Multi-GNSS Cooperation Through the ICG: A System Provider Perspective

ION PANEL

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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

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 Providers 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 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
  - 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 International Committee on Global Navigation Satellite Systems

12th MEETING KYOTO ICG 2017

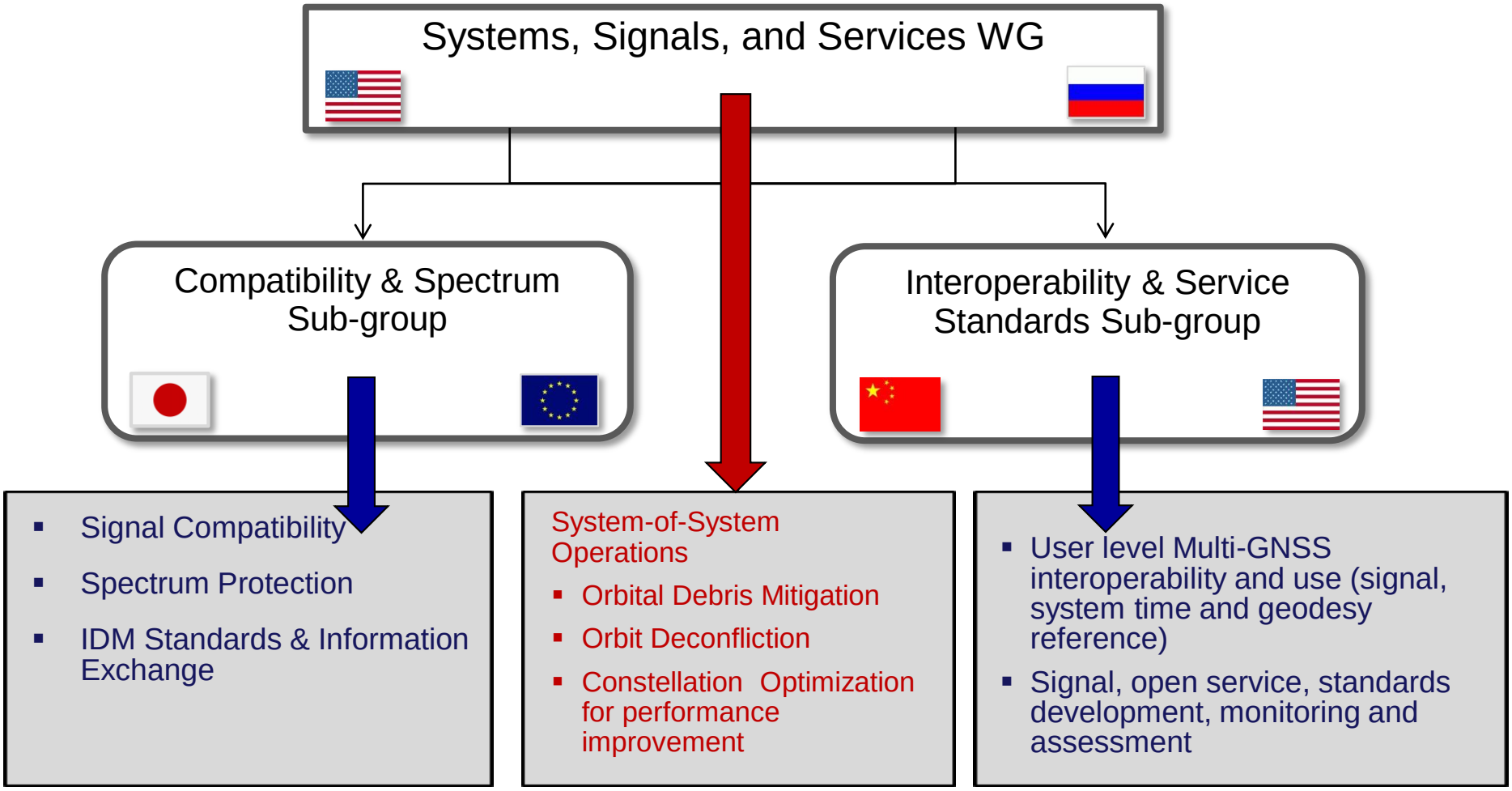
ICG-12 Significant Accomplishments

- 7th ICG **Interference Detection and Mitigation Workshop** held on May 8, 2018 as part of Baska GNSS Conference
- ICG **International Multi-GNSS monitoring (IGMA) workshop** held May 14-15, 2018 at the Noordwijk Galileo Reference Center (GRC) to discuss the multi-GNSS monitoring trial project established in 2016 between the ICG and IGS
- ICG workshop focused on promoting common terminology and definitions for individual **GNSS Open Service Performance Standards** also held May 14-15 at the Noordwijk GRC
- 2nd ICG expert level workshop on **Time and Interoperability** to be held in Vienna, June 20, 2018 to further discuss GNSS system time offsets among the systems
- GNSS Providers Booklet on **Space Service Volume** published in 2018 - continued outreach effort on benefits of an interoperable space service volume
- Discussion and exchange of information on **Orbital Debris Mitigation** plans by GNSS providers

