and specifically about the interoperability between GPS and Galileo. This document specifies that each system will implement a realization of a system, which will be as close as possible to ITRS. It is recognized that WGS84 designates the United States implementation of ITRS for GPS (at least for the nominal operational service, i.e. Broadcasted data). As consequence, WGS84 should be understood as a realization of ITRS associated with the operational use of GPS (namely use of message). Similarly, the operational tracking network to be deployed for Galileo will be expressed as a frame designated by GTRF, as a particular realization of ITRS.

The International Union of Geodesy and Geophysics (IUGG) has recently formally approved the definition of ITRS and its use as unique preferred system through a resolution adopted at its General Assembly in Perugia (July 2007):

"The International Union of Geodesy and Geophysics

*Considering* the increasing importance of geodetic reference systems in Geosciences, and more generally in numerous scientific or technical activities, such as satellite navigation systems or geo-information,

*Noting* the IUGG Resolution 2 and IAG Resolution 1, both adopted in 1991 at the Vienna General Assembly, defining the Conventional Terrestrial Reference System (CTRS),

*Recognizing* the quality of the work done by several IAG services (IERS, IGS, ILRS, IVS, IDS) to actually realize these systems and provide regular access for numerous users within and beyond the geosciences community,

Endorses the definition of a Geocentric Terrestrial Reference System (GTRS) as a "System of geocentric space-time coordinates within the framework of General Relativity, co-rotating with the Earth and related to Geocentric Celestial Reference System by a spatial rotation which takes into account the Earth orientation Parameters", in agreement with the IAU resolution B1.3, 2000,

Endorses the definition of the International Terrestrial Reference System (ITRS) as the specific GTRS for which the orientation is operationally maintained in continuity with past international agreements (so-called BIH orientation).

Furthermore adopts the ITRS as preferred system for any scientific application and urges other communities such as geo-information, or navigation to do the same."

*International Committee on Global Navigation Satellite Systems*

The International Committee on Global Navigation Satellite Systems was established in December 2005 on voluntary basis as an informal body gathering any country, national or international organizations involved in GNSS, either as service provider or user. In particular, IGS and BIPM are already members of the ICG.

It is expected that the International Civil Avaiation Organization (ICAO) or the International Hydrographic Organization (IHO) will also join the ICG.

**Proposal**

In recognition of the context, it is proposed to establish within the ICG a Working Group (or any equivalent structure) on Geodetic References.

The goals of this Working Goup would be:

(a) to gather all ICG participants interested by the subject (system and service providers, users);

(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 a recommendation about ITRS and its realizations, both from GNSS suppliers and user point of view;

(e) to discuss and sketch implementation plans in each concerned community (for instance modification of ICAO or IHO resolutions).

The recommendation of the Working Group A supported by the Working Group D: Coordination of navigation satellite systems space and time references.

**Recommendation**

The International Committee on Global Navigation Satellite Systems,

*Considering*

- the international value of having many GNSS operational with a composite contribution of several tens of satellites;

- the desirability of using all systems interchangeably;

- the use by GPS of references very close to UTC and ITRF;

- the GLONASS efforts to approach UTC and ITRF;

- the Galileo design referring to UTC and ITRF;

- that other important satellite navigation systems are now being designed and developed*),

*Recommends*

- that the reference times (modulo 1 s) of satellite navigation systems be synchronized as closely as possible to UTC;

- that the reference frames for these systems be in conformity with the ITRF;

- that these systems broadcast, in addition to their own System Time (ST):

1. the time difference between ST and a real-time realization of UTC, 2. a prediction of the time differences between ST and UTC.

* *Compass, IRNSS, QZSS, various SBAS*

**Appendix II**

***Extract from***

**Resolutions adopted by the Council at the XXIV International Union of Geodesy and Geophysics (IUGG) General Assembly, Perugia, Italy, 2 – 13 July, 2007**

**http://www.iugg.org/resolutions/perugia07.pdf**

**Resolution 2: Geocentric and International Terrestrial Reference Systems (GTRS and ITRS)**

The International Union of Geodesy and Geophysics,

*Considering,*

The increasing importance of geodetic reference systems in geosciences, and more generally in numerous scientific and technical activities, such as satellite navigation systems and geospatial information;

*Noting,*

The IUGG Resolution 2 and International Association of Geodesy (IAG) Resolution 1, both adopted in 1991 at the Vienna IUGG General Assembly, which defined the Conventional Terrestrial Reference System (CTRS);

*Recognizing,*

The quality of the work done by several IAG services (IERS, IGS, ILRS, IVS, IDS) to realize these systems and provide access for numerous users within and beyond the geosciences community;

*Endorses*

The definition of a Geocentric Terrestrial Reference System (GTRS) in agreement with the 2003 IAU resolution B1.3;

The definition of the International Terrestrial Reference System (ITRS) as the specific GTRS for which the orientation is operationally maintained in continuity with past international agreements (BIH orientation); and

*Adopts*

The ITRS as the preferred GTRS for scientific and technical applications; and

*Urges*

Other communities, such as the geo-spatial information and navigation communities, to do the same.