



International Cooperation on GNSS: A Provider Perspective on the ICG

International GNSS (IGNSS) Conference

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GNSS: A *Global Navigation Satellite System of Systems*

- Global Constellations

- GPS (24+3)
- GLONASS (24+)
- GALILEO (24+3)
- BDS/BEIDOU (27+3 IGSO + 5 GEO)



- Regional Constellations

- QZSS (4+3)
- IRNSS/NAVIC (7)

- Satellite-Based Augmentations

- WAAS (3)
- MSAS (2)
- EGNOS (3)
- GAGAN (3)
- SDCM (3)
- BDSBAS (3)
- KASS (2)



International Committee on Global Navigation Satellite Systems (ICG)

- Emerged from 3rd UN Conference on the Exploration and Peaceful Uses of Outer Space July 1999
 - Promote the **use of GNSS** and its **integration into infrastructures**, particularly in developing countries
 - Encourage **compatibility and interoperability** among global and regional systems
- Members include:
 - **GNSS Providers:** (U.S., EU, Russia, China, India, Japan)
 - Other Member States of the United Nations
 - International organizations/associations



<http://www.unoosa.org/oosa/en/ourwork/icg/icg.html>



ICG Mission Statement (2013)

- Promote voluntary cooperation on matters of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services
- Contribute to the sustainable development of the world
- Encourage coordination among GNSS Providers to ensure greater *compatibility, interoperability, and transparency*
- Promote the introduction and utilization of GNSS services in developing countries, by assisting with the integration into their infrastructure
- Assist GNSS users with their development plans and applications, by encouraging coordination and serving as a focal point for international information exchange



ICG Information Centres

- Establishment of UN Affiliated Regional Centres for Space Science and Technology Education
 - Africa: Morocco and Nigeria
 - Latin America and the Caribbean: Brazil and Mexico
 - Asia and the Pacific: India
 - Western Asia: Jordan
- Goal is to create a knowledgeable workforce which contributes to the advancement of GNSS and its applications in the regions
 - GNSS Curriculum has been introduced
- Other GNSS Centres of Excellence encouraged to work with the Regional Centres to promote better outreach activities and knowledge sharing



ICG Meetings

Past ICG Meetings

- ICG-1: UN Vienna, Austria – November 2006
- ICG-2: Bangalore, India – September 2007
- ICG-3: Pasadena, CA, USA – December 2008
- ICG-4: St Petersburg, Russia – September 2009
- ICG-5: Turin, Italy – October 2010
- ICG-6: Tokyo, Japan – September 2011
- ICG-7: Beijing, China – November 2012
- ICG-8: Dubai, UAE – November 2013
- ICG-9: Prague, Czech Republic – November 2014
- ICG-10: Boulder, CO, USA – November 2015
- ICG-11: Sochi, Russia – November 2016
- ICG-12: Japan – December 2017

Future Meetings

- **ICG-13: China – 2018**
- ICG-14: India – 2019
- ICG-15: UN Vienna, Austria - 2020

<http://www.unoosa.org/oosa/en/ourwork/icg/icg.html>



12th Meeting of the International Committee on GNSS (ICG-12)



- More than 200 participants
 - Representatives from 20 countries/organizations (including Australia)
 - Representation from 5 GNSS Providers
- Agenda included:
 - Meeting of the Providers' Forum
 - System Provider Updates
 - Applications and Experts Session
 - Meeting of all four Working Groups





ICG Provider Forum

- Established in 2007
- Terms of Reference created in 2008
- Members
 - Current and Future GNSS and Satellite Based Augmentation System (SBAS) Providers
 - China (BEIDOU/BDSBAS), India (NAVIC/GAGAN), Japan (QZSS/MSAS), Russia (GLONASS/SDCM), U.S. (GPS/WAAS), EU (GALILEO/EGNOS)
- Purpose
 - Focused discussions on compatibility and interoperability, encouraging development of complimentary systems
 - Exchange detailed information on systems & service provision plans
 - Exchange views on ICG work plan and activities
- Next Meeting: 20th Meeting, June 2018, Vienna, Austria

Providers participate in, and are supported by, the ICG Working Group on Systems, Signals and Services