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

Systems, Signals, and Services WG (WG-S)



IDM Task Force will continue under the sub-group

Specific Tasks to be managed by Co-chairs until the need for a permanent sub-group can be determined

IGMA Task Force will continue under the sub-group

ICG International Committee on Global Navigation Satellite Systems

Interference Detection and Spectrum Protection: A Multilateral Effort

- ICG Core Area of Focus since its inception
  - *"Develop a strategy for support by the International Committee of mechanisms to detect and mitigate sources of electromagnetic interference, taking existing regulatory mechanisms into consideration"*
  - Primarily discussed within the Working Group on Systems, Signals and Services (WG-S)
  - Subgroup on Compatibility & Spectrum Protection - 2010
  - Interference Detection and Mitigation (IDM) Task Force - 2013
- Recent and Near Future Activities
  - Three Seminars on Spectrum Protection (2015/2016/2017) **– Outreach and Education**
  - Reporting by COPUOS Member States on Spectrum Protection and IDM **– National-level Action and Accountability**
  - 7 IDM Workshops **– Discussion on tools and techniques**

ICG-12 RECOMMENDATION 12S-1

Recognizing;

a) Recommendations ITU-R M.1902, 1903, 1905 contain protection criteria for 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 in one country;

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),

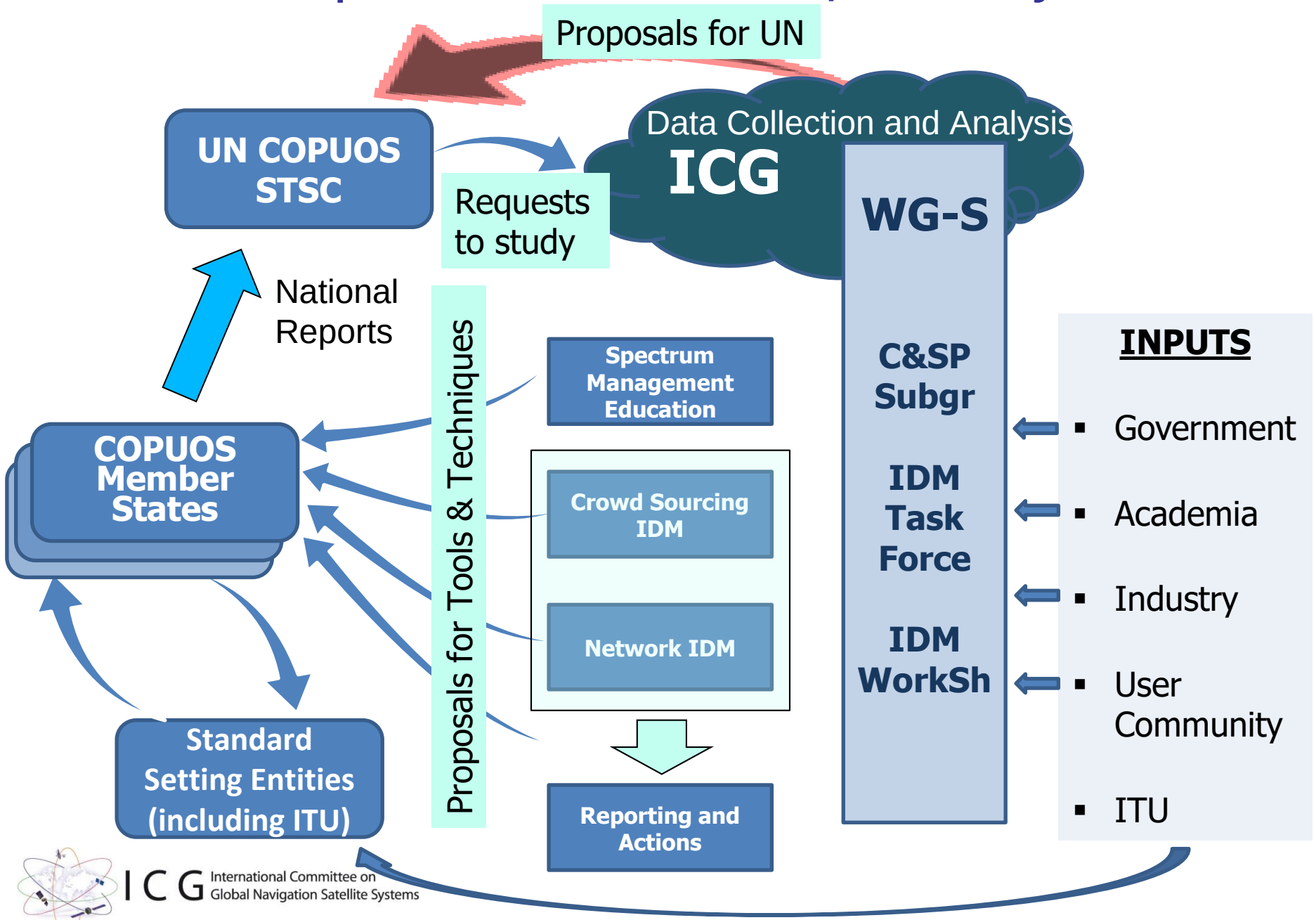
Recommends;

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.

