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

2019 Intersessional Presentation

07 September 2019
ISPRA, Italy

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

Systems, Signals, and Services WG

Compatibility & Spectrum Sub-group

- Signal Compatibility
- Spectrum Protection
- IDM Standards & Information Exchange

IDM Task Force will continue under the sub-group

System-of-System Operations

- Orbital Debris Mitigation
- Orbit Deconfliction
- Constellation Optimization for performance improvement

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

Interoperability & Service Standards Sub-group

- User level Multi-GNSS interoperability and use (signal, system time and geodesy reference)
- Signal, open service, standards development, monitoring and assessment

IGMA Task Force will continue under the sub-group

2019 Intersessional Working Group Schedule

- 8th IDM Workshop – Baska, Croatia, May
- Compatibility & Spectrum Subgroup meeting – Baska, Croatia, May
- Interoperability & Service Standards Subgroup meeting – Vienna, 11 June
- Performance Standards and IGMA Workshop – Vienna, 12-13 June
- 3rd Timing Workshop – Vienna, 14 June
- 4th Regional Spectrum Protection Seminar – Suva, Fiji, 25-26 June
- Joint WG-S, WG-B and WG-D Workshop on Precise Point Positioning (PPP) – Suva, Fiji, 27 June
- WG-S Intersession Meeting – Ispra, Italy, 4-7 September

SYSTEM UPDATES

GLONASS (1)

- In the constellation 22 satellites are operational and healthy
  - 21 sats are Glonass-M
  - 1 sat Glonass-K1
- Two satellites Glonass-M (with exceeded design life time) are in the orbital reserve and can be operational with reduced performance
- Recently dead satellite Glonass-M # 42 (second orbital plane) is under investigation and could survive after two weeks passing the shadows
- Fresh Glonass-M satellite from the ground reserve is prepared to launch originally planned for November 2019. Two more Glonass-M satellites are still in the ground reserve waiting for launch

GLONASS (2)

- Nine Glonass-K1 satellites are in the final phase of manufacture. First satellite from the nine shall be ready for launch by the end of 2019
- Four Glonass-K1 satellites from this nine will carry onboard the COSPAS-SARSAT payload and L3 signal in addition to full set of FDMA
- Five Glonass-K1 satellites from this nine will transmit also L2 CDMA signal in addition to FDMA and L2 CDMA signal
- New generation Glonass-K2 satellite is in the development expecting the flight test start by the end of 2022
- Further constellation sustainment will be done with Glonass-K2 satellites transmitting full set of FDMA in L1 and L2 and full set of CDMA in L1, L2, L3 bands

GPS (1)

- GPS Constellation Status:
  - 36 Satellites / 31 Set Healthy Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	1	25.5	25.5
GPS IIR	11	17.3	21.8
GPS IIR-M	7	11.8	13.6
GPS IIF	12	5.3	9
GPS III	2	< 1	< 1
Constellation	31	11	24.8

GPS (2)

- GPS III Space Vehicles
  - SV01 launched 23 Dec 18; currently undergoing on-orbit check out
  - SV02 launched 22 Aug 19; currently undergoing on-orbit check out
  - SV03 Available for Launch; planned for fall 2019
- GPS III Follow-On (GPS IIIF)
  - GPS IIIF Contract awarded on 26 Sep 18
  - Will leverage production maturity of GPS III SV01-10
  - Partnering with Air Force Research Laboratory (AFRL) for technology opportunities:
    - Digital Payloads
    - High Power Amplifiers
    - Advanced Clocks
    - Near Real-Time Commanding/Crosslinks

GALILEO

- The Galileo constellation is currently composed of 22 operational satellites, two satellites in anomalous orbits, plus one spare. Further procurements are in progress and launches are expected in 2020
- Regular performance exceeds expectations…
- The July incident that affected Galileo's provision of timing and navigation was due to a problem in one part of the ground infrastructure
- An important upgrade in progress, affected the usual redundancy
- As a result, the Galileo navigation message could not be generated and uploaded to the satellites
- Note that Galileo's signals remained available and that SAR provision was unaffected
- Galileo services are now fully restored and measures have already been put in place to avoid similar incidents
- A review board is fully analysing the incident
- The full incident review will help identify measures to make Galileo's services as robust as possible in time for declaration of full operational capability in 2020

BDS

5 satellites have been launched successfully since ICG-13, 2 MEO satellites, 2 IGSO satellites and 1 GEO satellite (back-up satellite of BDS-2). All the satellites are operating steadily on-orbit. BDS-3 started to provide global service from December, 2018. 5 to 7 more BDS-3 satellites will be launched in the second half of 2019, and 2 to 4 more BDS-3 satellites will be launched next year. Moreover, the construction of BDS-3 system will be fully completed by the end of 2020.

QZSS

- To be provided

NAVIC

- No Report

COMPATIBILITY and SPECTRUM

co-chairs

Dominic HAYES

Takahiro MITOME

Compatibility & Spectrum Protection Sub-group

- Co-chairs:
  - **Takahiro MITOME, Japan**
  - **Dominic HAYES, EU**
- Members:
  - China: Shengtao GUO, Lin LI, Weimin ZHEN
  - European Union: Dominic HAYES
  - India: S. SAYEENATHAN, K. K. SOOD
  - Japan: Yoshimi OHSHIMA
  - Russia: Dmitry ARONOV
  - United States: Karen Van Dyke, Rick Hamilton, David Choi

Objectives of Compatibility and Spectrum Sub-Group

- **Compatibility issues and information sharing regarding the protection of GNSS spectrum from interference from other radio services, as well as IDM issues;**
- **Document agreed results in the form of findings, reports, or whatever form may be appropriate for the case;**
- **Provide proposals to WG-S on compatibility issues, for discussion and decision.**

Interference Detection & Mitigation Task Force

- **Co-Chairs**:
  - **Rick Hamilton, U.S., Co-lead stephen.r.hamilton@uscg.mil**
  - **Weimin Zhen, China, Co-lead crirp_zwm@163.com**
- Members:
  - Matteo Paonni, EU matteo.paonni@ec.europa.eu
  - Rafael Lucas-Rodriguez, ESA Rafael.Lucas.Rodriguez@esa.int
  - Stanislav Kizima, Russia 5314368@mail.ru
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  - Deok Won Lim, ROK dwlim@kari.re.kr


8TH Interference Detection and Mitigation
Workshop - Baska, Croatia
14 May 2019

International Committee on GNSS (ICG)
8th IDM Workshop
Royal Institute of Navigation (RIN) Baška GNSS Conference
Baška, Croatia 14-15 May, 2019

UN

14 May, 2019 **(***Open to all conference participants and ICG WG-S members***)**

1500: **Opening Discussion** / *Introductions*

1510: **Development and Operation of a GPS Jammer Localization System at Incheon International Airport -** *Dr. Deok Won Lim, Ph.D./Senior Researcher, Navigation R&D Division, Korea Aerospace Research Institute*

1530: **Measurement Test of Purchased Radio Equipment - Short Range Device -** *Mr. Takahiro Mitome, SKY Perfect JSAT Corporation*

1550: **Interference from Amateur Services to GNSS within the 1260-1300 MHz band (Galileo E6 /BeidouB3 band) –** *Mr. Matteo Paonni, Scientific/Technical Officer, European Commission, Joint Research Centre*

1610: Project Introduction: GNSS Interference Detection and Localization in the City - *Ms. JIN Ruimin, China Research Institute of Radio-wave Propagation*

1640: Systematization of Information on Various Types of GNSS Receivers and Various Types of Interference – *Mr.Egor Zheltonogov, Geyser-Telecom Ltd.*

1710: GNSS RFI Status Downlink– *Mr. Gerhard Berz, Focal Point Navigation Infrastructure, EUROCONTROL (by Teleconference)*

1740: Actual Question of Monitoring in the Navigation Situation – *Mr. Sergey Silin, Design Bureau of Navigation Systems (NAVIS Inc.)*

1800: Discussion

Adjourn

Development and Operation of a GPS Jammer Localization System at the Airport

Deok Won Lim
Korea Aerospace Research Institute

KARI

Conclusions

- South Korea experiences nation-state purposeful jamming affecting thousands of wireless communications stations, ships and aircraft.
- Localization system developed and tested at Incheon International Airport using algorithms guaranteeing integrity and continuity of air navigation systems.
- System verification tested in indoors environment
- Week-long live-sky test provided results indicating real jamming case, <6 second localization and position origin of interference signal.

Measurement Test of Short Range Device Samples

The 8th Interference Detection and Mitigation (IDM) Workshop - International Committee on GNSS (ICG) -

14 May 2019

Takahiro MITOME (Japan)

Measurement Test of Short Range Device Samples in Japan

- In Japan, electromagnetic emission limits of non-licensed emitters are defined and a “Measurement Test of Short Range Device (SRD) Samples” is conducted every year.
- In this test, some commercially available non-licensed emitters/devices are randomly selected, purchased by the telecommunication administration and checked for compliance with established limitations.
- In this year’s test, one device was found to exceed the limit at the frequency of 1585.464 MHz, as shown below.

Frequency (MHz)	Polarization	Measured result (μV/m)	Limit(μV/ m)
1585.464	Horizontal	389045.1	35
1585.464	Vertical	131825.7	35

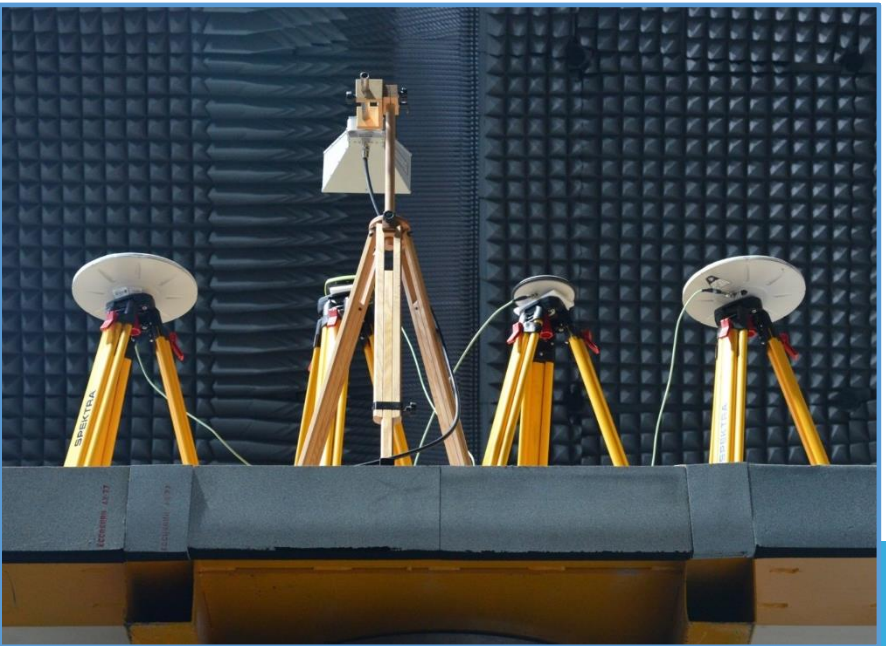
- An example of Japan’s regulatory process to suppress devices which produce larger emissions than allowable. It is encouraged that each country exchange in ICG their practical framework for the prevention of GNSS jammers.

European Commission

Compatibility Assessment Between Amateur Radio Services and Galileo in the E6 Band

- **M. Paonni**

Joint Research Center (JRC), European Commission, Ispra, Italy



8th Workshop on Interference Detection and Mitigation

Baska, Croatia

14.05.2019

The European Commission's in-house science service

Joint Research Centre

Summary

- **Experimental tests** with **live signals** were carried out using high-end **E6**-enabled receivers and a testplan coordinated with IARU members
- Realistic scenarios have been considered with a variety of **emissions** with different **power/distance** profiles
- **Very important degradation** for different KPIs (C/N_0, Pseudorange variance and Bit Error Rate) for different E6 receivers measured
- Noting the ATV impacts on the Galileo E6 signals (and certainly **other RNSS systems** using the same frequencies):
  - ✓ AS already acknowledges its secondary status and has indicated **compliance** where necessary
    - but, **additional** radio regulatory **decisions** may be required
  - ✓ Galileo working with EU national authorities to determine **appropriate measures**
  - ✓ wider decisions at **CEPT** and **ITU** level could be expected in future
- Important to underline that **some AS applications** may be easily **compatible with GNSS**

GNSS interference detection and localization in city

Ruimin Jin , Weimin Zhen, Dongliang Lv, Xin Chen, Di He

Conclusion

- A project named “GNSS Interference Detection and Localization in City” from the China Ministry of Science and Technology was briefly introduced.
- A critical technology called GNSS interference detection and localization based on pattern recognition was presented in detail.
- The GNSS electromagnetic environment was measured in some typical cities and scenarios including an airport, central business district, harbour, city road, etc.
- Because transmission of RFI in a city maybe affected by reflection and refraction of buildings, it is difficult to localize the RFI source with traditional methods.
- Detection and localization of GNSS interference through feature study of carrier and noise ratio at the monitor node is the focus of this study.
- The project will be completed by the end of 2020.
- The technology will be applied to engineering of GNSS detection and localization in China.

ULTIMATE SOLUTIONS FOR TELECOMMUNICATIONS

Systematization of Information on Various Types of GNSS Receivers and Various Types of Interference

Dr. D. Aronov
E. Zheltonogov

Baška, Croatia, 12-15 May 2019

Further actions

Systematization of protection criteria, and approaches to interference estimation depending on the types of RNSS receivers to elaborate reference values of the electromagnetic environment for their subsequent monitoring to protect GNSS spectrum from radio interference from other radio services other than the radionavigation satellite service.

Interference types / Receiver types	**Wideband**	**Narrowband**	**Pulsed**
Air-navigation	-	-	-
Maritime	-	-	-
Ground-based	-	-	-
Space-based	-	-	-

ICG participants are invited to supplement the proposed material regarding possible types of receivers, and their protection criteria for various types of interference, including established limits in their countries (if available)

GNSS RFI Status Downlink

Gerhard BERZ
Senior Expert Navigation Systems
CNS Evolution Unit, DECMA/RTD

UN ICG / IDM Workshop
Baska, Croatia 14 May 2019

gerhard.berz@eurocontrol.int

Presentation Summary

- EUROCONTROL developing near and long term RFI mitigation capabilities for aviation
  - ➢ Driven by increase of GNSS issues in pilot reporting in 2018
- Evaluating use of ADS-B in “aircraft crowdsourcing”
  - ➢ Determine area of impact for operational management to keep airspace open safely as long as possible
  - ➢ Approximate airborne RFI source location to enable efficient elimination by radio regulatory enforcement on ground
- Proposing improvements to future equipment functions
  - ➢ Direct detection of RFI at GNSS receiver and broadcast to ATC
  - ➢ Many technical, operational and programmatic open questions remain, R&D exchanges on topic are welcome
  - ➢ Main technical challenge remains getting suitable test data to validate approach and quantify benefits

Arguments for Jammer Prevention

- Ensure implementation of suitable location privacy laws and awareness to help limit motivation of private citizens and employees to purchase jamming devices

- Consider outreach to ensure that / to:

  - Help citizens and employees understand that location privacy laws are in place to protect them

    - ✓ Operating a jammer in a company vehicle is a legal reason to fire someone, tracking an employee is not (EU regulation)!

  - Information is available in local and relevant foreign languages about jammers being illegal (internet searches) and the significant fines in place when caught

  - Alert to the risks they can pose to infrastructure and services (without too detailed explanations)

  - Explain that operating a jammer may lead to being tracked by law enforcement as a suspect of illegal activities

Actual Issues of Navigation Conditions Monitoring

International Committee on GNSS (ICG)
Working Group S

IDM Subgroup

Alexey MURAVYEV
Sergey SILIN
NAVIS Inc.

Conclusions

- Monitoring of the spectrum environment for appropriate navigation conditions is an important task
- A method to use navigation and information systems for interference monitoring in areas of critical infrastructure is proposed
- Studies of various analytical methods for monitoring of navigation and information systems are in planning within the GLONASS program.
- The first study results were discussed during a Working Group S meeting of the 2018 International Committee on GNSS, at the International GLONASS/GNSS Forum in Moscow in 2019 and at some Russian scientific conferences.
- Proposals for the organization of this international project are being prepared.


Una splendida vista a Ispra

GNSS RFI Mitigation Efforts in Aviation: Update on RFI Status Downlink

Supporting European Aviation

Valeriu VITAN, Gerhard BERZ, Kseniia NIZIAIEVA
CNS Evolution Unit, Directorate European Civil Military Aviation
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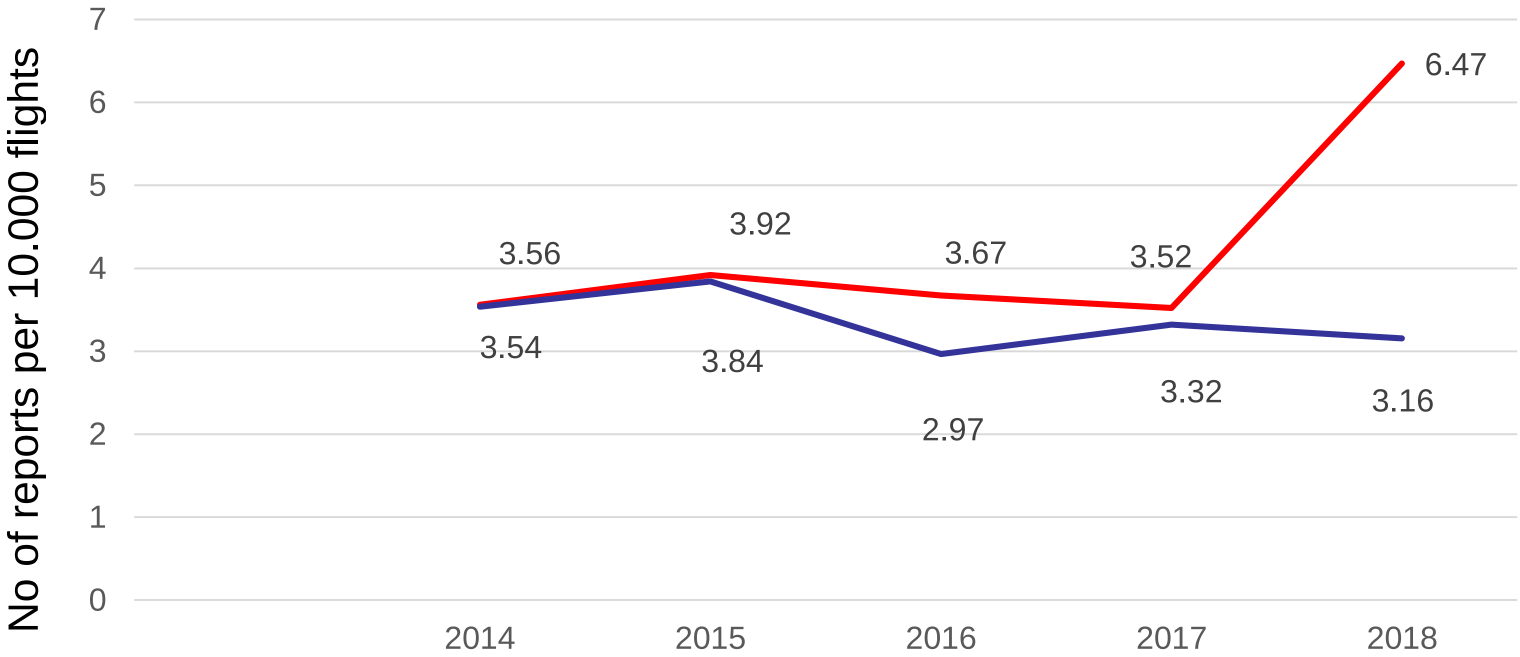
UN ICG / WG-S and IDM Meetings
Ispra, Italy September 2019