ICG Working Groups

2006 Terms of Reference and Work plan:

4 Working Groups Established

- A. WG-S: Systems, Signals and Services (Co-Chairs: U.S. & Russia)
 - Focus on compatibility and interoperability, encouraging development of complimentary systems
 - Exchange information on systems and service provision plans, spectrum protection
- B. WG-B: Enhancement of GNSS Performance, New Services and Capabilities (Co-Chairs: China, India & European Space Agency)
 - Focus on system enhancements (multipath, integrity, interference, etc.) to meet future needs, interoperable GNSS Space Service Volume, space weather
- C. WG-C: Information Dissemination and Capacity Building (Chair: UN Office for Outer Space Affairs)
 - Focus on training/workshops, promoting scientific applications, outreach
- D. WG-D: Reference Frames, Timing and Applications (Co-Chairs: IAG, IGS & FIG)
 - Focus on monitoring and reference station networks, timing issues



ICG Working Group on Systems, Signals and Services (WG-S)

- Co-chaired by the United States and the Russian Federation
- Workplan focused on assisting Providers in the pursuit of complimentary systems
 - *Compatibility and Interoperability* – Consider the perspective of various user applications and manufacturers
 - *Spectrum Protection* - Interference Detection, and Mitigation - Develop a strategy for supporting mechanisms to detect and mitigate sources of electromagnetic interference
 - *Open Service Information Sharing* – Pursue principle of Transparency: every GNSS provider should publish documentation that describes the system information, the policies of provision and the minimum levels of performance for open services
 - *Service Performance Monitoring* – potential cooperation in the development of the necessary ground infrastructure to monitor signal and service performance for open services



Compatibility and Spectrum Protection

- Seek common understanding on ***appropriate methods to determine compatibility*** among all GNSS
- ***Review existing ITU regulations and recommendations*** related to the avoidance of harmful interference to GNSS
 - ***Propose new questions or studies for ITU consideration***, as necessary, to protect all GNSS from harmful interference
- ***Develop educational material*** on sources of interference to GNSS, in an effort to educate governments of user community member nations on GNSS spectrum protection and management



Interference Detection & Mitigation (IDM)

- Develop a ***strategy to support mechanisms to detect and mitigate sources of electromagnetic interference***
- Focus on worldwide effort to ***implement coordinated interference detection and mitigation capabilities at the national level***
- Develop ***standards for interference reports submitted to GNSS Civil Service National Centers*** and establish routine communications among the centers
- ***Recommend standards for IDM capabilities to be implemented*** by national governments and industry
- ***Facilitate information exchange*** among system providers on positioning, navigation, and timing capabilities to complement GNSS



GNSS Interference and Spectrum Protection: A Multilateral Effort

- Core Area of Focus of the International Committee on GNSS (ICG)
 - Primarily discussed within the Working Group on Systems, Signals and Services (WG-S)
 - Subgroup on Compatibility and Spectrum Protection established in 2010
 - Task Force on Interference Detection and Mitigation (IDM) established in 2013
 - Six IDM Workshops have been held since 2012 – organized by the ICG
- Recent and Near Future Activities in the ICG
 - Two Seminars on Spectrum Protection (2015 and 2016)
 - Presentation to the UN Committee on the Peaceful Uses of Outer Space (COPUOS) Science and Technical Subcommittee on the importance of GNSS Spectrum Protection and IDM (February 2017)
 - 7th IDM Workshop will take place as part of the Baska Conference in Croatia, 6-8 May 2018 – All are welcome to participate!



GNSS Jammers – National Legal Status (As Reported at ICG-9)

Jammers	US	RU	China	EU
manufacture	illegal	illegal	illegal	Nation-by-nation
sell	illegal	illegal	illegal	illegal
export	illegal	illegal	illegal	Nation-by-nation
purchase	Undefined (consumer import illegal)	illegal	illegal	illegal
own	legal	Undefined	Undefined	legal
use	illegal	illegal	illegal	illegal



Recommendations Related to Interference and Spectrum Protection

Recent Recommendations Adopted by the ICG	
2014	ICG Members to join efforts in ITU-R and WRC-2015 for GNSS spectrum protection from IMT
2014	Evaluate existing and emerging IDM capabilities and consider developing, testing and implementing these or similar capabilities
2014/2017	Crowdsourcing capabilities analysis for IDM
2015/2016/ 2017	UN regional workshops on GNSS spectrum protection and IDM
2015/2016	Campaign of Protection of RNSS operations – GNSS providers and GNSS user community member states promote spectrum protection
2015/2016	UN COPUOS multi-year agenda item focused on National Efforts to protect RNSS Spectrum, and develop IDM capability
2017	Encourage national regulators to use the protection criteria in relevant ITU-R Recommendations