ICG-12 RECOMMENDATION 12S-2
3GPP Crowd Sourcing

- 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***
- Therefore, System Provider delegations to the ICG should:
  1. *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*
  2. *If device-based detection is endorsed by Providers, consider presenting this ICG recommendation at the appropriate Plenary-level 3GPP Meeting*
  3. *Consider how data from device-based detection can be integrated into national/governmental mitigation efforts – September 2018 and beyond*

ICG Spectrum Stewardship Life-Cycle



Interoperability and Service Standards

- **User level Multi-GNSS Interoperability and Use**
  - Interoperability definition adopted at the first Providers Forum meeting and updated at the third meeting
  - 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
- **Open service Information Sharing and standards development**
  - Each Provider will strive to publish and disseminate all signal and system information necessary to allow manufacturers to design and develop GNSS receivers
  - Develop common terminology and definitions in individual GNSS Open Service Signal Specifications and Performance Standards

ICG-12 RECOMMENDATION 12S-3
2nd System Time Workshop

- The workshop 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
- ***Recommendation: Conduct a second System Time Workshop in 2018 in coordination with WG-D***

2nd workshop to be held in Vienna, June 20, 2018

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 4th 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. Discussed at 2018 Workshop
Each GNSS/RNSS identify calculation methods	In progress	Discussed at May 14-15 Workshop @ Noordwijk Galileo Reference Center (GRC)
Finalize set of definitions		
Issue Performance Standard template		

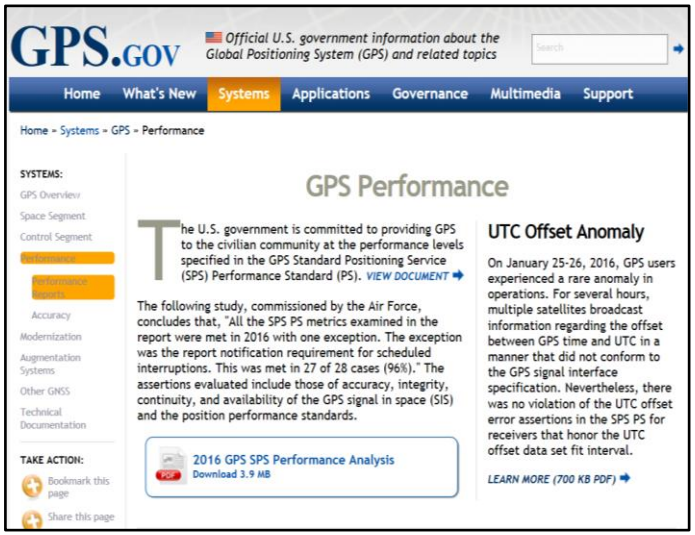
Service Performance Monitoring

- **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/

GPS Performance Report Cards



- 2013-2016 performance reports now available on gps.gov
- 2017 performance report in coordination
- These reports measure GPS performance against GPS SPS PS commitments
- Reports generated by Applied Research Laboratories at the University of Texas at Austin

Performance Standard Metric		2013	2014	2015	2016
SIS Accuracy	URE Accuracy	✓	✓	✓	✓
	UTCOE Accuracy	N/A	N/A	✓	✓
SIS Integrity	Instantaneous URE Integrity	✓	✓	✓	✓
	Instantaneous UTCOE Integrity	N/A	N/A	✓	✓
SIS Continuity	Unscheduled Failure Interruptions	✓	✓	✓	✓
	Status and Problem Reporting	N/A	×	✓	×
SIS Availability	Per-Slot Availability	✓	✓	✓	✓
	Constellation Availability	✓	✓	✓	✓
	Operational Satellite Counts	✓	✓	✓	✓
Position/Time Standards	PDOP Availability	✓	✓	✓	✓
	Position Service Availability	✓	✓	✓	✓
	Position Accuracy	✓	✓	✓	✓

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 Workshop - 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 were clarifications is needed
    - Calculation Methodology, Data Formats, Definitions

Progress made at May 14-15 Workshop held in Noordwijk at the Galileo Reference Center (GRC)

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*

24

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THANK YOU!

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