Introduction

- Previous UN ICG meetings
  - First introduction to aircraft-data based RFI mitigation concept using RFI Status downlink (ADS-B)
  - Including approximate airborne RFI source geo-location to enable efficient ground-based radio regulatory enforcement intervention
  - Much can be done with current (serendipitous) capabilities, but also proposing improvements for tailor-made function in next generation aviation equipment
  - Overview of proposed approach, focus on further developments, work in progress

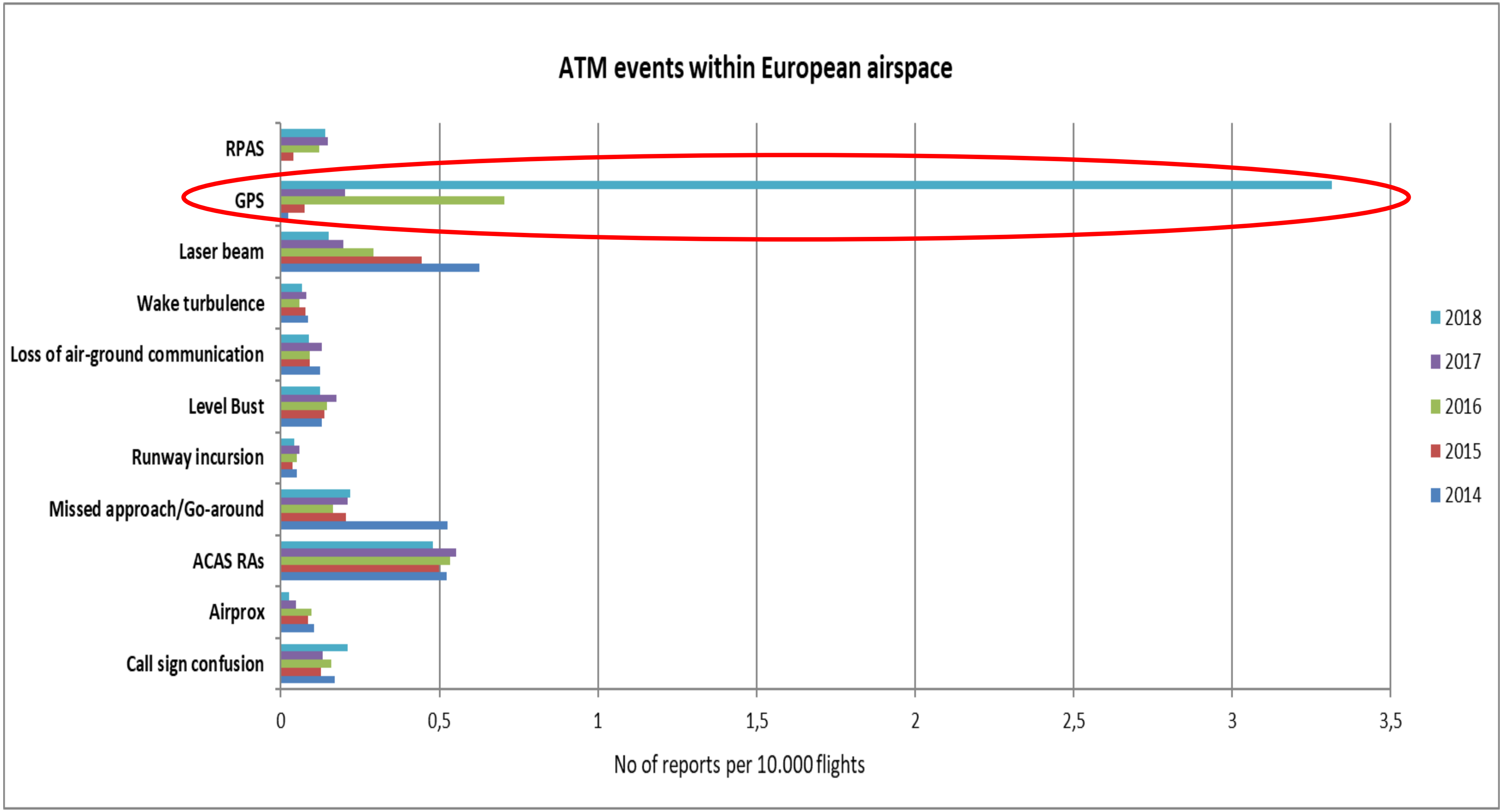
- One of many GNSS RFI mitigation efforts by EUROCONTROL
  - EVAIR (EUROCONTROL Voluntary ATM Incident Reporting) - pilot reporting
  - Improvement of GNSS RFI “testing” guidance (ICAO DOC 8071)
  - Increase preventive outreach against jammers (PPD)
  - Operational contingency management (“GNSS Reversion”)
  - Supporting European paper to ICAO Assembly on Resilient CNS

Overall Trend of EVAIR Incident Reports



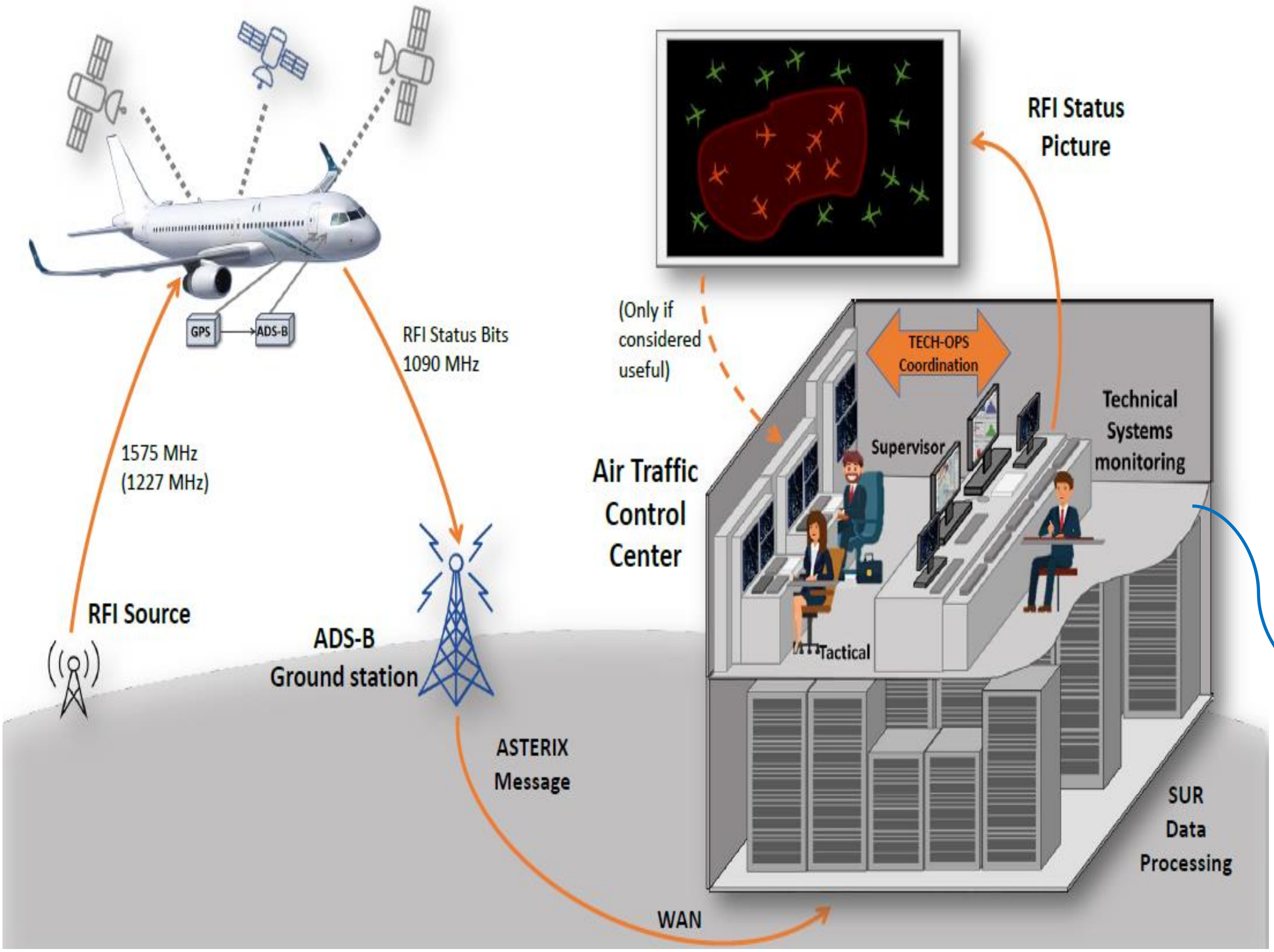
Incident Trend: ---- with GPS Outages ---- without GPS Outages

EVAIR reports - 2018

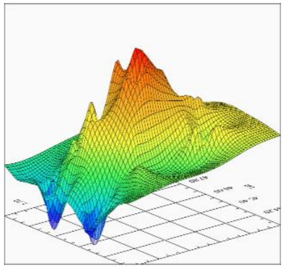


68% of EVAIR AOs' ATM reports

Functional Picture



RFI geo-location support

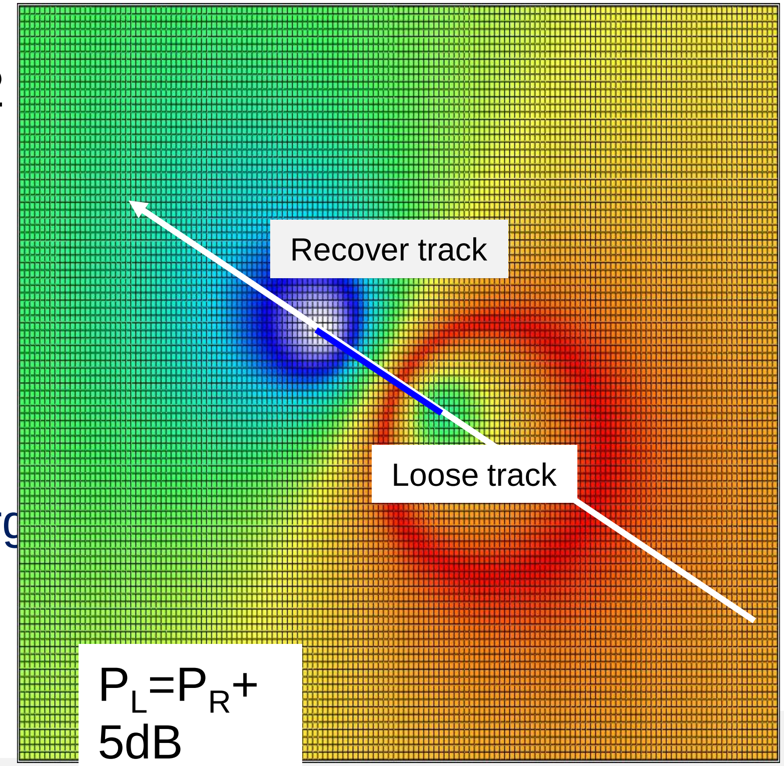


- Still TBD if downlink should be on ADS-B

Geo-location based on PDOA + RFI level estimation

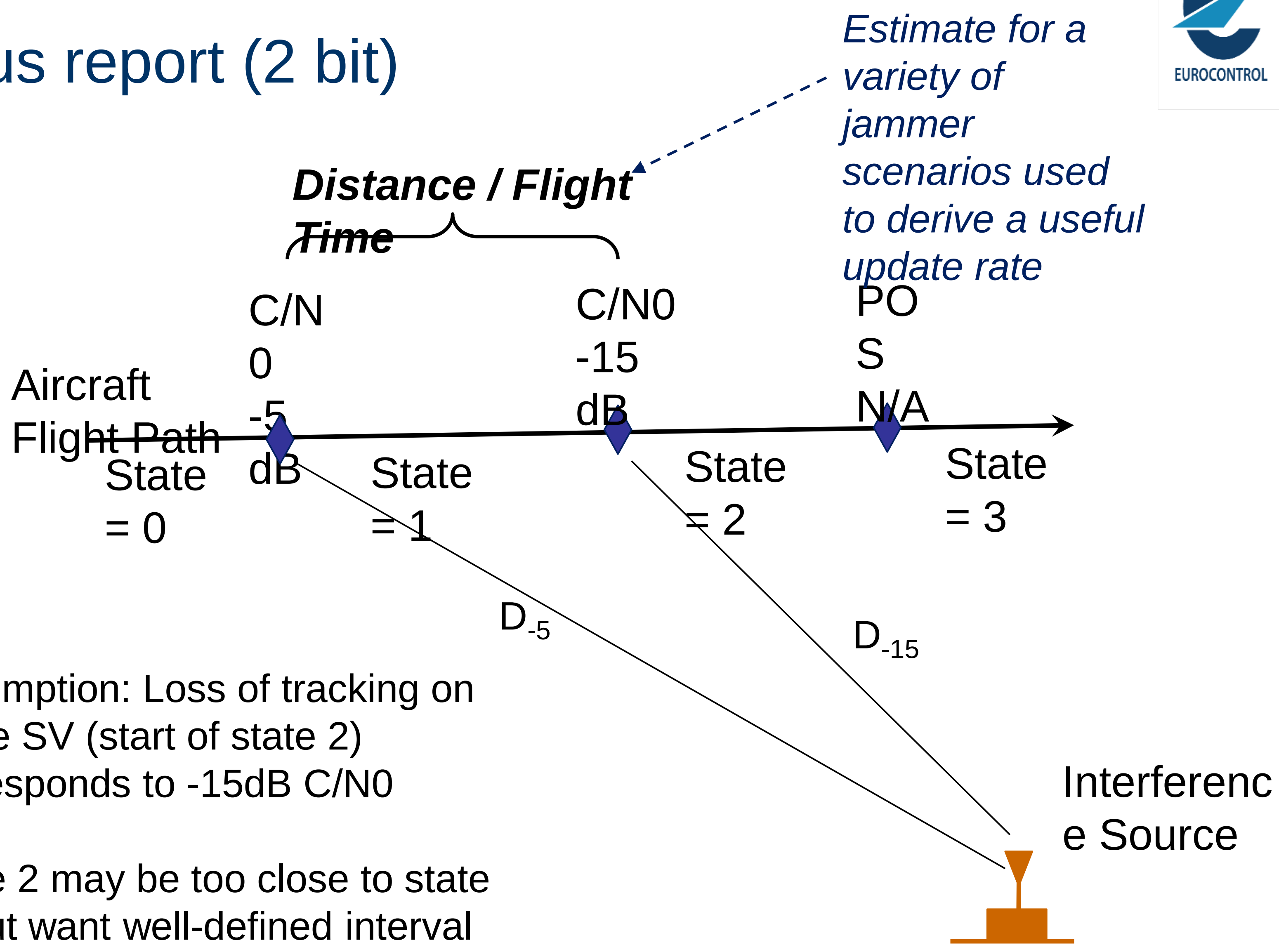
- Degradation of C/N0 = C/N0 before RFI / C/N0 during RFI
  - $\frac{C/N}{C/(N+I)} = \frac{N+I}{N} = 1 + \frac{I}{N}$
  - For 5 dB degradation, **I = 2,16 N**
  - For 15 dB degradation, **I = 30,6 N**
- Noise power for T = 20deg and BW = 2
  - N = kTB = -111dBm
- “Target” RFI Power
  - I_{-5dB} = 3,3dB – 111dBm = **-107,7 dBm**
  - I_{-15dB} = 14,8dB – 111dBm = **-96,2 dBm**
- “Target” FSPL and resulting Distance
  - Assumed Jammer Power – FSPL = Targ
  - $FSPL_{GPS\ L1}$ = 20 log D + 36,4
  - $D = 10\text{\^{}}(\frac{FSPL-36,4}{20})$

Power Difference Of Arrival – PD
Probability density (2 samples / tr



$P_L = P_R +$ 5dB

Status report (2 bit)



Assumption: Loss of tracking on some SV (start of state 2) corresponds to -15dB C/N0

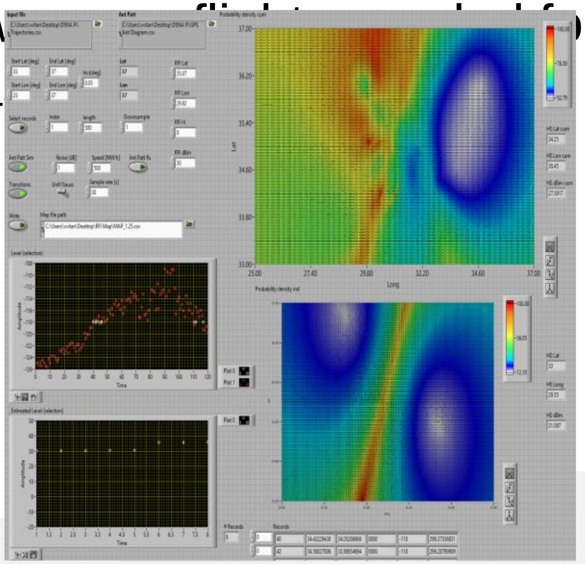
State 2 may be too close to state 3. But want well-defined interval between state 1 and 2 which is not too short

Assumptions / Unknowns

- Static RFI source
- Omnidirectional RFI radiation
- No occlusion
- Omnidirectional A/C antenna pattern
- FSPL attenuation
- C/N0 to RFI level correlation

- How accurate is PDOA ?
- Impact of wrong assumptions ?
- Enough to report only 4 states (only 2 providing useful information) ?
- Report at fixed intervals or report transitions?
- Hov … r rea

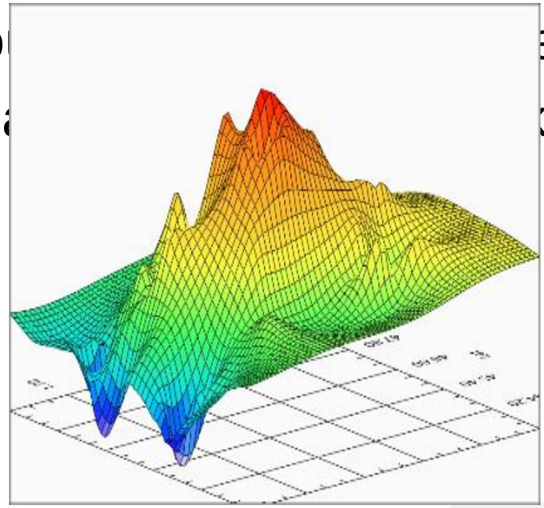
    - Modelling platform to test algorithm and assess impact of different variables
    - Use real RFI data for validation