GNSS Interoperability

- ***Interoperability definition adopted at the first Providers Forum meeting and updated at the third meeting***
- Consider the perspective of various user applications and equipment manufacturers by interacting ***with industry experts and user community representatives 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
- ***Focus on the open service signal development*** and broadcast plans of the system providers
- ***Consider the role of system time and geodetic reference frames in enabling interoperable*** multi-GNSS service



Interoperability Workshops Hosted by GNSS Providers

Interoperability and Service Standards Subgroup co-chaired by the U.S. and China

- Five Workshops held between 2013 & 2015:
 - **U.S.** hosted workshop – April 2013, Honolulu
 - **Russia** hosted workshop – April 2014, Moscow
 - **China** hosted workshop – May 2014, Nanjing
 - **Japan** hosted workshop – August 2014, Osaka
 - **EU** hosted workshop – March 2015, Munich
- Focused on receiving industry/user feedback on Interoperability and multi-GNSS use
- Led to in depth discussions within the Interoperability Subgroup and recommendations adopted by the full ICG



Open Service Information

- From the current work plan of the ICG Working Group on Systems, Signals, and Services:
 - 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 Interoperability and Service Standards Sub-Group will develop a template:
 - To promote **common terminology and definitions** in individual GNSS Open Service Signal Specifications
 - 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**



Status of GNSS ICDs and Open Service Performance Standards

	GPS	GLONASS	BDS	GALILEO	NAVIC	QZSS
Interface Control Documents/ Specifications	✓	✓	✓	✓	✓	✓
	IS GPS 200-H, 705D, 800D	ICD 5.1 for L1&L2 FDMA (2008) ICD 1.0 for L1, L2&L3 CDMA (2017)	ICD 2.1 Open Service signals B1C & B2a (test version)	ICD 1.2	ICD 1.0	IS-QZSS-PNT-001 IS-QZSS-L1S-001 IS-QZSS-L6-001 IS-QZSS-TV-001 (4 of 5 Svs.)
Open Service Performance Standards	✓	Draft for L1&L2 service is in approval stage	✓	Galileo SIS Operational Status Definition V 1.1 , 7/16 Galileo OS Service Definition Document First version in 16 Update in 17-18		✓
	SPS PS 4 th edition (L1-only)	English Draft Provided to WG	OS PS 1.0			PS-QZSS-001
Web Access	GPS.gov	GLONASS-IAC.RU	en.beidou.gov.cn/	ec.europa.eu/galileo	irnss.isro.gov.in/	qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html



Focus Group on Performance Standards Guidelines

Status as Reported at ICG-12 Meeting – December 2017

Item	Status	Comments
Recommend content for Performance Standards	Complete	Draft Performance Standard Template prepared in 2012
Collect inputs on minimum common set	Complete	Survey conducted in Dec 2016
Finalize minimum common set	Complete	Resolved at Sep 2017 meeting
Each GNSS/RNSS provide definitions for terms	In progress	Request for definition of continuity. Preparing document tree. Discuss at 2018 Workshop.
Each GNSS/RNSS identify calculation methods	In progress	Plans to hold 2018 Workshop in Spring in Europe
Finalize set of definitions		Target complete by ?
Issue Performance Standard template		



Service Performance Monitoring

- ***Discuss*** proposals ***to widely monitor the performance of GNSS open signals*** and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability
- ***Translate open service performance standards into parameters for multi-GNSS monitoring***
- Adopt recommendations, as necessary, for ***monitoring infrastructure and organizational approaches***



Civil Service Monitoring Information Sources

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



International GNSS Monitoring and Assessment (IGMA) Trial Project

2015 ICG 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



Status of ICG-IGS Joint Trial Project

- In December 2016 – IGS Governing Board approved the ICG-IGS Joint Trial Project (JTP)
- In July 2017 at IGS Work Shop - Kick-off of ICG-IGS JTP
 - 13 IGS Analysis Centers (ACs) are involved
 - 1 IGS Analysis Center Coordinator (ACC) - ESOC
- Agreement to process a limited dataset in order to
 - gain experience in cooperation within ACs
 - identify areas where clarifications are needed
 - Formats, Algorithms, Reference,...