Variables and Metrics

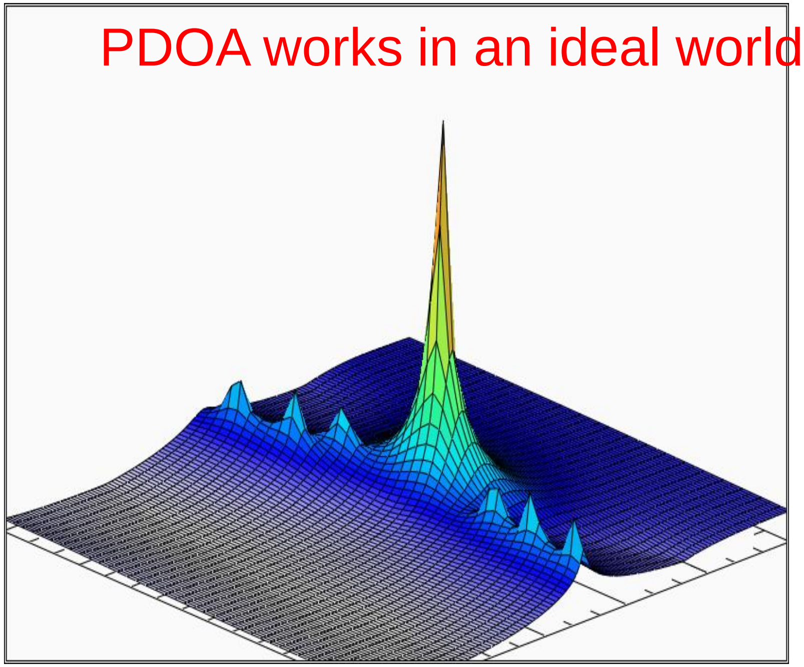
- RFI Location & Power
- Flight paths (straight segments)
- Number of flights
- Aircraft speed
- Uncertainty (noise) in received RFI
- A/C antenna pattern (modelled pattern)
  - Compensated (FI A/C)
  - Not compensated (commercial A/C)
- RFI level report:
  - Real level (FI A/C)
  - 2 bit reports (commercial A/C)
- Sample rate

- Location Accuracy : Distance from actual to predicted location (probability density peak)
- RFI power prediction Accuracy
- Ambiguity: Relative "height" of the first peak
- Ro eaks
- Sh ks

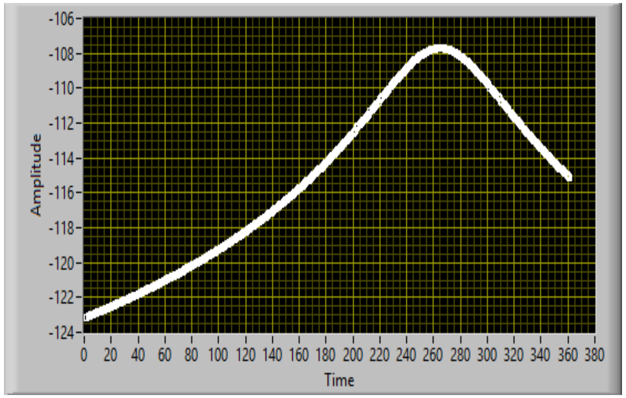


Ideal scenario

- Flight paths: 6
- Number of flights: 6
- Aircraft speed: 500 NM/h
- Noise: No
- Radiation pattern: Omni
- A/C antenna pattern: Omni



- Location: Exact
- Power prediction: Exact
- Ambiguity: Low
- Roughness: Depends on # flights
- Sharpness: high



- Calculation on a lat/long grid
- Probability density derived from 2nd order moment about mean for Tx power estimates for all samples

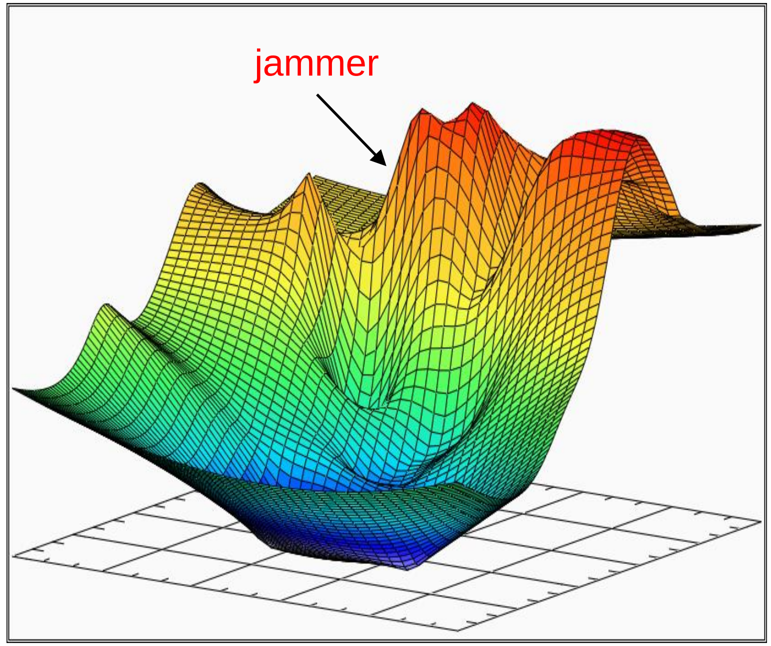
Impact of variables

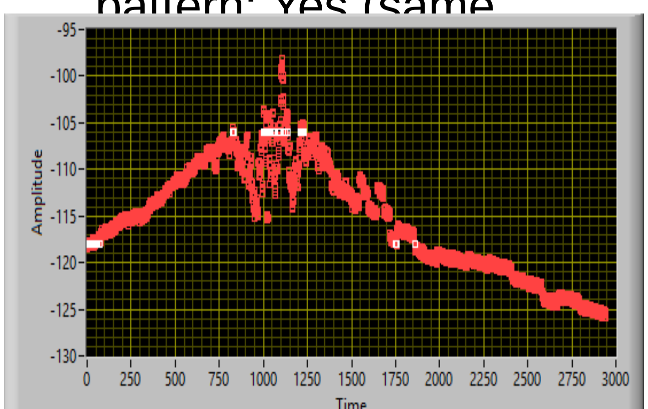
Metrics / Variables	Loc Acc	Power Acc	Ambig.	Roughn.	Sharpn.	Remarks
Low sample rate						Only for FI A/C
Regular 2 bit report						Depends on speed; RFI power
Transition 2 bit report						Requires high # flights
Noise						Comp. by # flights
Rx antenna pattern (non compensated)						May be comp. by flight paths geometry & A/C diversity
Rx antenna pattern Compensated						Only for FI A/C Generates secondary peaks
High A/C speed						May compensate noise
High # flight path & good geometry						ssential for accuracy ...th comm. A/C data (arrival angle diversity)

Beneficial	Neutral	Low impact	Medium impact	High impact

Poor scenario

- Flight paths: 6
- Number of flights: 6
- Aircraft speed: 500 NM/h
- Noise: zero mean, σ=0.5dB
- Radiation pattern: Omni
- A/C antenna pattern: Yes (same





- Location error:
  30NM / first peak
  16NM / second peak
- Power est. error:
  1.5 dB
- Ambiguity: High
- Roughness: High
- Sharpness: Low

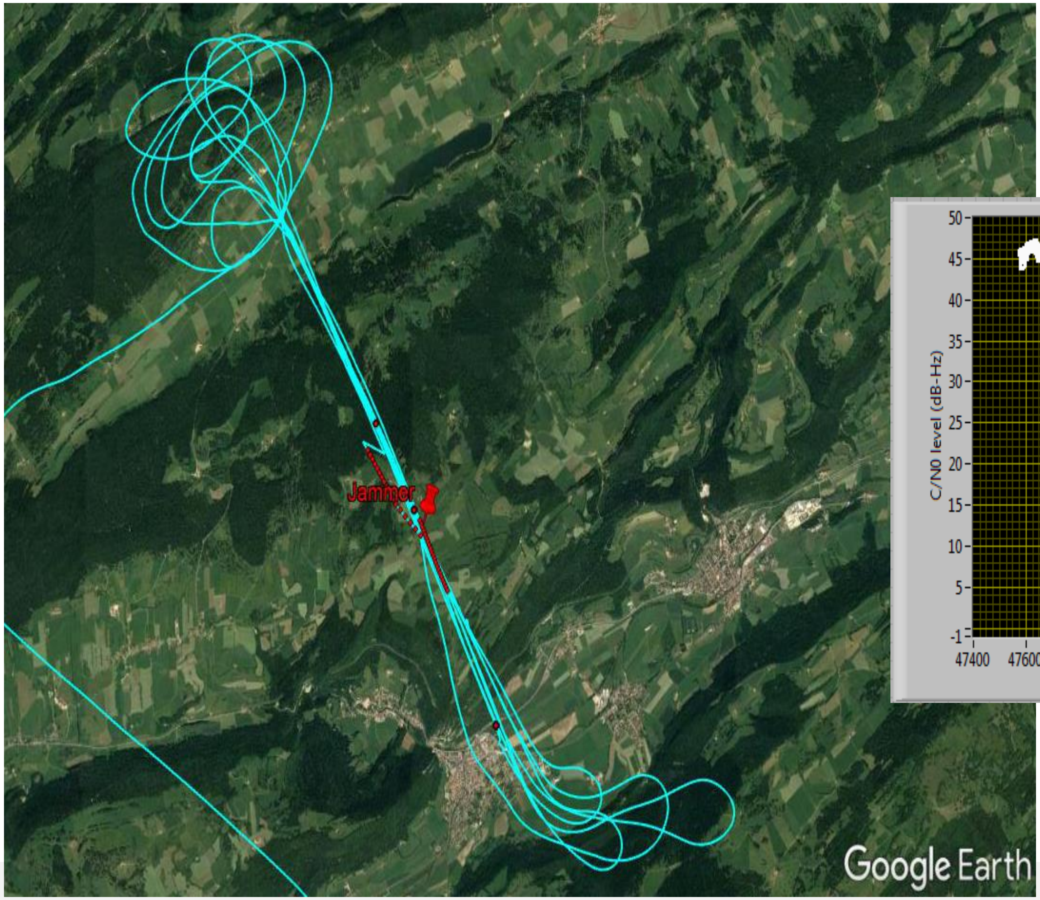
- Higher number of flight paths / flights needed to improve location accuracy

Real RFI data processing

- Jamming tests executed in cooperation by Skyguide, Swiss Air Navigation Services Ltd, Swiss Air Force, OFCOM, FOCA, REGA and Armasuisse.
- Flights: several helicopter and one fixed wing
- Different jamming modes: PRN, CW, Pulsed with 2048 Hz PRF, Frequency hopping
- Analysis focused on the jamming impact on positioning accuracy and integrity
- Results presented to ION 2017 GNSS Conference : “Jamming of Aviation GPS Receivers: Investigation of Field Trials performed with Civil and Military Aircraft”
- One of the conclusions: “an interference event can be detected earlier in the range domain by monitoring the average C/N0”
- Our analysis focused on geo-location
- Preliminary analysis of partial data set (only fixed wing flight)

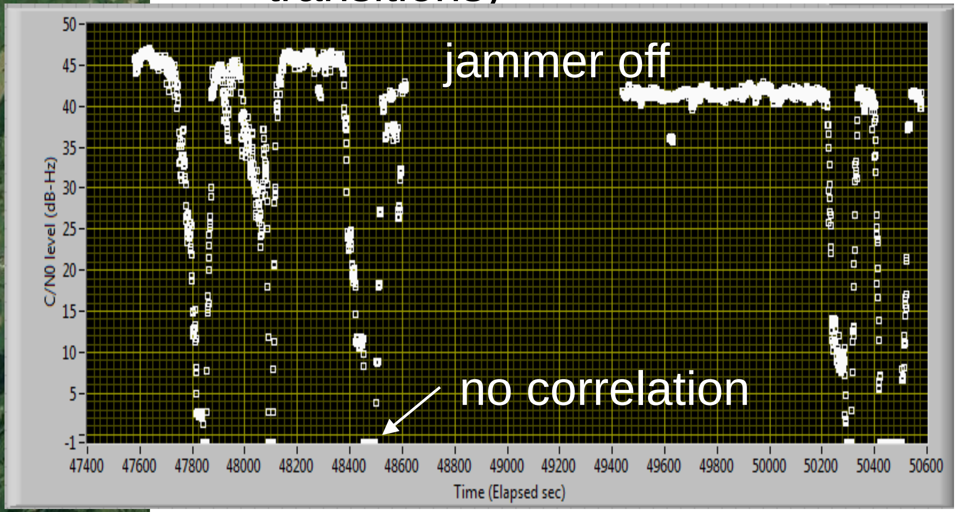
Input data

Flight path and jammer location



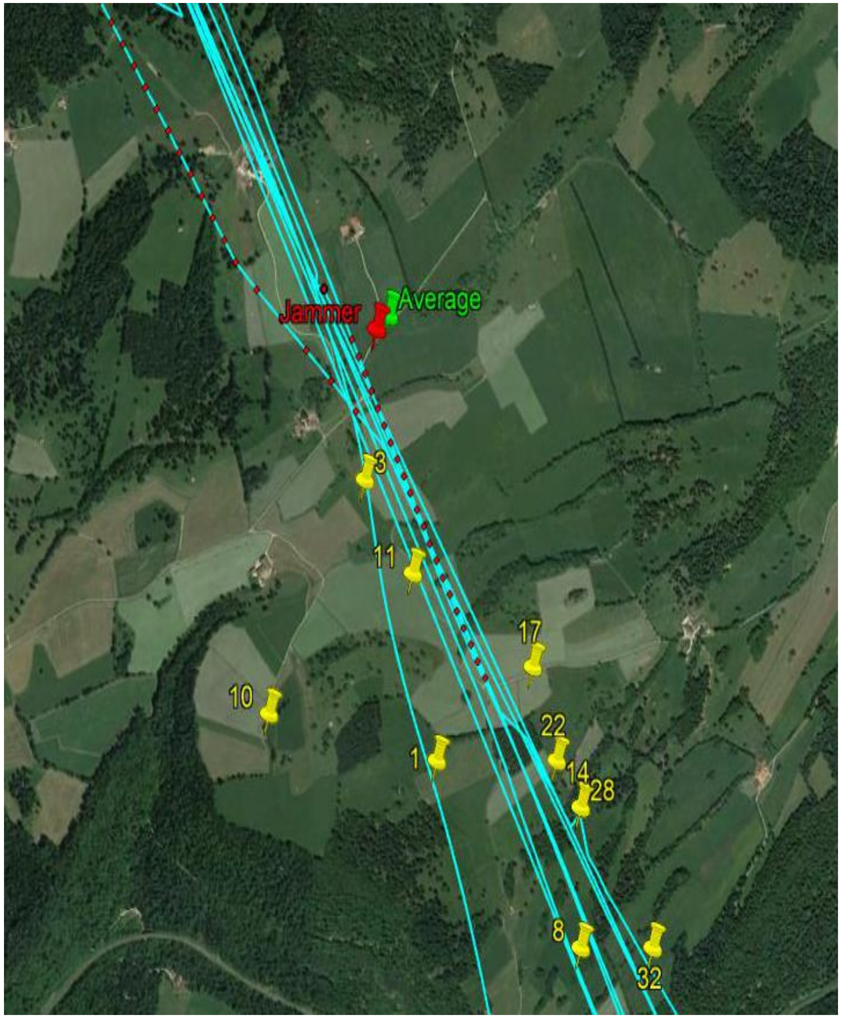
Analysis considers

- Only jammer on time intervals
- No correlation intervals discarded
- Actual values (not only level transitions)



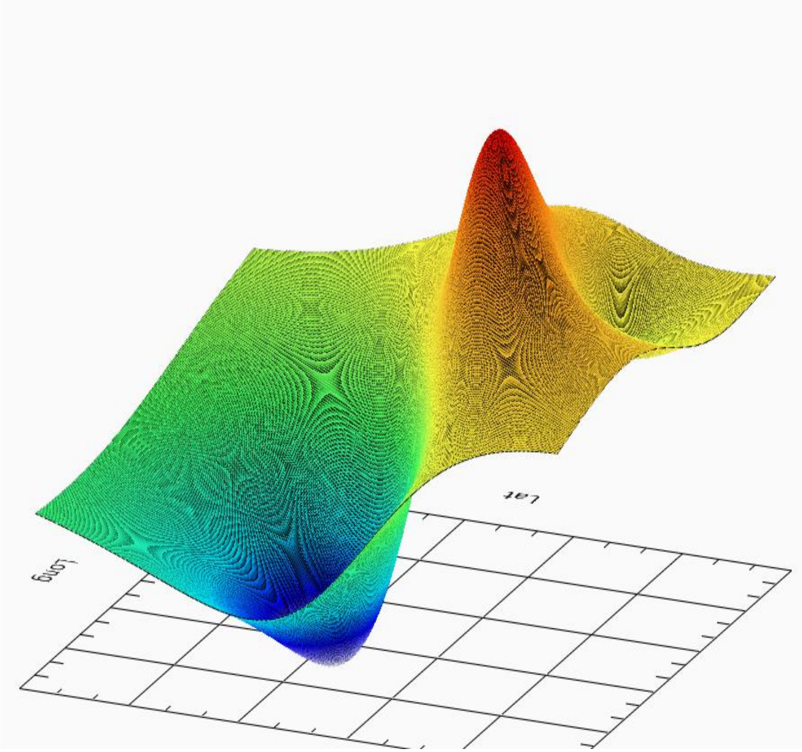
C/N0 in time domain (single PRN)

Preliminary results



Location using average and individual SV C/N0

Heatmap for average C/N0 – all SV

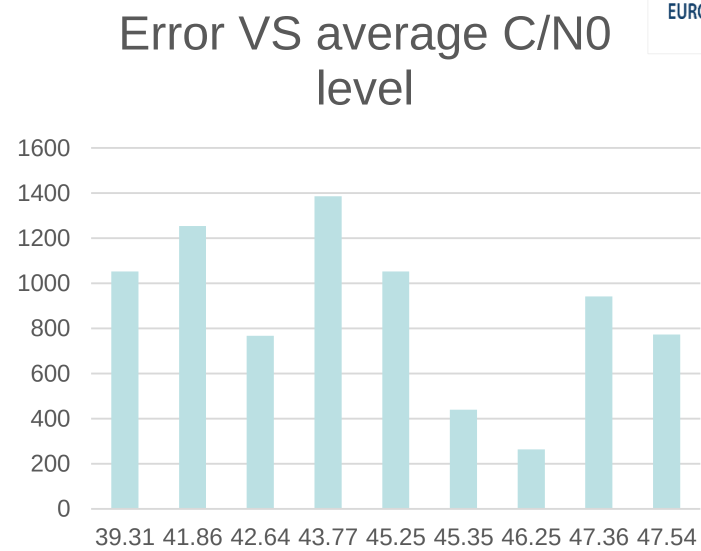


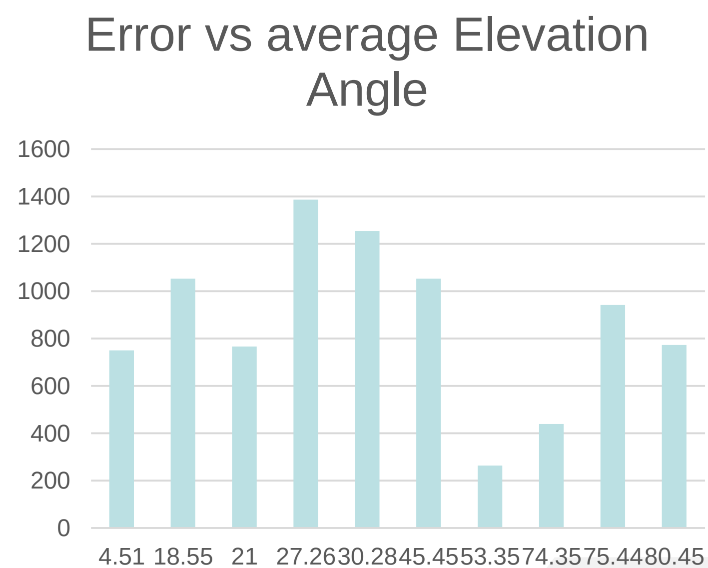
Comparative analysis

Results per satellite

# Satellite	Elevation Angle average	C/N0 average	Error [m]
1	80.45	48	773
3	53.35	47.36	264
8	30.28	42.64	1254
10	4.51	39.31	750
11	74.35	46.25	440
14	45.45	45.35	1053
17	21	43.77	767
22	75.44	47.54	942
28	18.55	41.86	1053
32	27.26	45.25	1386
Average		**43**	**45**

- Asymmetric impact: depends on antenna location (ION paper)
- Further analysis needed to explain the low error
  when using average C/N0
- No clear correlation between SV elevation or C/N0





Conclusions & Further work

- Potential to detect and locate jammer by C/N0 monitoring confirmed
- Accuracy impacted by various variables
- Further analysis needed to better estimate impact and mitigations
  - Improve modelling and test large number of scenarios
  - Further analysis of 2 bits & fixed time reporting scenario
  - Complete analysis of Swiss data
  - Validate modelling using additional real RFI data

- Invitation to UN ICG
  - GNSS RFI is increasing in aviation operations and needs proactive mitigation
  - Synergies exist between aviation and non-aviation efforts
  - ***Cooperation with other entities on this topic is highly welcome***
  - In particular on obtaining useful datasets for validating detection and geo-localisation methods

Thank you for your attention

Acknowledgements:

Skyguide, Swiss Air Navigation Services Ltd, Swiss Air Force OFCOM, FOCA, REGA and Armasuisse for making available the RFI tests dataset

ICG WG-S Intersession Meeting

Potential Discussion at Future WRC

Ispra, Italy

5 to 7 September 2019

Takahiro MITOME (Japan)

Background

- WRC (World Radiocommunication Conference) is held every three to four years and has the job to revise the Radio Regulations, which is the international treaty governing the use of the radio-frequency spectrum. Revisions are made on the basis of agenda, which is determined based on the decisions by previous WRC.
- WRC-19 is going to be held on 28 October to 22 November 2019 and will discuss future WRC agenda items as well.
- Potential impact on RNSS from expected discussion at WRC-19 should be analyzed and necessary preparation should be made by RNSS operators. RNSS operators are encouraged to talk with associated telecommunication administrations for the preparation to WRC-19.

Potential Proposal at WRC-19

- The study for a possible mobile service allocation in the frequency band 1300-1350 MHz as an agenda item of WRC-23 is going to be proposed from US and other countries at WRC-19. This mobile service is intended to be used for IMT, though it is called “mobile broadband” in the potential US proposal.

- The frequency band 1300-1400 MHz was discussed for IMT in one of WRC-15 agenda items and was removed from the IMT candidate bands in the early stage within WRC-15 cycle because of the potential impact into radars in the same band and RNSS in the adjacent band. From this precedence, it is very likely that the proposed mobile service allocation in the frequency band 1300-1350 MHz would impact on RNSS below 1300 MHz.
- Other proposal for WRC-23 agenda items should also be reviewed from the viewpoint of benefit to RNSS as well as potential impact on RNSS.

Recommended WG-S Actions

1) to alert RNSS/GNSS providers about the potential impacts on possible WRC-23 agenda items, which will be discussed at WRC-19.

2) to encourage RNSS/GNSS providers to analyze the potential impact on the operation of RNSS/GNSS below 1300 MHz by the impact from potential mobile service allocations in the frequency band 1300-1350 MHz, in particular.

3) based on the above 1) and 2), to encourage RNSS/GNSS providers to contact their national telecommunication administration for their national preparation process for WRC-19, as appropriate.

(WRC-19 Schedule: 28 October-22 November 2019).

Backup Slides

Discussion for non-GSO Orbit Parameter Tolerance Limitations in RR

- CPM19-2 (February 2019) discussed WRC-19 agenda item 7, issue A (definition of non-GSO bringing into use). Before this meeting, there were proposals to introduce new data item obligations which will request to include specific tolerance to non-GSO orbit parameters, while current ITU practice does not require such tolerance data (in the current practice of ITU, the need of non-GSO orbit parameter tolerance is discussed only in the bilateral coordination). *(NOTE: This was reported at ICG-13 in November 2018.)*
- In the discussion at CPM19-2, the impact into RNSS from potential restriction of non-GSO orbit parameters was discussed. The output from CPM19-2 (CPM19-2 Report to WRC-19) does not include the option to restrict the range of non-GSO orbit parameters.
- Even without options in CPM19-2 Report to WRC-19, some administrations may try to propose this idea at WRC-19 directly. Thus, it is still encouraged to watch WRC-19 agenda item 7, issue A.

International Committee on GNSS (ICG)
Working Group - Systems, Signals and Services Compatibility and Spectrum Sub-Group Report

Ispra, Italy

5 to 7 September 2019

Takahiro MITOME (Japan), Dominic HAYES (EC)

Co-Chairs of Compatibility and Spectrum Sub-Group

Objectives of Compatibility and Spectrum Sub-Group

- **Compatibility issues and information sharing regarding the protection of GNSS spectrum from interference from other radio services, as well as IDM issues;**
- **Document agreed results in the form of findings, reports, or whatever form may be appropriate for the case;**
- **Provide proposals to WG-S on compatibility issues, for discussion and decision.**

ICG-10 Recommendation #1:
Campaign on Protection of RNSS Operations

- **The third RNSS spectrum protection seminar was held during UN GNSS Workshop in June 2019 in Fiji.**
- **This seminar audience had diverse backgrounds, different to those from the past seminars held in December 2015 in Austria, December 2016 in Nepal, and March 2018 in Argentina. As such the importance of RNSS spectrum protection was more broadly disseminated.**
- **Thus, ICG's outreach that aims to inform decision makers about the importance of GNSS spectrum protection is being successfully conducted. The sub-group agreed to continue this activity and also discussed preparation of a summary report of the seminars for wider distribution.**

ICG-10 Recommendation #1:
Campaign on Protection of RNSS Operations

- **Materials from the June 2019 GNSS Workshop can be found here: http://www.unoosa.org/oosa/en/ourwork/psa/schedule/2019/2019-workshop-IDM_-presentations.html**
- **The Spectrum Seminar materials include;**
  - **Fundamentals of GNSS**
  - **Interference Threats**
  - **Interference and Spectrum Management**
  - **Current Interference Challenges; Jammers, Adjacent Band Compatibility**
- **The Expert Team is considering capturing the presentation material in a booklet**

DRAFT ICG-14 RECOMMENDATION 14S-1

[Recognizing;

- To be completed]

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]
- that the ICG consider formal endorsement of the draft booklet at a future meeting

GNSS Interference Detection

Devise-Based GNSS Interference Detection -Crowed Source-

- The sub-group discussed the use of raw data from GNSS chipsets which is now accessible on Android devices (still unclear on Apple devices)
- The sub-group was also informed about the EU's work to promote this capability - GNSS raw measurement task force.
- The sub-group discussed other possible raw data outputs that would improve capabilities and ways to encourage manufacturers to make them available
- In response to Rec. 12S-2, the sub-group also discussed ways such raw GNSS data might be used to benefit national interference detection systems

RFI Downlink – ADS-B -

- The sub-group discussed the Eurocontrol’s trail for RFI Downlink using ADS-B to report the RFI incidence.
- The sub-group recognized Eurocontrol is welcoming possible cooperation with other entities, expecting synergies between aviation and non-aviation efforts.

Testing Approval Public Notification

- The sub-group received a presentation titled "GPS Interference Test Approval Process".
- The sub-group agreed to consider the proposed draft ICG Recommendation "Testing Approval Public Notification"
- To review this proposed ICG Recommendation, each provider should provide how this proposed process will work in their countries, in particular regarding interagency discussion framework, treatment of testing activities and involvement of telecommunication administration.
- The sub-group also discussed that non ICG members (countries which do not have GNSS providers) may be difficult to implement this proposed process. Thus, the details of the draft ICG Recommendation should be reviewed further.

8^{th} IDM Workshop related Proposal

- **8^{th} IDM Workshop was held on 14 May 2019 in Baska, Croatia and discussed the following presentations;**
  - **Development and Operation of a GPS Jammer Localization System at Incheon International Airport**
  - **Measurement Test of Purchased Radio Equipment - Short Range Device -**
  - **Interference from Amateur Services to GNSS within the 1260-1300 MHz band**
  - **Project Introductions: GNSS Interference Detection and Localization in the City**
  - **Systematization of Information on Various Types of GNSS Receivers and Various Types of Interference**
  - **GNSS RFI Status Downlink**
  - **Actual Question of Monitoring in the Navigation Situation**

Ongoing WG-S Action
Protection RNSS Spectrum from non-RNSS Sources

Background:

There are many studies to protect/quantify the interference into RNSS spectrum from other RF sources.

Thus, it would be worthwhile to summarize these available information comprehensively.

WG-S Action - to continue work on summarizing the available information on the following issues:

- Acceptable levels of protection from interference and measurement methods
- Monitoring of interference environment
- Identification of interference sources
- Recommendations on the elimination/minimization of interference impact.

Regarding the following two presentations at 8th IDM workshop, the sub-group agreed to invite ICG members to make comments on them prior to the ICG-14 meeting in December 2019:

- "Systematization of Information on Various Types of GNSS Receivers and Various Types of Interference " Dmitry Aronov, Egor Zheltonogov, Geyser-Telecom, Ltd., Russian Federation
- "Actual Question of Monitoring in the Navigation Situation" Sergey Silin, NAVIS Inc., Russian Federation

Ongoing WG-S Action
Protection RNSS Spectrum from non-RNSS Sources (2)

- Under the auspices of the Compatibility & Spectrum subgroup, the IDM Task Force and spectrum compatibility experts will jointly consider the relationship between the EU STRIKE3 report and the on-going work by Russian Experts for "Practical assessment of electromagnetic and interference environment at the measurement point in GNSS frequency bands" on characterizing and measuring the RNSS spectrum environment.
- Recognizing the almost identical document was approved by ITU-R Study Group 1 and now become Report ITU-R SM.2454 "Spectrum monitoring techniques in the radionavigation-satellite service frequency bands", the IDM Task Force and the subgroup will also be invited to consider the content of this ITU-R Report together with the comments on this ITU-R Report from RNSS experts in ITU-R WP 4C.

Proposed WG-S Action from Intersession Meeting in September 2019

1) to alert RNSS/GNSS providers about the potential impacts (including impact from unwanted emission) on all potential WRC-23 agenda items, which will be discussed at WRC-19. The following are currently identified for action;

- **to recognize the European Common Proposal to WRC-19 regarding WRC-23 agenda item, "to review the amateur service secondary allocation in the 1 240-1 300 MHz frequency band to determine if additional measures are required to ensure the protection of the RNSS in the same band"**
- **to encourage RNSS/GNSS providers to analyze the potential impact on the operation of RNSS/GNSS below 1300 MHz by the impact from potential mobile service allocations in the frequency band 1300-1350 MHz, in particular.**

2) based on the above, to encourage RNSS/GNSS providers to contact their national telecommunication administration for their national preparation process for WRC-19, as appropriate.

(WRC-19 Schedule: 28 October-22 November 2019).

GNSS Interference Detection

Devise-Based GNSS Interference Detection -Crowed Source-

- The sub-group discussed the use of raw data from GNSS chipsets which is now accessible on Android devices (still unclear on Apple devices)
- The sub-group was also informed about the EU's work to promote this capability - GNSS raw measurement task force.
- The sub-group discussed other possible raw data outputs that would improve capabilities and ways to encourage manufacturers to make them available
- In response to Rec. 12S-2, the sub-group also discussed ways such raw GNSS data might be used to benefit national interference detection systems

RFI Downlink – ADS-B -

- The sub-group discussed the Eurocontrol's trail for RFI Downlink using ADS-B to report the RFI incidence.
- The sub-group recognized Eurocontrol is welcoming possible cooperation with other entities, expecting synergies between aviation and non-aviation efforts.

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.

Implementation of Recommendation 12S-1

- Japan – prior to the ICG recommendation, ITU-R M.1902, 1903, 1905 were already being used as the basis for RNSS spectrum management
- EU – interference protection criterion of C/No degradation of 1 dB (equivalent to I/N of -6 dB) has been used as the basis for the ETSI standard associated with the Radio Equipment Directive (RED) applicable to GNSS receivers sold in the EU
- [China - ITU-R M.1902, 1903, 1905 **should** be used to protect critical uses of GNSS]
- Russia – National regulator has been informed of the ICG recommendation
- USA – Spectrum regulators are aware of the ICG recommendation
- India – To be submitted before ICG-14

INTEROPERABILITY & SERVICE STANDARDS

Co-chairs

Xiaochun LU, China

Jeff AUERBACH, U.S.

Interoperability & Service Provision Subgroup

Jeff Auerbach, U.S. - Co-lead

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N M Desai
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Workshop Summary Slides

ICG Performance Standards & IGMA Workshop

Hosted by United States Delegation

United Nations Office in Vienna

June 12 & 13, 2019

IGMA Task Force

- "Open" meeting on June 12
- Attended by China, Europe, IGS, Japan, Russia, and United States
- IGMA Joint Trial Project –
  - Presentations by China, Europe, IGS, Japan, Russia, and United States
  - Described methodologies used in the their trial project monitoring system
  - Provided trial project status
- "Closed" meeting on June 13 for Task Force members
  - Trial Project Results
    - Results of orbit/clock errors, user range error, PDOP, and UTC offset error
    - Presentations by China, Europe, IGS, Russia, and United States
    - The document "**Summary on Methodology of GNSS Monitoring and Assessment for ICG IGMA-IGS TJP**" was discussed and the column identified as "Recommend" was completed, which provides the final harmonized statement for each of the parameters.
- Next steps –
  - Update IGMA Trial Project Methodologies document
  - Standardize time and grid selections; meet again to compare results
  - Russia to host workshop in Spring 2020

Performance Standards Dream Team

- “Open” Meeting on June 12
- Attended by China, Europe, Japan, Russia, and United States
- Performance Standards Definitions
  - Update was proposed to PS Guidelines to make the standards for Range Availability Optional and Slot Availability Key
- Next steps –
  - Share hints & tips; harmonize calculation methods
  - Consider updates to PS Guidelines
  - Russia to host workshop in Spring 2020

Using Broadcast versus Estimated GGTO in Harsh Environments

F.Melman, P.Crosta, X.Otero, R.Lucas

ICG WG-S, Intersessional Meeting
06 September 2019, ISPRA, Italy

Background

- At the June 2019 Timing Workshop, the point was made that the broadcast values of XYTO* should be used only when the number of satellites available prevents its determination.

- Feedback received from a well-known manufacturer of mass-market GNSS chips indicate that although opportunistically they can compute XYTO, they still would like a reliable and accurate broadcast value. They also reported that their receiver biases are well calibrated already.

- A mass-market user is exposed to harsh environments (i.e urban) where measurements are polluted with multipath errors (LOS and NLOS) impacting the XYTO estimation and the PVT.

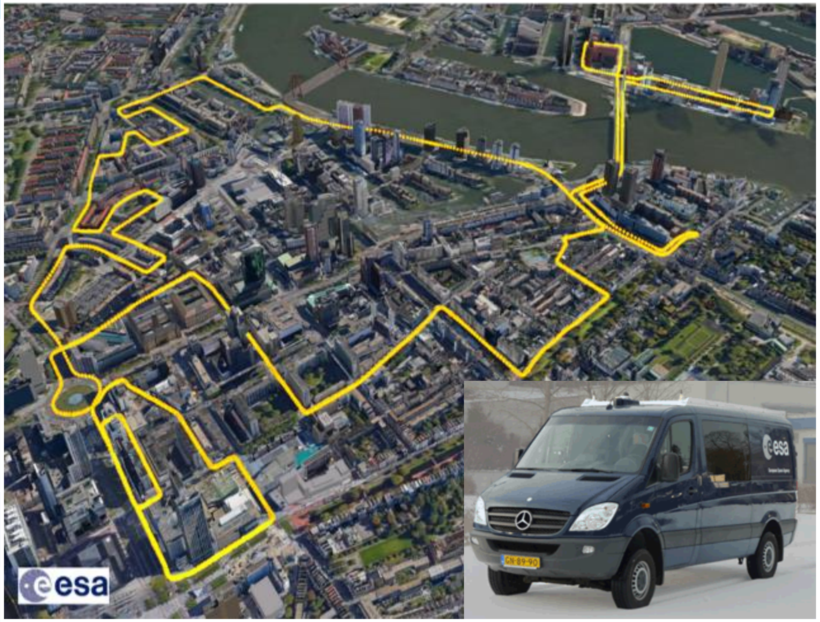
- The majority of the users operate in harsh environments.

- This presentation addresses the above issue comparing the impact on the PVT of using the broadcast GGTO versus estimating its value on the receiver.

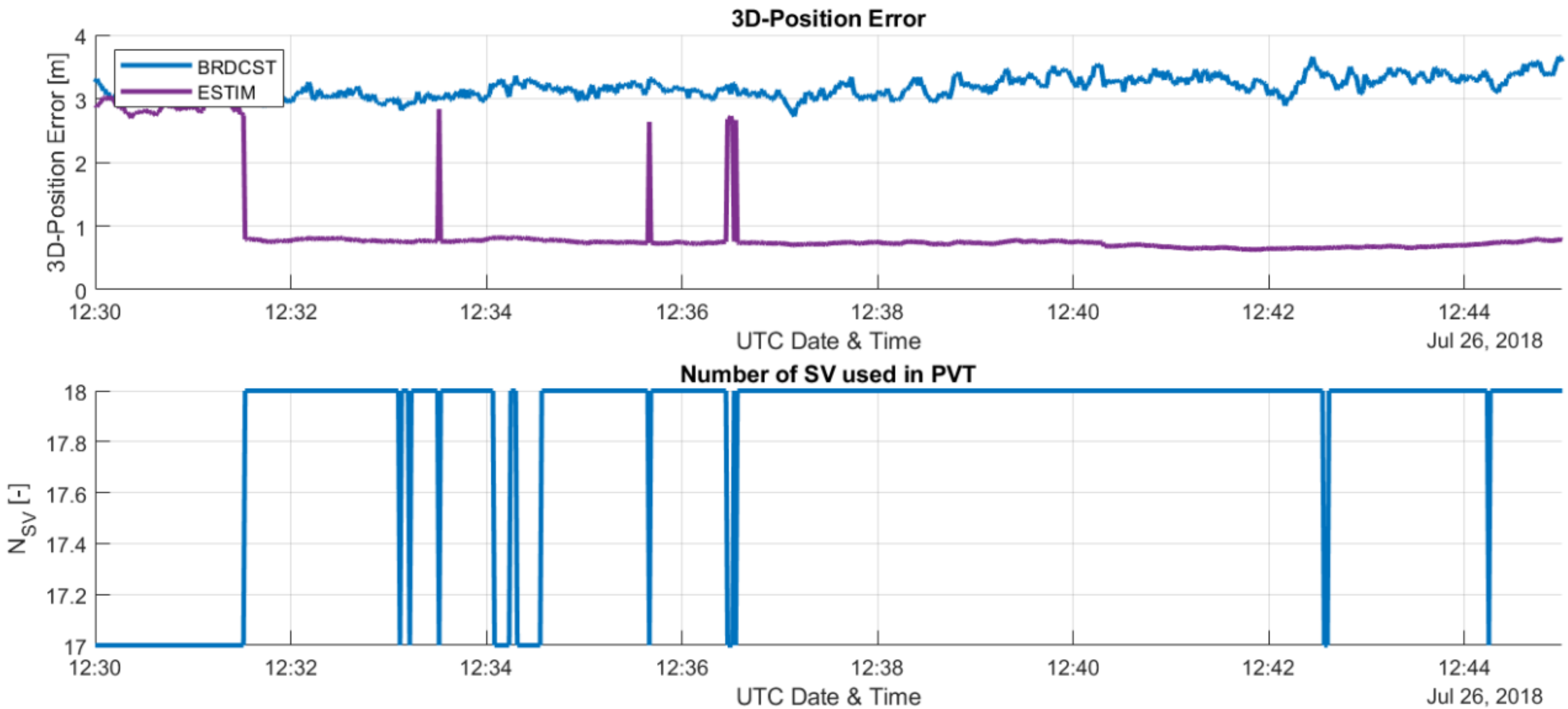
*XYTO = Inter-System Time Offsets,e.g. via GGTO, via UTC broadcast, ….