Recommendations Related to Interoperability

Recent Recommendations Adopted by the ICG	
2011/2012	Open Service GNSS performance parameters, including Definitions and Calculation Methods
2012/2013	Interoperability Workshops with industry
2014/2015	National service monitoring center websites to connect to ICG internet portal
2014/2016	Performance Monitoring Workshop
2015	Joint trial project with IGS to demonstrate a global GNSS Monitoring and Assessment capability
2016	Protection from Provider Signal Patents Workshop to discuss system time and offsets
2016/2017	Workshop to discuss system time and offsets
2017	Develop guidelines on how to select and prioritize GNSS satellite laser tracking



Space Service Volume Cooperation

- GNSS Providers working through the ICG to create an interoperable Space Service Volume (SSV) that can be used for real-time navigation
 - Significantly improves real-time navigation performance
 - GNSS timing reduces need for expensive on-board clocks
 - Supports increased satellite autonomy
- Recommendations adopted by the ICG include:
 - Development of an SSV booklet by GNSS Providers
 - Outreach effort on SSV initiative
 - Use of GNSS for exploration activities in cis-Lunar space and beyond



System-of-System Operations

- ***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
- Discuss ***coordination of constellation configurations and replenishment of satellites*** in specific orbital locations in an effort to improve open service performance provided by the system of global and regional navigation satellite systems
- Investigate the overall ***GNSS open service volume*** in order to consider improvement in terms of accuracy, integrity, availability, reliability and service coverage



Orbital Debris Mitigation Discussions

- At ICG-12 GNSS providers discussed how they are applying IADC and United Nations orbital debris mitigation guidelines to their respective GNSS constellations or satellite systems
- System providers agreed to continue to exchange information on their GNSS orbital debris mitigation plans and identify an Expert Point of Contact
- Additional discussions will occur within the Working Group on Systems, Signals and Services at the next meeting



ICG Meetings/Events in 2017

- Working Group B Space Service Volume Outreach Session at Munich Satellite Summit – March 2017
- 6th Workshop on GNSS Interference Detection and Mitigation in Baska, Krk Island, Croatia – May 2017
- Intersessional Meeting of the ICG Working Group on Systems, Signals and Services in Baska, Krk Island, Croatia – May 2017
- International Multi-GNSS monitoring (IGMA) Workshop in Shanghai, China – May 2017
- Providers' Forum Meeting in Vienna, Austria – June 2017
- Intersessional Meeting of the Working Group B in Vienna, Austria – June 2017
- Intersessional Meeting of the ICG Working Group on Systems, Signals and Services in Paris, France – July 2017
- Expert level timing workshop in conjunction with the annual IGS Workshop in Paris, France – July 2017
- Performance Standards Subgroup Meeting in Portland, U.S. – September 2017
- ICG-12 Meeting – Kyoto, Japan



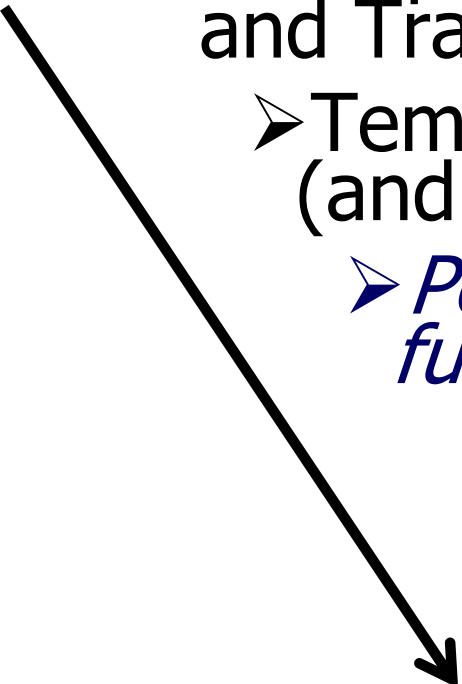
U.S. Objectives in Working with Other GNSS Service Providers

- Ensure **compatibility** — ability of U.S. and non-U.S. space-based PNT services to be used separately or together without interfering with each individual service or signal
 - Radio frequency compatibility
 - Spectral separation between M-code and other signals
- Achieve **interoperability** — ability of civil U.S. and non-U.S. space-based PNT services to be used together to provide the user better capabilities than would be achieved by relying solely on one service or signal
- Promote fair competition in the global marketplace

Pursue through Bilateral and Multilateral Cooperation



Progress at ICG in GNSS Civil Service Provision

- ✓ Providers Forum
 - ✓ Providers Forum System Report
 - ✓ Principles of Compatibility, Interoperability, and Transparency
 - Template for Performance Standards (and ICDs)
 - *Postulated Performance Standards for future services*
 - Service Assurances or Commitments
 - *Monitoring of service performance*
 - *Interference monitoring*
- 



THANK YOU!