Test Setup (Professional Receiver)

Test Setup	
Date	7 July 2018
Duration	12:30:00 – 14:30:00 (2 hours)
Constellation	GPS + Galileo
Elevation Mask	5 degrees
Smoothing	Carrier Phase Based Hatch Filter
PNT algorithm	Weighted Least Squares
Receiver	Professional Antenna + Receiver
Environment	Open Sky (15 minutes) -> Urban (1:45 hr)



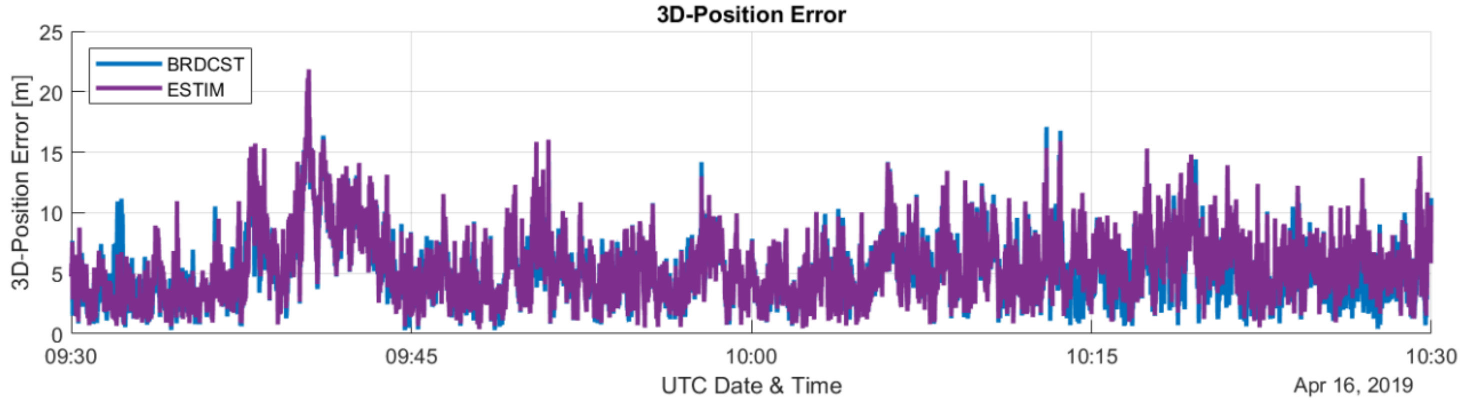
3D-Position Error (Professional – Static – Open Sky)

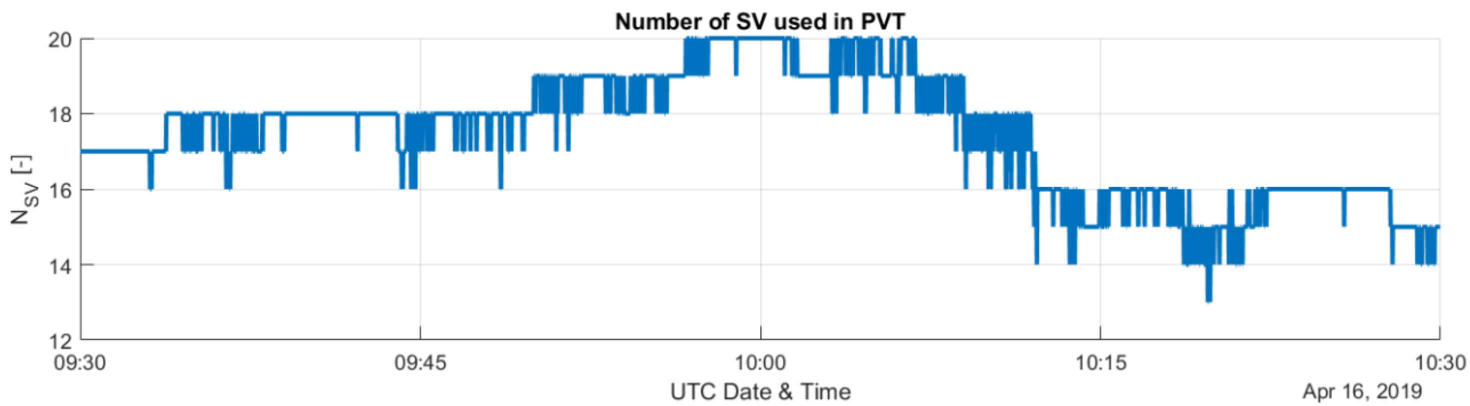


Test Setup (Smartphone – Static – Open Sky)

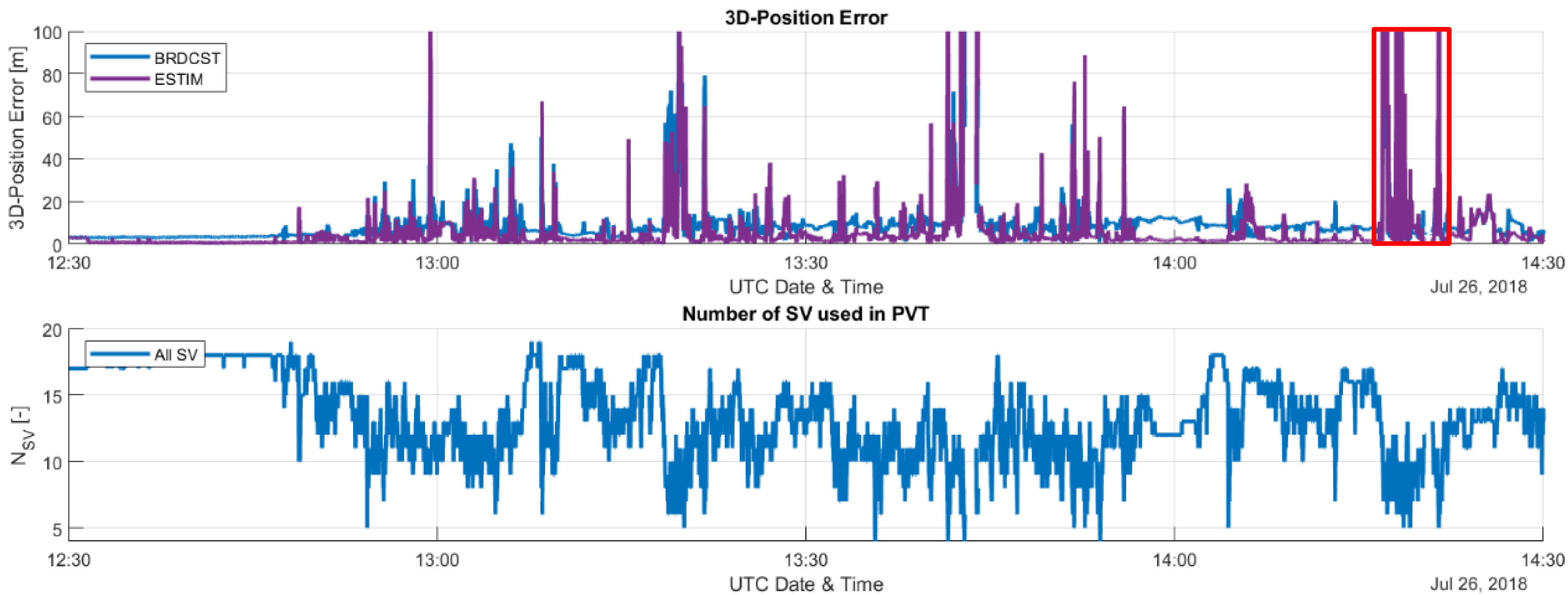
Test Setup	
Date	16 April 2019
Duration	09:30:00 – 10:30:00 (1 hours)
Constellation	GPS + Galileo
Elevation Mask	5 degrees
Smoothing	None
PNT algorithm	Weighted Least Squares
Receiver	Smartphone Antenna + Receiver
Environment	Static Open Sky

3D-Position Error (Smartphone – Static – Open Sky)

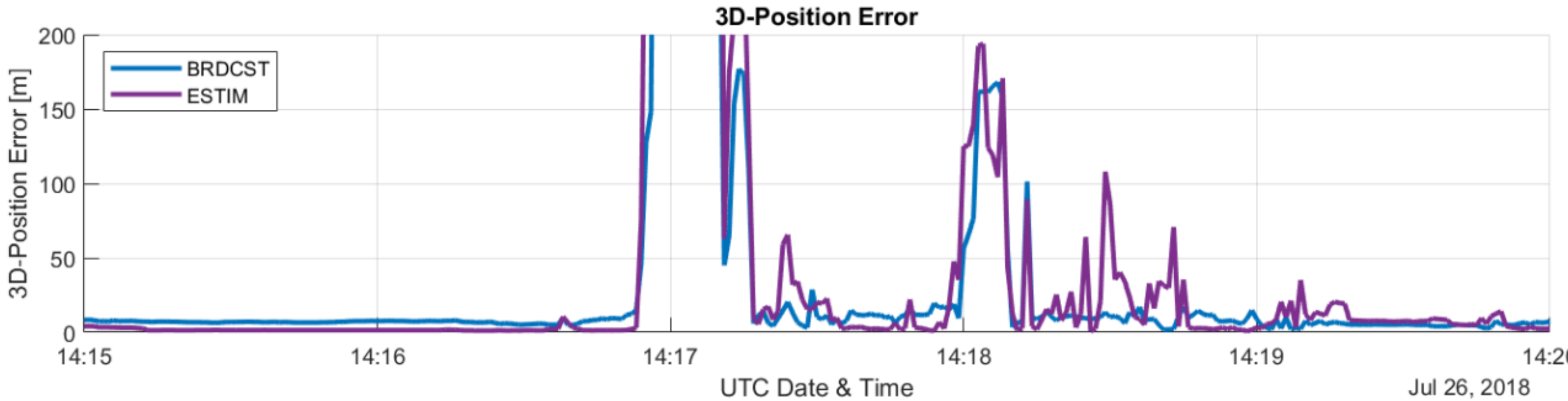


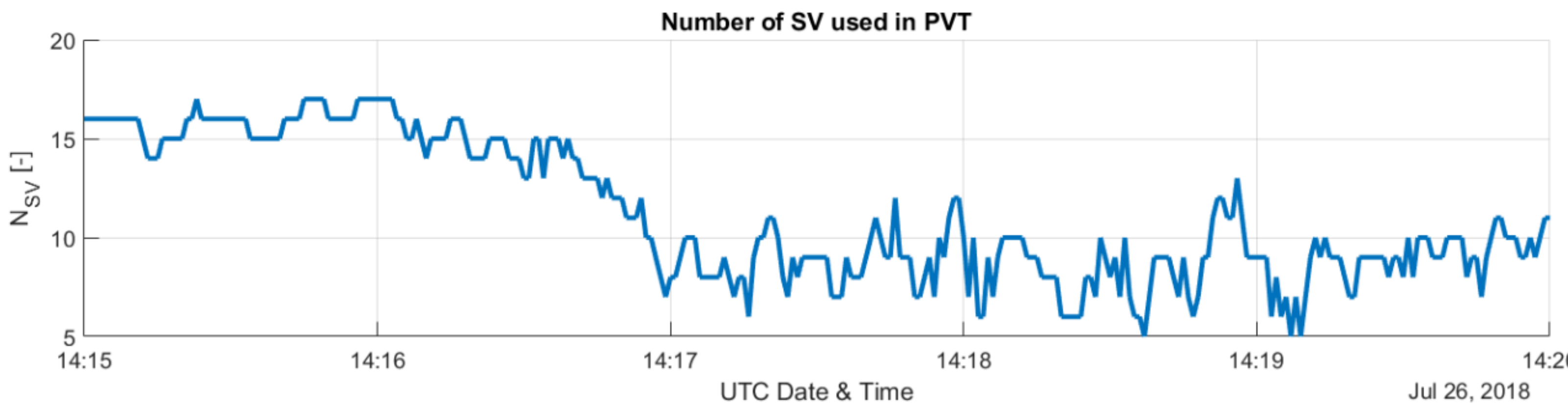


3D-Position Error (Professional – Dynamic - Urban)

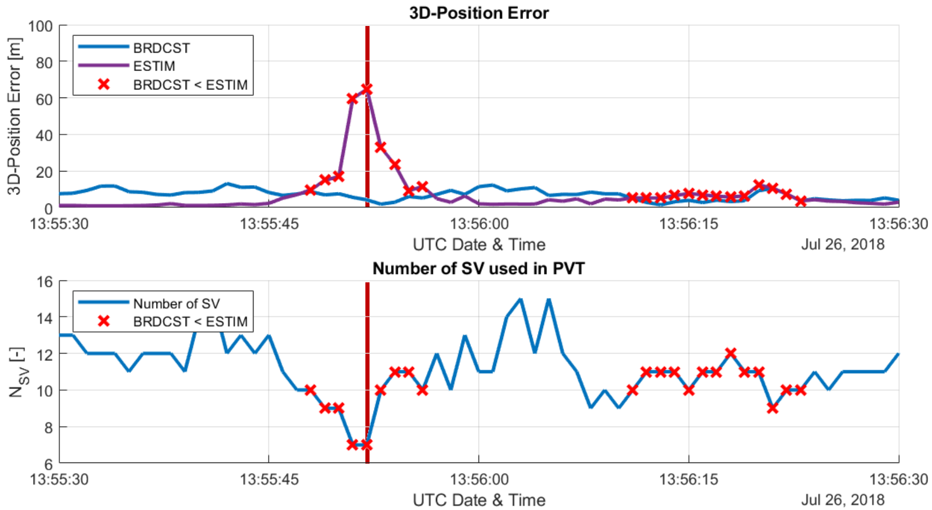


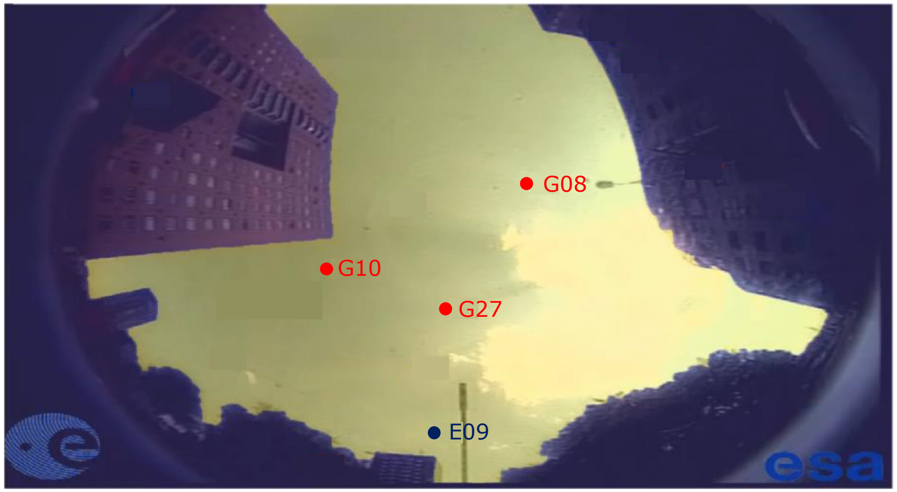
3D-Position Error (Professional Receiver) - Snapshot





3D-Position Error (Professional Receiver) - Snapshot

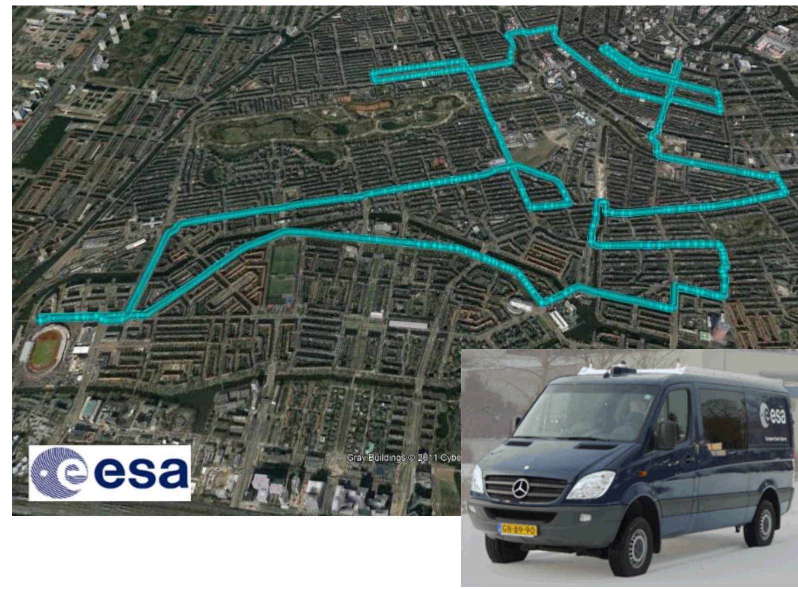




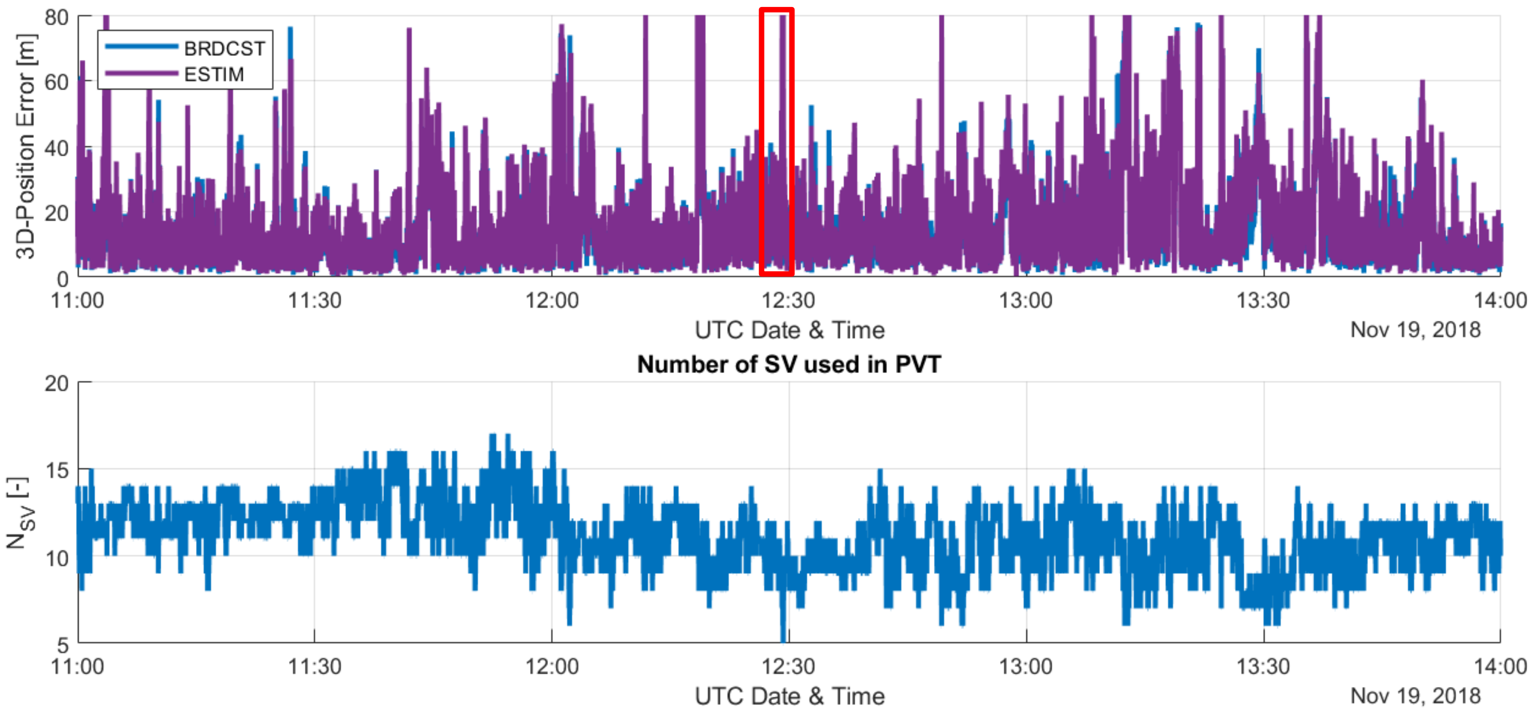
- 7 satellites are tracked by Rx and used by PVT
- G11 - G16 - G28 -> Out-of-view of the camera
  High Residuals -> Multipath

Test Setup (Mass Market Receiver)

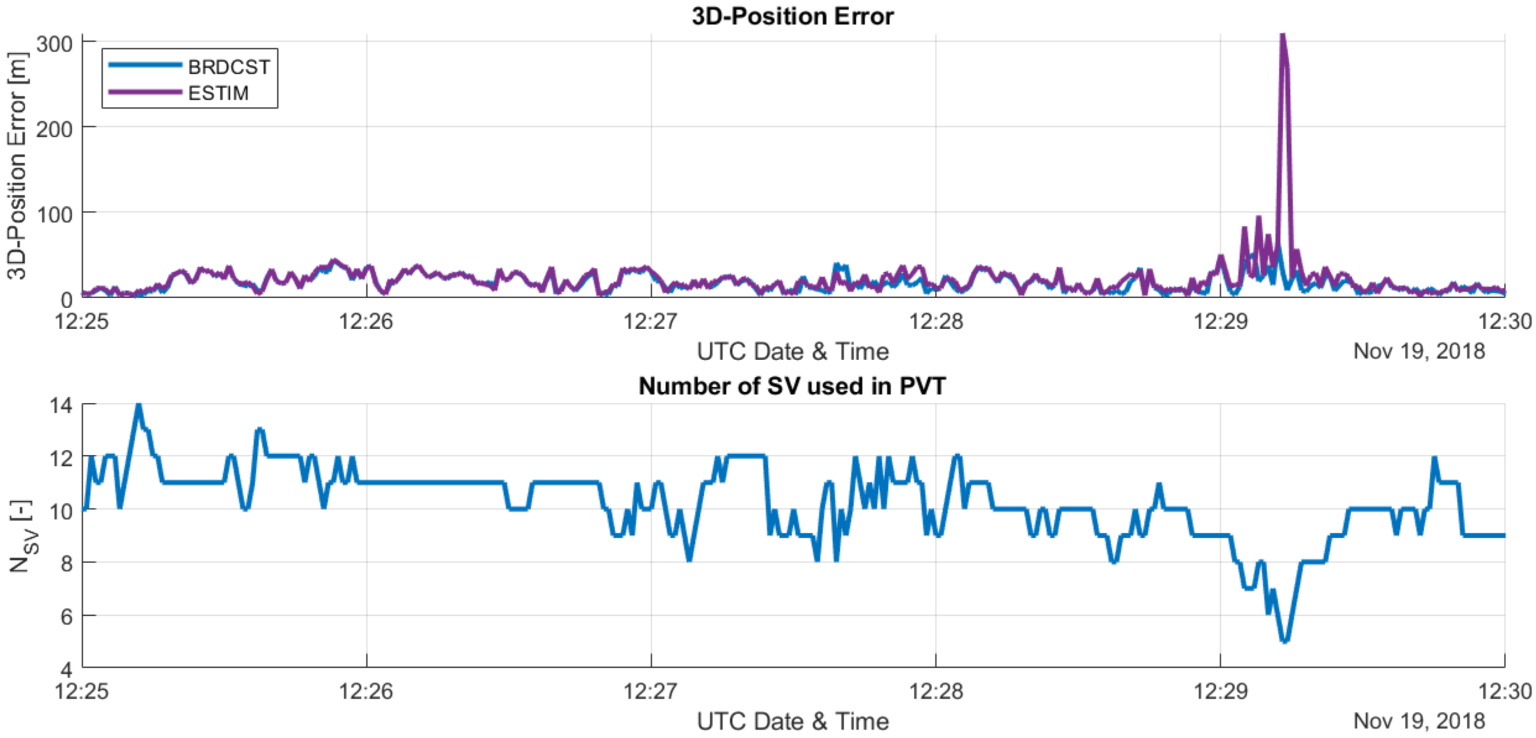
Test Setup	
Date	19 September 2018
Duration	11:00:00 – 14:00:00 (3 hours)
Constellation	GPS + Galileo
Elevation Mask	5 degrees
Smoothing	Carrier Phase Based Hatch Filter
PNT algorithm	Weighted Least Squares
Receiver	Mass Market Antenna + Receiver
Environment	Mild Urban



3D-Position Error (Mass Market – Dynamic – Urban)



3D-Position Error (Mass Market) - Snapshot



Static Open Sky Position Performance

- For the professional receiver it appears to be better to use **estimated GGTO**, mainly due to the **accuracy** of the **broadcasted GGTO** at that time.

- For the **smartphone** receiver there appears to be **no difference** (benefit) of using the estimated GGTO.

- In the smartphone the **accuracy** of the solution is **dominated** by the **errors** in the **measurements** and the accuracy of the broadcasted GGTO does not have an impact.

Dynamic Urban Position Performance

- In **good visibility** cases:
  - Professional receiver: better GGTO estimation compared with broadcast but no large difference in PVT error, which appear to be bounded by the broadcast GGTO accuracy.
  - Mass-Market Receiver: No significant difference between using estimation of GGTO or its broadcast.

- In **poor visibility** cases (deep urban canyon) the **estimated GGTO** has large **error peaks** while the **broadcast GGTO** is more **accurate**. This is the case for both, professional and mass market receivers.

- Overall, using the **broadcasted GGTO** brings a **significant benefit** compared to estimated GGTO.

Conclusions

- The results of short tests using mass market and professional receivers appear to confirm the view of the mass-market GNSS chip manufacturer.

- The use of broadcast XYTO vaues (e.g. GGTO for GPS and Galileo) brings benefits to a majority of users (e.g. smartphones) when compared to the use of only an estimation of XYTO in the receiver.

- ICG WG-S is encouraged to continue its work in defining the optimum way of computing and disseminating XYTO, focusing in particular to the benefits provided to mass-market users in harsh environments:
    - A workshop with representatives of mass-market GNSS receivers/chips may be an adequate way to advance in understanding their needs and requirements with regard to XYTO.
    - Experimental work using offsets with respect to UTC prediction as pivot for XYTO, in conditions of mass-market users, is recommended.

Timing Workshop Results - Russia

After the discussion the following directions of ICG WG S Time interoperability activities were proposed:

1. **Providers are to indicate in their ICDs and/or other basic documents that for calculating GNSS-GNSS Time offset by multi-system users the broadcast GGTO corrections should be used only in case it is impossible to calculate the offset in the autonomous mode due to the lack of SVs in view.**
2. **Interoperability and Service Standards Sub-group is to shift the focus of its attention to time transfer problems.**
3. **The members of ICG WG S and WG D are to present the results of GNSS Time Interoperability analysis and GNSS-GNSS time offsets to ICG 14.**
4. **ICG IGMA Task Force is to consider GNSS-GNSS Time offset as one of Monitoring parameters.**
5. **IGS GNSS Monitoring Working Group is asked to present the results of their activity at ICG Annual Meetings and intersessional WG S/ WG D meetings.**

ICG WG-S and WG-D
Timing Workshop
14 June 2019

Conclusions and Actions

WG-S/WG-D Timing Workshop – June 2019

1. Background and Previous Actions – *Interoperability Subgroup Co-Chairs*
2. GLONASS Time and GNSS Time Interoperability – *Russia*
3. Interoperability through accurate prediction of [GNSS time – UTC] – *BIPM*
4. Different ways of estimating the GGTO, and their impact on the position accuracy – *Royal Observatory of Belgium*
5. The new results of GNSS Time Offsets Monitoring and the Opinion about MGET and xGTO – *China*
6. Progress on Multi-GNSS Timing Offsets: XGTO, MGET – ESA
7. Considerations on GNSS Timescale Offsets – *BIPM*

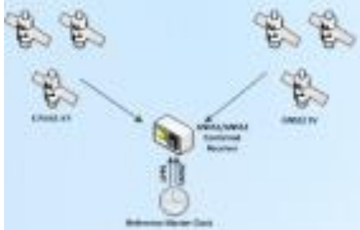
GNSS Timing Workshop – Conclusions

[CONCLUSION 1: The single station time offset monitoring technique, as presented by China at the Workshop, is currently being implemented by all GNSS providers]

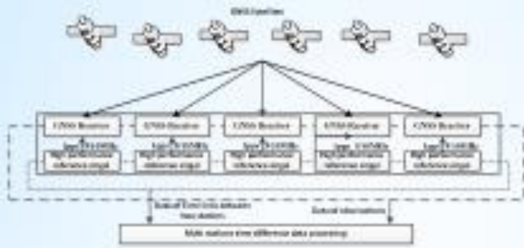
China Presentation - Timing Workshop (1)

1. BDS Time Offsets Monitoring

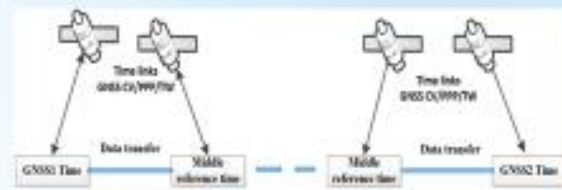
Three methods For GNSS Time Offsets Monitoring



Single Station



Multi Stations

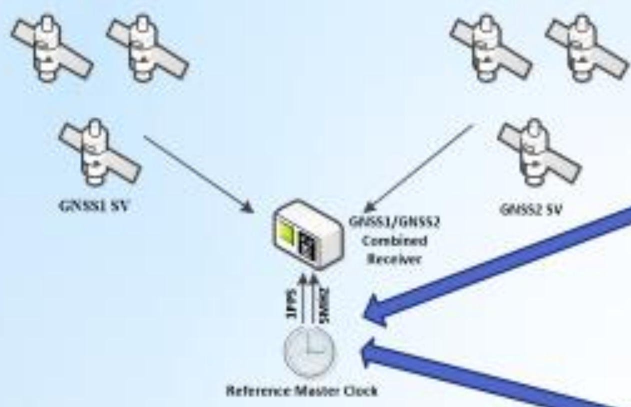


Time Comparison Links

Items	Single station	Multi Stations	Time links
Equipment	Multi mode GNSS Receiver In Time Lab.& GNSS MCS	Multi mode GNSS Receiver In different time laboratory	Time comparison between each GNSS MCS
Data processing	Real time calculation	Data selection, fusion, Post processing	Data interchange, Post processing
Time limit	Real time	Latency 1day or more	Due to time comparison links
Accuracy	~10ns	5~10ns	~5ns

China Presentation - Timing Workshop (2)

1.1. Single Station method and GNSS time offsets differential station



The reference signal: a clock
Factors: Receiver, Signal quality, Environment, the reference clock, prediction algorithm,...

The reference signal:UTC(k)
Factors: Receiver, Signal quality, Environment, UTC(k), prediction algorithm,...

Relative time offsets between two GNSS time

Absolute time offsets between GNSS Time and UTC(k), UTC(k) is used as a dirrerential station.

GNSS Timing Workshop – Conclusions

CONCLUSION 2: No consensus among ICG for establishing a task force to examine the XGTO and MGET proposals using live signals, as proposed by ESA – Agreement that no further discussion is warranted at this time

GNSS Timing Workshop – Actions

ACTION 1: Estimation of the GNSS time offset is best accomplished by estimation within the individual user receiver. Providers should try to ensure that GNSS receiver manufactures understand this and only use the broadcast GGTO values when internal receiver estimation is not available. Where appropriate include guidance in user ICD, performance specifications, best practices guides, etc…

ACTION 2: The IGMA Task Force will consider including time offset monitoring under the ICG/IGS Trial Project

ACTION 3: IGS will provide a briefing at ICG-14 on what the IGS Timing Subgroup is and what it produces and provide future updates as necessary

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

2019 Intersessional Meeting

Interoperability and Service Provision Subgroup Report

Ispra, Italy
5-7 September 2019

Interoperability & Service Provision Subgroup

Jeff Auerbach, U.S. - Co-lead

Xiaochun LU, China - Co-lead

China
SONG Shuli
DU Juan
SHEN Jun
LI Jianwen

Japan
Satoshi Kogure

U.S.
Bethany Kroese
John Lavrakas
Andrew Hansen

European Union
Hillar Tork
Peter Buist
Werner Enderle
Joerg Hahn

Russia
Igor Larin
Tatyana Mirgorodskaya
Alex Bolkunov
Igor Silvestrov
Tatiana Primakina
Andrey Druzhin
Sergey Silin

Interoperability and Service Standards

- **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
- **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

International Committee on Global Navigation Satellite Systems

OPEN SERVICE INFORMATION SHARING

Work Plan - Open Service Performance Standards

- 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).

Sub-Group Members focused on Performance Standards – *Dream Team*

- **Alexey Bolkunov (co-lead),** Igor Silvestrov, Sergey Kaplev **-** Russian Federation
- **John Lavrakas (co - lead),** Andrew Hansen **-** United States
- Hillar Tork, Rafael Lucas-Rodriguez**,** Daniel Blonski**,** Peter Buist **-** European Union
- Yoshihiro Iwamoto, Masaharu Kugi**,** Satoshi Kogure **-** Japan
- Jianwen LI, Juan DU **–** China
- R. Ramasubramanian - India

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 1.3	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 OS Service Definition Document v1.0 Dec 2016		✓
	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/	gsc-europa.eu	irnss.isro.gov.in/	qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html

Roadmap & Scorecard – GNSS Performance Standards Guidelines – to be updated

Item	Status	Comments
Recommend draft content for Performance Standards	Complete	Draft Performance Standard Template prepared and provided in 2012 (DDST-2012)
Draft Calculation Methods applicable with DDST-2012	Complete	Draft Calculations Methods Document prepared and provided in 20145
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	Ongoing. Discussed on monthly teleconference calls (MTC)
Each GNSS/RNSS identify calculation methods	In progress	Ongoing. Discussed on MTCs
Finalize set of definitions	In progress	Ongoing
Issue Performance Standard Guideline Document ("Guidelines for Developing Performance Standards")	Complete	Recommendation for WG-S and ICG-13
Set of Calculation Methods used in PSs and SDDs	Under discussion	To be discussed on MTCs and ICG-13
Hints and Tips on PSs and SDDs (or their new revisions) development and parameters estimation and evaluation	Under discussion	To be discussed on MTCs and ICG-13
Calculation methods Guidelines	Under discussion	To be discussed on MTCs and ICG-13
Further tasks and challenges, including maintaining of issued documents	Under discussion	To be discussed on MTCs and ICG-13

Performance Standards Workshop – June 2019

- “Open” Meeting on June 12
- Attended by China, Europe, Japan, Russia, and United States
- Performance Standards Definitions
  - Update was proposed to PS Guidelines to make the standards for Range Availability Optional and Slot Availability Key
- Next steps –
  - Share hints & tips; harmonize calculation methods
  - Consider updates to PS Guidelines
  - Russia to host workshop in Spring 2020

PERFORMANCE MONITORING

IGMA Task Force

- Co-Chairs:
  - Satoshi Kogure, CAO, Japan
  - Shuli SONG, China
  - Allison Craddock, IGS
- Members:
  - Igor Silvestrov, Alexey Bolkunov, Russia
  - LI Jianwen, China
  - Yoshihiro Iwamoto, Japan
  - Karen Van Dyke, John W. Lavrakas, Andrew J. Hansen, United States
  - Hillar Tork, Werner Enderle, Peter Buist, European Union

Work Plan – 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

- ***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

Existing 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://sys.qzss.go.jp/dod/en/
	India	
IGS portal	IGS	http://igs.org/

IGMA Activities and Progress

Providers' Nomination Status SUMMARY

Country	Signed CL	Category	Organization Name
Russia	X	MAC	PNT Center in TSNIMASH
		Monitoring site(2)	Klyuchi, Korolyov
		Data Center	PNT Center in TSNIMASH
U.S.	X	MAC	DOT/Volpe Center
		Monitoring site(6)	Boston, Honolulu, Los Angels, Miami, Juneau, and Merida
		Data Center	USCG
EU	X	MAC	GSA/Galileo Reference Centre
		Monitoring site	To be provided
		Data Center	To be provided
China	X	MAC	RISM/NTSC
		Monitoring site(3)	Shanghai, Lhasa, and Urumqi
		Data Center	TARC/CSNO
Japan		To be provided	To be provided

IGMA Workshop – June 2019

- “Open” meeting on June 12
- Attended by China, Europe, IGS, Japan, Russia, and United States
- IGMA Joint Trial Project –
  - Presentations by China, Europe, IGS, Japan, Russia, and United States
  - Described methodologies used in the their trial project monitoring system
  - Provided trial project status
- “Closed” meeting on June 13 for Task Force members
  - Trial Project Results
    - Results of orbit/clock errors, user range error, PDOP, and UTC offset error
    - Presentations by China, Europe, IGS, Russia, and United States
    - The document “**Summary on Methodology of GNSS Monitoring and Assessment for ICG IGMA-IGS TJP**” was discussed and the column identified as “Recommend” was completed, which provides the final harmonized statement for each of the parameters.

IGMA Task Force

- Next steps –
  - Update IGMA Trial Project Methodologies document
  - Standardize time and grid selections; meet again to compare results
  - Russia to host workshop in Spring 2020

TIMING INTEROPERABILITY

Work Plan - Interoperability

- 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:
  - ***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;
  - ***Maintain a focus on the open service signal development*** and broadcast plans of the system providers; and,
  - In cooperation with Working Group D***, consider the role of system time and geodetic reference frames in enabling interoperable*** multi-GNSS service

ICG International Committee on Global Navigation Satellite Systems

WG-S/WG-D Timing Workshop – June 2019

1. Background and Previous Actions – *Interoperability Subgroup Co-Chairs*
2. GLONASS Time and GNSS Time Interoperability – *Russia*
3. Interoperability through accurate prediction of [GNNS time – UTC] – *BIPM*
4. Different ways of estimating the GGTO, and their impact on the position accuracy – *Royal Observatory of Belgium*
5. The new results of GNSS Time Offsets Monitoring and the Opinion about MGET and xGTO – *China*
6. Progress on Multi-GNSS Timing Offsets: XGTO, MGET – ESA
7. Considerations on GNSS Timescale Offsets – *BIPM*

2019 GNSS Timing Workshop – Conclusions

- [CONCLUSION: The single station time offset monitoring technique, as presented by China at the Workshop, is currently being implemented by all GNSS providers]

- CONCLUSION: No consensus among ICG for establishing a task force to examine the XGTO and MGET proposals using live signals, as proposed by ESA – Agreement that no further discussion is warranted at this time

2019 GNSS Timing Workshop – Actions

- **ACTION:** Estimation of the GNSS time offset is best accomplished by estimation within the individual user receiver. Providers should try to ensure that GNSS receiver manufactures understand this and only use the broadcast GGTO values when internal receiver estimation is not available. Where appropriate include guidance in user ICD, performance specifications, best practices guides, etc…
- **ACTION:** The IGMA Task Force will consider including time offset monitoring under the ICG/IGS Trial Project
- **ACTION:** IGS will provide a briefing at ICG-14 on what the IGS Timing Subgroup is and what it produces and provide future updates as necessary

Timing Interoperability Tasks to Subgroup

1. Reach consensus on conclusions and actions from June 2019 workshop by [October 4, 2019]
2. Propose next steps to WG-S at ICG-14
   – Conduct another workshop or seek alternative approaches to investigate time interoperability?
   – Other actions?
3. Discuss the conclusions from ESA presented at the intersessional meeting

PPP INTEROPERABILITY

PPP Interoperability

- Interoperability and Service Provision Subgroup Meeting, June 2019 in Vienna
  - Discussion about PPP interoperability as a topic of future discussion within the Subgroup
    - Agreement that this is a topic of interest to Subgroup members
- PPP Workshop, June 2019 in Fiji
  - Chaired by WG-D with participation from WG-S and WG-B
  - Attendees included representatives from: Australia, China, Japan, EU, Russian Federation, U.S., FIG and IGS
  - Focused on understanding proposed designs from service providers and discussing next steps

PPP Workshop – Recommendations/Outcomes

- **Recommendation 1:** Consider involving/discussing with the SBAS Interoperability Working Group and the ICAO Navigation Systems Panel moving forward
- **Recommendation 2:** Concentrate on establishing the foundational documents, and baseline language to develop a common language on the basic parameters, etc. – WG-D Proposal: *Publish and disseminate PPP signal and system information*
- **Recommendation 3:** Consider establishing a task force within the Interoperability Subgroup
- **Recommendation 4:** WG-S should consider a draft recommendation for discussion and approval at their intersessional meeting in September 2019

PPP Workshop – Recommendations/Outcomes

- **Recommendation 5:** In preparation for the WG-S intersessional, the group should develop questions to stimulate discussion in WG-S intersessional meeting in September and also to highlight the importance to develop such foundational documents to PPP services. It is also recommended that providers should consider the questions and prepare a response for the WG-S intersessional meeting.

PPP Questions for WG-S Consideration

1. During the Joint WG-S/-B/-D workshop in Fiji, the participating experts recognized the importance of "Interoperability of Precise Point Positioning (PPP) Services". Is this finding shared and therefore worthy of further discussion and cooperation within the ICG? (Yes/ No)
2. If "Yes", how can this be achieved? Is the current multi-WG team of experts under the umbrella of the Interoperability Sub-group of WG-S a suitable setup? (Yes/ No)
3. Should in the ICG WG's (S/B/D) experts work towards a roadmap detailing the activities aimed at interoperability and compatibility of PPP service providers?

PPP Questions for WG-S Consideration (2)

4. Should foundational documents be identified as part of the activities (i.e. templates containing information about the PPP services)?
5. Should a baseline language, e.g., basic set of parameters (i.e. unified terms and definitions) and methods of calculation and monitoring, be developed for sharing of PPP service information?

DRAFT ICG-14 Recommendation 14S-2

- The ICG should establish a Task Force within the WG-S Interoperability Subgroup, with participation from WGs B and D. 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:
  - Consider involving/discussing with the SBAS Interoperability Working Group and the ICAO Navigation Systems Panel moving forward
  - Concentrate on establishing the foundational documents, and baseline language to develop a common language on the basic parameters, etc. – WG-D Proposal: *Publish and disseminate PPP signal and system information*
  - 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

Related Action for WGs S, B, and D

- Nominate Candidates to Co-Chair the Task Force
- Candidates discussed by WG-S include Australia, China, the EU, Japan, and Russia

SYSTEM-OF-SYSTEM OPERATIONS

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

Disposal Strategy and Collision Probability of BDS MEO Satellites

Zhou Jing, Yang Hui
Beijing Institute of Spacecraft System Engineering, CAST

UN ICG WG-S Intersessional Meeting
5-7 September 2019， Ispra, Italy

Contents

GNSS Space Debris Status and International Guidelines

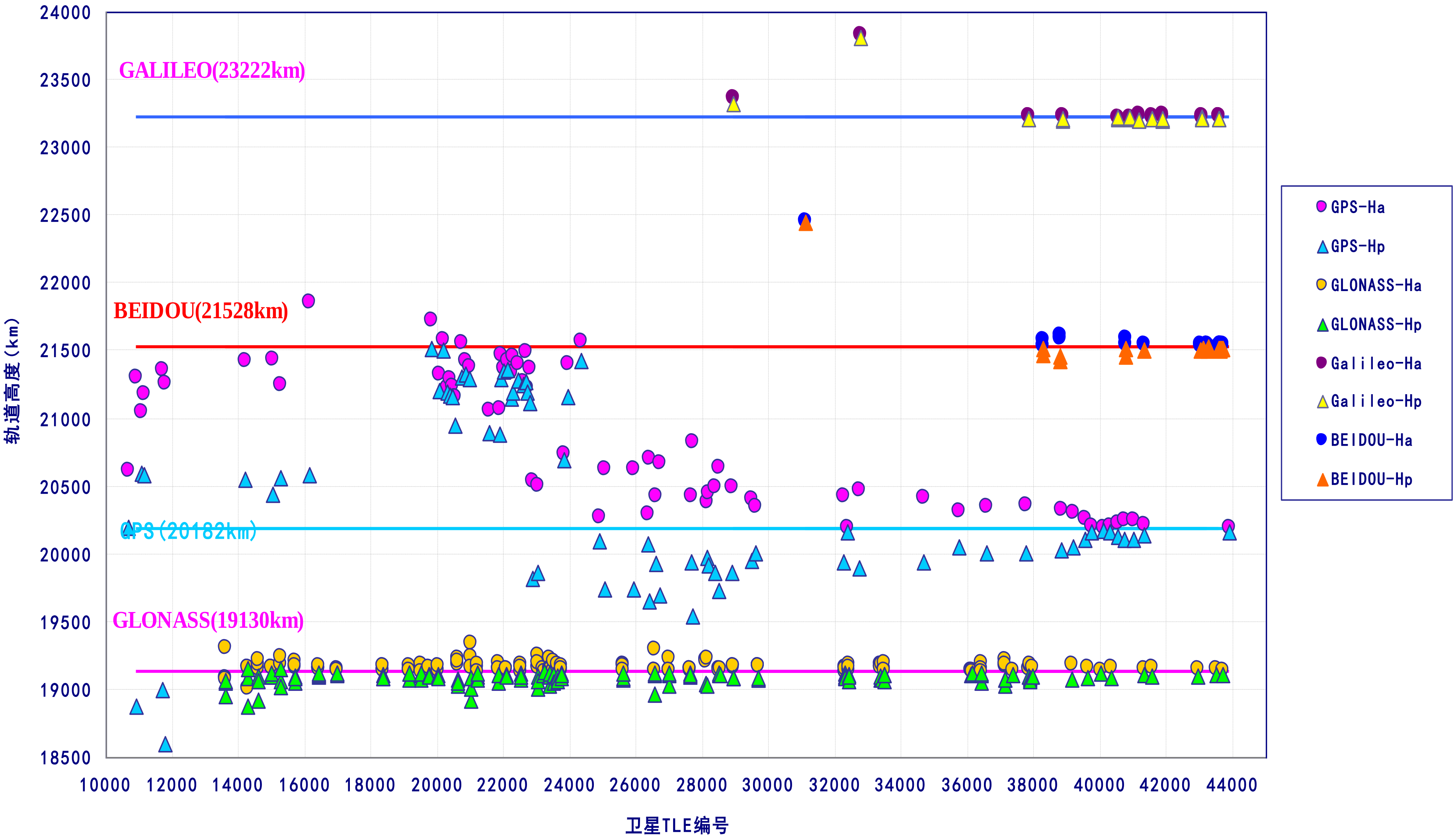
GNSS/RNSS Satellites in Orbit

Constellation	Nation/Area	Number of SVs *			
		GEO	IGSO	MEO	Total
GPS	USA	0	0	71	71
GLONASS	Russia	0	0	133	133
Galileo	Europe	0	0	28	28
BDS	China	13	10	26	49
QZSS	Japan	1	3	0	4
NAVIC	India	3	6	0	9

Data collected from www.space-track.org by the end of May 2019

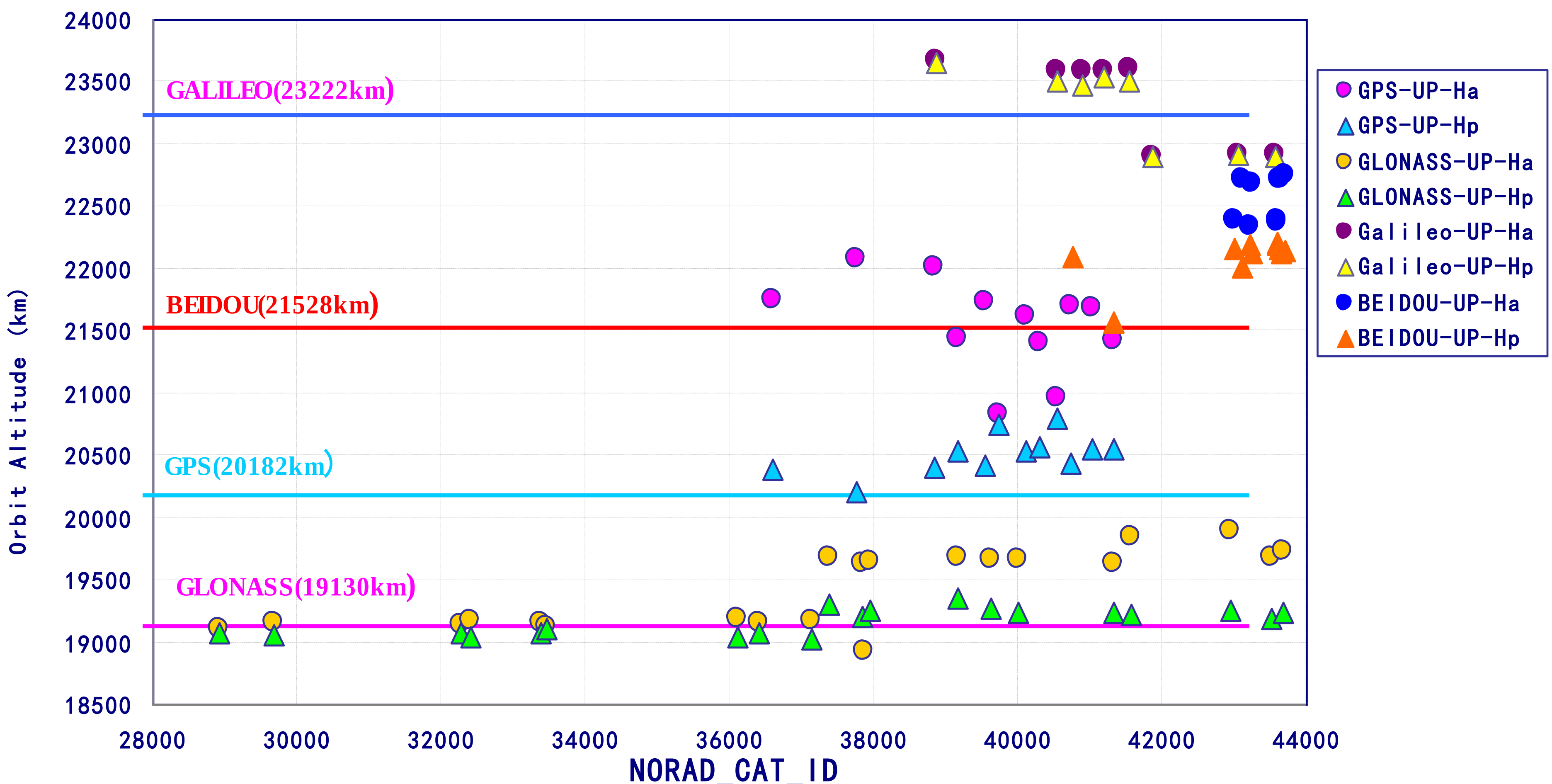
GNSS Satellites Orbit Altitude

ISSE



Data collected from www.space-track.org by the end of May 2019

GNSS Upper-stage Orbit Altitude



Data collected from www.space-track.org by the end of May 2019

GNSS Spacecraft Disposal Orbit

Constellation	De-orbited Satellites		De-orbited Upper-stage	
	Number	△Ha (Increase in apogee altitude)	Number	△Ha (Increase in apogee altitude) /km
GPS	**36**	+350~+1700	12	+600~+1900
GLONASS	0*	0*	21	0~+700
Galileo	2	+120~+600	9	+350~+2900 -300
BDS	4(3GEO/1 MEO)	GEO:+140~+300 MEO:+900	11	+200~+6000
QZSS	—	—	—	—
NAVIC	—	—	—	—

*Glonass SVs at the end of life didn't have increase in orbit altitude yet.

GNSS Disposal Orbit Interference

Operating Orbit	Disposal Satellites Intersected the Operating Orbit		Disposal Upper-stage Intersected the Operating Orbit	
	Number	Disposal Satellites	Number	Disposal Upper-stage
GPS 21200km	0	—	0	—
GLONASS 19100km	3	GPS	0	—
Galileo 23200km	0	—	0	—
BDS 21500km	>30	GPS	10	GPS

MEO Disposal Requirements of IADC

Disposal Action	MEO Navigation Satellite Orbit
25-year decay	Not recommended due to large ΔV required
Disposal orbit	TBC: 1.Minimum long term perigee of 2000km,apogee below MEO 2.Perigee **500km above** MEO or nearby operational region and **e≤0.003**;RAAN and argument of perigee selected for stability
Direct Reentry	Not recommended due to large ΔV required

Requirements from 'Support to the IADC Space Debris Guidelines'

Proposed Disposal Strategy of BDS MEO Satellites

Disposal Safety Restrictions for BDS MEO satellites

To protect nearby constellation and follow-up MEO satellites operational safety, restrictions for EOL disposal of BDS MEO satellites are suggested as follows:

- Based on research of NASA and other organizations, disposal for post mission MEO satellites should ensure no collision risk with operational orbit and nearby constellations within **200 years**.

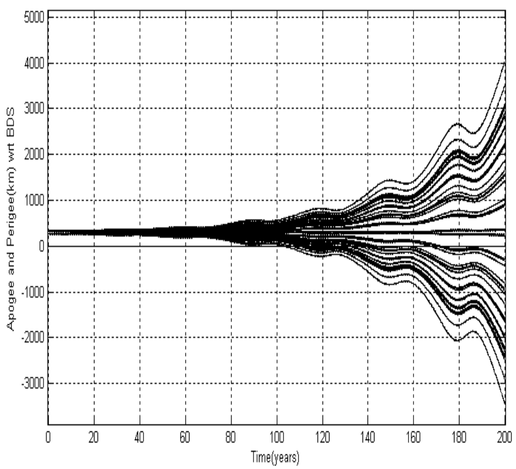
②Considering propellant limitation and isolation from nearby MEO satellite orbits, the increase in altitude at the end of re-orbiting maneuver of MEO satellites should be **more than 300km**.

③The variation of altitude after disposal should be minimized over 200 years, and the variation of orbit altitude should be **less than 200 km within 200 years**.

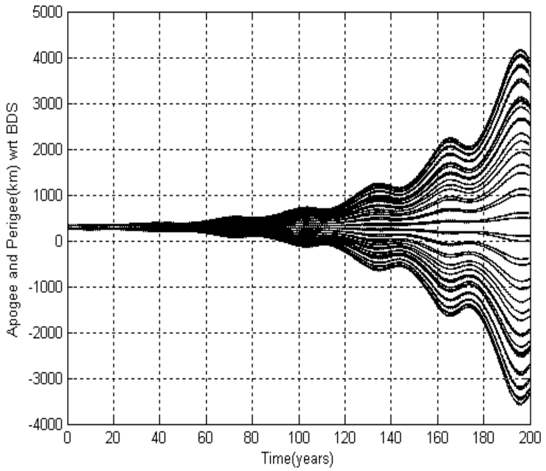
Evolution of BDS MEO Satellites with Different ω_0

- Minimum eccentricity growth strategy: ω0 = 190/320/240 deg, the disposal orbit is very stable (perigee remains above BDS constellation within 200 years)

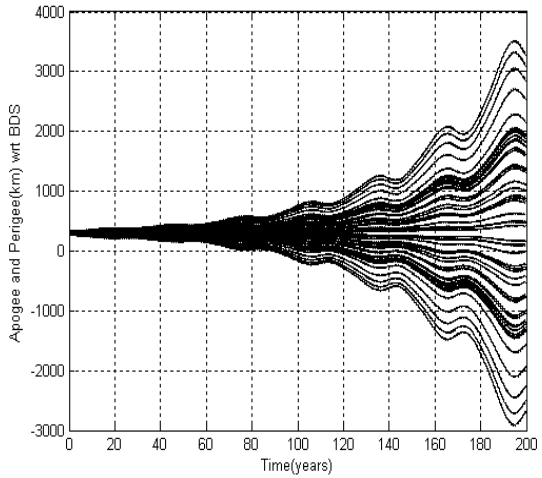
- High eccentricity growth strategy: ω_0 = 290/70/350 deg, the disposal orbit eccentricity grows significantly (perigee crosses the BDS constellation but does not reach GEO within 200 years)



Ω_0=30°，e_0=0.001，ω_0=0~360



Ω=150°，e=0.001，ω=0~360°



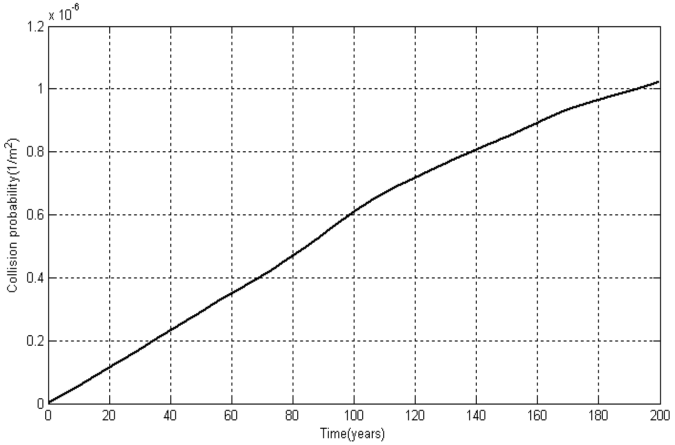
Ω=270°，e=0.001，ω=0~360°

Recommendations for BDS MEO Disposal Orbit Elements

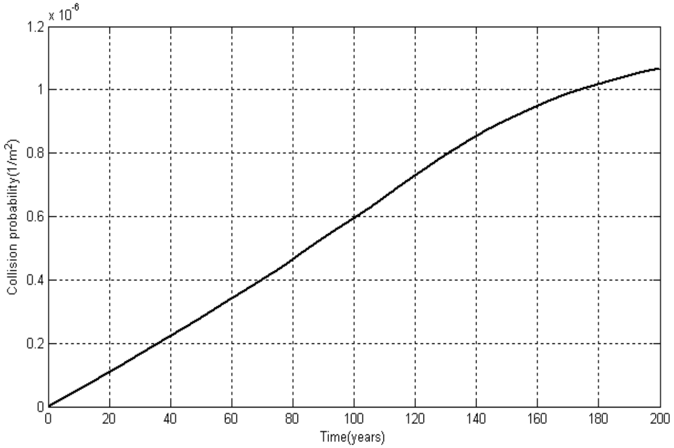
RAAN	Increase in orbit altitude/km	Eccentricity	Minimum Eccentricity Growth		High Eccentricity Growth	
			ω_0 / deg	Max Eccentricity in 200 years	ω_0 / deg	Max Eccentricity in 200 years
30	300	0.001	190	0.002	290	0.16
150	300	0.001	320	0.006	70	0.14
270	300	0.001	240	0.004	350	0.11

Collision Probability Posed to GPS and BDS Constellations

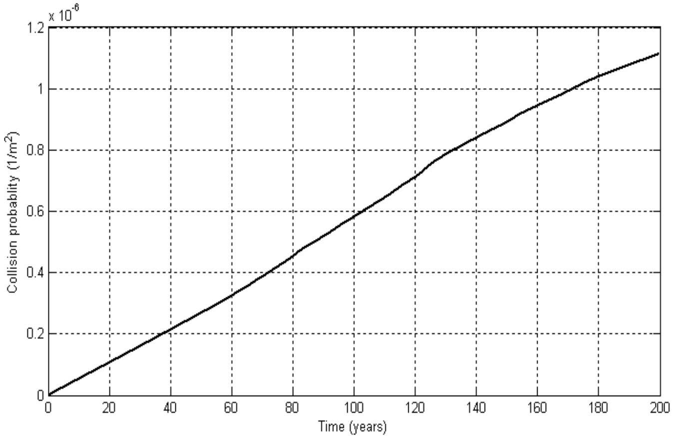
Collision Probability posed to all GPS and BDS Satellites in Orbit



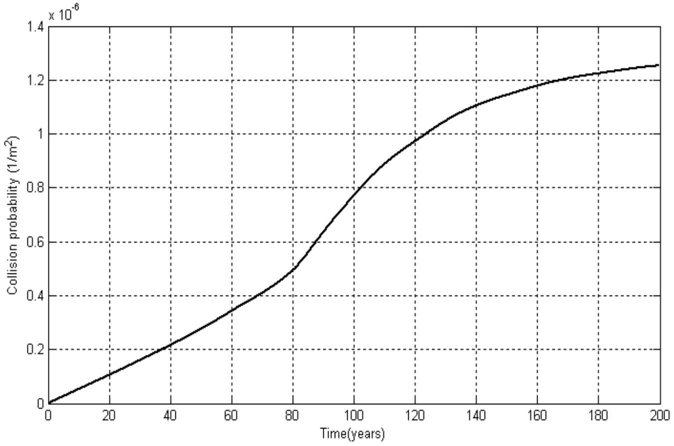
Collision probability posed to all 63 GPS satellites in orbit by one disposal satellite with minimum eccentricity growth strategy



Collision probability posed to all 63 GPS satellites in orbit by one disposal satellite with high eccentricity growth strategy

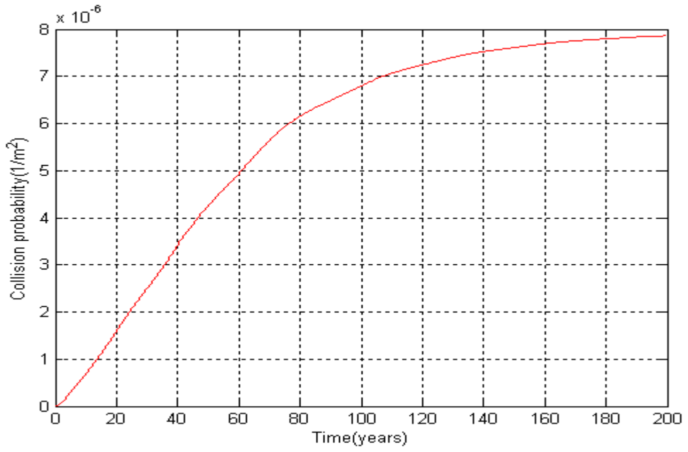


Collision probability posed to all 25 BDS satellites in orbit by disposal satellite with minimum eccentricity growth strategy

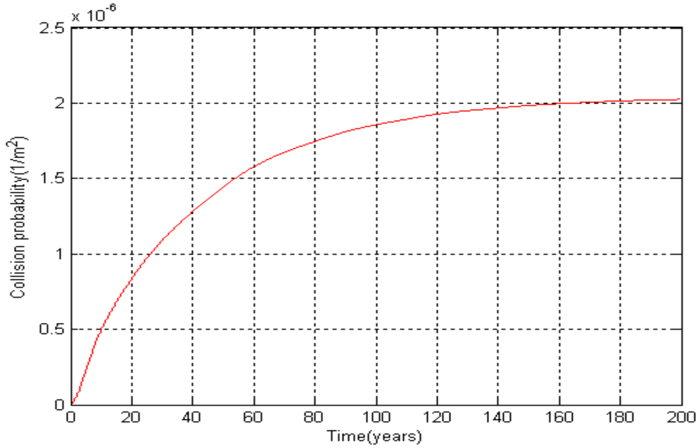


Collision probability posed to all 25 BDS satellites in orbit by disposal satellite with high eccentricity growth strategy

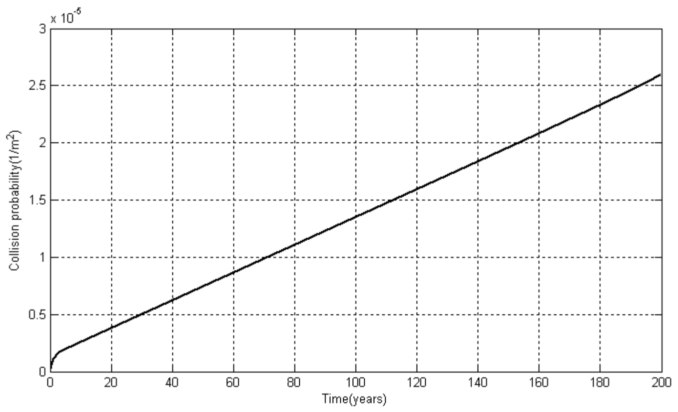
Collision Probability posed to the Graveyard Orbit and BDS Operational Constellation



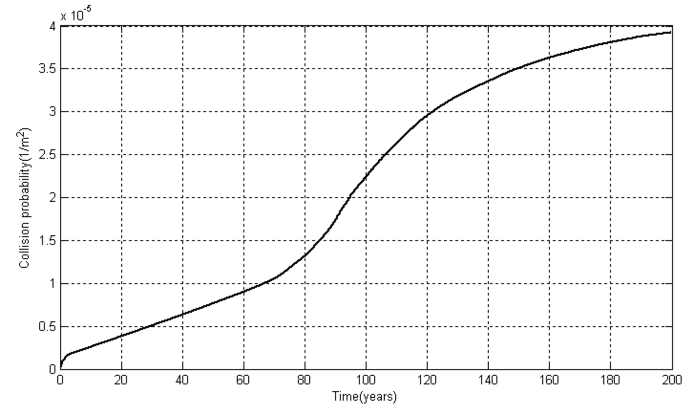
Collision probability posed to the graveyard orbit by all the disposal satellite with minimum eccentricity growth strategy



Collision probability posed to the graveyard orbit by all the disposal satellite with high eccentricity growth strategy



Collision probability posed to the nominal BDS constellation by the disposal satellite with minimum eccentricity growth strategy



Collision probability posed to the nominal BDS constellation by the disposal satellite with high eccentricity growth strategy

Comparison of the Collision Probability

	Cumulative Collision Probability after 200 years	
	Minimum eccentricity growth strategy	High eccentricity growth strategy
Posed to all 69 GPS satellites in orbit by one BDS disposal Satellite	1.02×10^{-6}	1.08×10^{-6}
Posed to all 25 BDS satellites in orbit by one disposal satellite	1.1×10^{-6}	1.25×10^{-6}
Posed to graveyard orbit by one BDS disposal satellite	7.9×10^{-6}	2.0×10^{-6}
Posed to nominal constellation by 24 BDS disposal satellites	2.6×10^{-5}	3.9×10^{-5}

- The collision probability posed to operational orbit or graveyard orbit is of a $10^{-5} \sim 10^{-6}$ order of magnitude, which is less than the 0.001 threshold for LEO-crossing objects.
- The high eccentricity growth strategy results in a lower collision probability to the BDS graveyard orbit than the minimum eccentricity growth strategy.
- The minimum eccentricity growth strategy results in a lower collision probability to the BDS nominal constellation than the high eccentricity growth strategy.
- As for BDS MEO EOL satellites, the minimum eccentricity growth strategy would be proposed.

Summary

Summary

①There are **no final guidelines** for GNSS MEO satellites post-mission disposal from international organizations (IADC), while post-mission disposal strategy and safety restrictions of GNSS EOL satellites are not exactly the same.

②As there will be more GNSS satellites deployed in the future, there will be more intersections among the GNSS constellations as well. As a result, further investigations of the collision probability after disposal of GNSS MEO satellites with own constellation and nearby constellations should be carried out by all system providers.

Summary

•ICG members should pay more attention to the safety of MEO and IGSO space debris:

➢System providers should continue to exchange information on their GNSS/RNSS satellites post-mission disposal plans and implements in WG-S.

③System providers should try to establish the GNSS/RNSS space debris guidelines together with IADC.

ICG-13 Recommendation 13S-2 (1)
IADC MEO/IGSO 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.

ICG-13 Recommendation 13S-2 (2)
IADC MEO/IGSO Study

- **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 progress annually 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

ICG International Committee on Global Navigation Satellite Systems

NEXT STEPS

Proposed Post-ICG-14 Working Group Schedule

- Compatibility & Spectrum Subgroup Events
- Interoperability & Service Standards Events
- PPP Workshop with WG's B & D – to be determined
- WG-S Intersessional Meeting

- Related meetings to be aware of:
  - iGNSS 2020, February 5-7
  - Munich Satellite Navigation Summit, March 16-18
  - Moscow GNSS Forum, April 21-22
  - ITU WP-4C, May 13-19
  - Baska GNSS Conference, May 17-21
  - CSNC 2020, May [20-22]
  - ICG 15, September 14-18

ICG International Committee on Global Navigation Satellite Systems

Previous Recommendations and Status – to be updated

Previous ICG WG-A recommendations implementation summary - 2009 (ICG-4)

No/Year	Brief description	Status
1 / 2009	Revised Work Plan for WG-A	Closed
2 / 2009	Continue seeking inputs on interoperability from industry and users - Conduct a workshop at iGNSS 2009	Closed – new effort initiated @ ICG-5
3 / 2009	Conduct a compatibility-focused meeting prior to ICG-5 – scheduled for June 2010 in Vienna	Closed – led to formation of sub-group
4 / 2009	Endorse the multi-GNSS demonstration campaign and encourage Provider participation	Closed – Some providers actively participate
5 / 2009	**Principle of Transparency** - 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	Closed – Principle adopted by Providers

Previous ICG WG-A recommendations implementation summary - 2010 (ICG-5)

No/Year	Brief description	Status
2.1 /2010	Continue the Work of the Sub-group Compatibility (Organizational Models and Procedures for Multilateral Discussions)	Specific focus abandoned – sub-group continues
2.2 /2010	Common Reference Assumptions for Compatiblity Coordination	Specific focus abandoned by sub-group
3.1. /2010	IDM Study Plan and ICG Participation	Closed – evolved to IDM task force
5.1 / 2010	New approach to continued collection of user and industry views on interoperability	Open - Task Force evaluating workshop results
5.2 /2010	Continue to investigate system time and geodetic reference frame aspects of interoperability within the WG-D task forces on time and geodesy	Ongoing – templates completed by WG-D
5.3 / 2010	ICG participant participation in Asia-Oceania Multi-GNSS Demonstration Campaign and interaction with receiver manufacturers	Closed – effectiveness should be evaluated

Previous ICG WG-A recommendations implementation summary 2011 (ICG-6)

No/Year	Brief description	Status
2.1 /2011	Continuation of WG-A compatibility subgroup	Closed. SG is Active
3.1 /2011	Workshop on GNSS Spectrum Protection and IDM	Closed. Became 1st IDM workshop
4.1 /2011	Open Service GNSS performance parameters, including Definitions and Calculation Methods	Open
4.2 / 2011	International GNSS Monitoring and Assessment Sub-Group	Implemented - Became Task Force with WG-A and D Still Active

Previous ICG WG-A recommendations implementation summary 2012 (ICG-7)

No/Year	Brief description	Status
2.1 2012	RNSS spectrum protection from ITM. Joint efforts in ITU	Closed 8A.2.1 issued
3.2 2012	Conduct IDM workshops	Implemented - 4 workshops to date
4.1 2012	Extend tasks of IGMA Task Force to include the parameters definition elaboration	Implemented – work is incomplete
5.1 2012	Interoperability workshops based on the Questionnaire	Implemented – 5 of 6 Providers held workshops

Previous ICG WG-A recommendations implementation summary 2013 (ICG-8)

No/Year	Brief description	Status
8A.2.1 2013	ICG Members to joint efforts in ITU for GNSS spectrum protection from ITM	Closed 9A.2.1. issued
8A.2.2. 2013	Update brochure on GNSS with existing or expected performance for open service	Open
8A.3.1. 2013	Educational materials on GNSS features and why they are differ from communication	Open
8A.3.2. 2013	Establish an IDM Task Force	Implemented - Task Force still active
8A4.1	Rearrange the WG-A(B,D) IGMA Task Force to ICG IGMA Task Force	Open
8A5.1 2013	Establish an Interoperability Task Force to process data from workshops	Implemented - Task Force still active

Previous ICG WG-A recommendations implementation summary 2014 (ICG-9)

No/Year	Brief description	Status
9A.2.1. 2014	ICG Members to join efforts in ITU-R and WRC-2015 for GNSS spectrum protection from ITM	Closed – revised as new recommendation for ICG-11
9A.3.1 2014	Evaluate existing and emerging IDM capabilities and consider developing, testing and implementing these or similar capabilities	Open
9A.3.2. 2014	Crowdsourcing capabilities analysis for IDM	Open
9A.3.3.	UN regional workshops on GNSS spectrum protection and IDM	Open. Moved to Comp. Subgroup
9A.4.1. 2014	National service monitoring center websites to connect to ICG internet portal	Updated as 10A/S.3 and Closed
9A.4.2. 2014	IGMA Workshop in Xi'an in May, 2015	Completed, Closed

Previous ICG WG-A recommendations implementation summary 2015 (ICG-10)

No/Year	Brief description	Status
10A/S.1 2015	Campaign of Protection of RNSS operations – GNSS providers and GNSS user community member states promote spectrum protection	Open – Implementation through spectrum protection seminars
10A/S.2 2015	UN COPUOS multi-year agenda item focused on National Efforts to protect RNSS Spectrum, and develop IDM capability	Open
10A/S.3 2015	Existing GNSS open service information linked to the ICG portal	Open
10A/S.4 2015	IGMA TF and IGS joint trial project to demonstrate a global GNSS Monitoring and Assessment capability	Open – project initiated
10A/S.5 2015	Updated work plan focused on GNSS civil service provision by a system-of-systems and WG name change	Completed, Closed

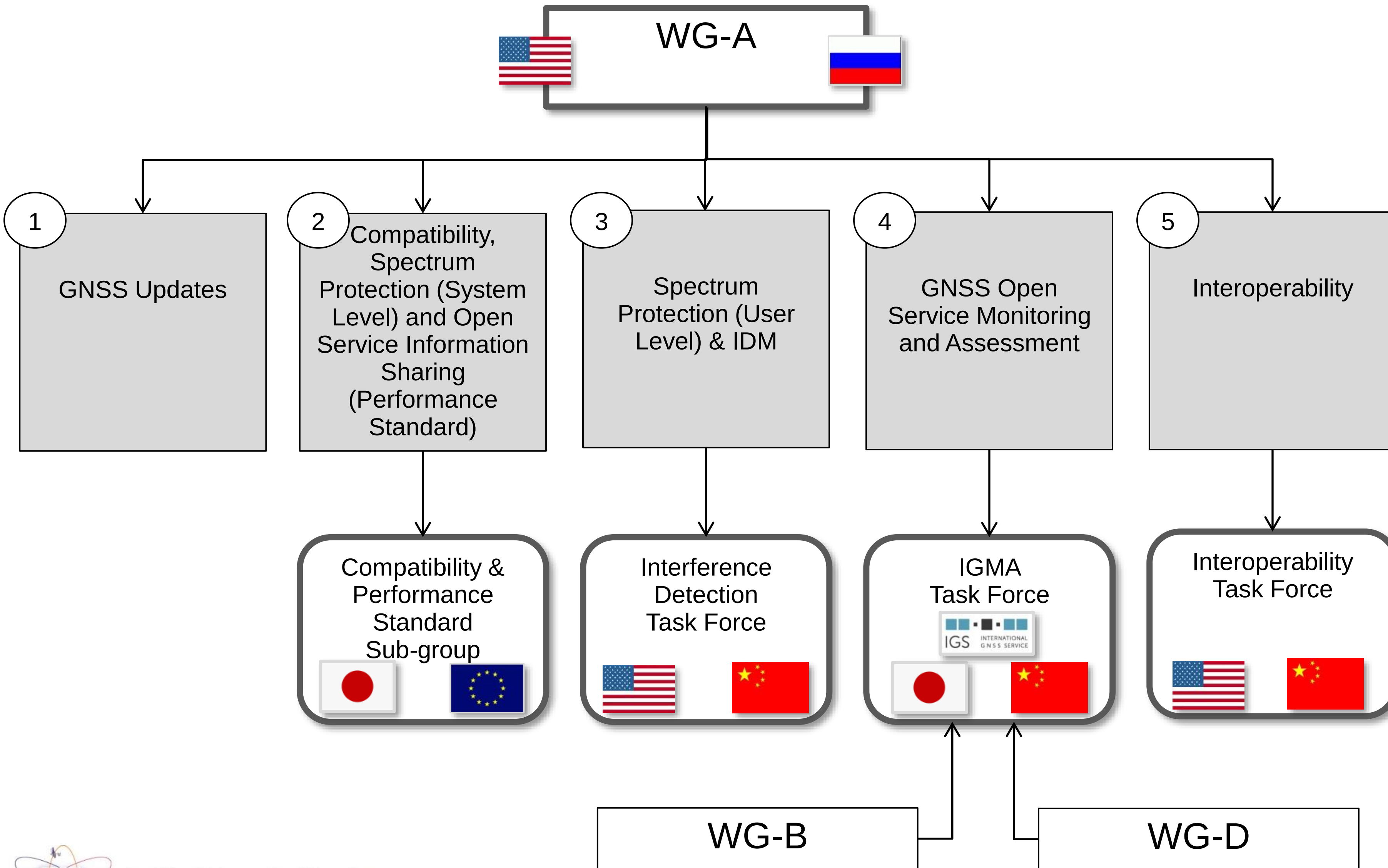
GNSS Jammers – National Legal Status (As Reported at ICG-9)

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

GNSS as Critical Infrastructure (as reported at ICG-9)

US	RU	China	EU
There is official Critical Infrastructure definition	There is no official Critical Infrastructure definition	There is no official Critical Infrastructure definition	There is official Critical Infrastructure definition
GPS is not a critical infrastructure	Navigation is a critical technology	BeiDou is Essential Space Infrastructure	Galileo will be designated as critical infrastructure
GPS integrated in most of all critical infrastructures	GLONASS is integrated in most of all priority development directions of science and technique	Beidou is integrated in most of all economy branches	Galileo service is critical to Energy and Transport critical infrastructure sectors

Former WG-A Architecture



ICG Spectrum Stewardship Life-Cycle