

## Report of the Systems, Signals and Services Working Group (WG-S)

1. The International Committee on Global Navigation Satellite Systems (ICG) Working Group S (WG-S) on Systems, Signals and Services, met Tuesday, Wednesday and Thursday, 08-10 November 2016, in Sochi, Russian Federation, under the co-chairmanship of Mr. Sergey Revnivykh, Russian Federation, and Mr. David Turner, United States of America (U.S.).
2. After brief welcoming remarks, the co-chairs reviewed and adopted the agenda noting a request from the European Union (EU) to add a presentation under the session on GNSS Compatibility. This was followed by a brief discussion of the working group activities which took place in 2016, including the intersessional meeting held in Vienna, Austria in June. The co-chairs noted that the discussions at this meeting will be based on ideas that were discussed during the intersessional meeting. The work plan of the working group was also reviewed, and Mr. Turner highlighted the changes that were adopted in 2015 at the ICG-10 meeting.
3. The co-chairs then began the session covering **System Provider Updates** by explaining that this session was designed to offer Providers the opportunity to present any new information that was not covered during the opening Plenary Session. The Russian Federation began with a presentation by Mr. Andrey Druzhin, on GLONASS Time Current Status and the Accuracy of UTC(SU) Broadcast by GLONASS. Mr. Druzhin discussed improvements made to GLONASS time between 2014 and 2016. He noted that the error of broadcast corrections to GLONASS Time relative to UTC(SU) is below 10 ns, and is expected to be below 2 ns by 2020. Mr. Druzhin also noted that the errors of GLONASS time relative to UTC (SU) were not affecting the positioning accuracy.
4. The next session was a meeting of the **Compatibility & Spectrum Sub-Working Group**, co-chaired by Mr. Dominic Hayes from the EU, and Mr. Takahiro MITOME from Japan. The co-chairs began by introducing the topic of GNSS Spectrum Protection & Signal Compatibility. The first presentation under this topic was given by Ms. Karen Van Dyke from the U.S., on the U.S. Adjacent Band Compatibility Study. Ms. Van Dkye discussed the U.S. approach to the compatibility study, noting public outreach that included workshops and a public notice. She also described the radiated testing which took place earlier in 2016 and explained that the next steps include defining propagation models and determining tolerable equivalent isotropically radiated power (EIRP) levels.
5. The co-chairs noted a change to the agenda, with an added presentation by the EU, given by Mr. Hayes, on the Radio Equipment Directive and what it means to GNSS. The presentation explained new regulations in the EU that became effective on 13 June 2016, under a directive of the EU Parliament and Council. The Radio Equipment Directive (RED) affects all manufactures who want to sell equipment within the EU and calls for radio equipment to effectively use and support efficient spectrum to avoid interference. Mr. Hayes further noted that the European Telecommunications Standards Institute (ETSI) is developing a draft European Norm, which defines the technical requirements and test specifications. The goal

is to have this completed by June 2017, and manufacturers are encouraged get in involved in the development process. The working group co-chair, Mr. Turner noted that there seems to be a correlation to the adjacent band compatibility data presented by the U.S., and suggested that the data be compared to determine if this is the case. He also strongly encouraged other GNSS providers to consider industry requirements within their country.

6. The co-chairs of the Compatibility & Spectrum Sub-Working Group presented the report on the activities of the subgroup. They discussed International Telecommunications Union (ITU) spectrum issues from the World Radio Conference 2015, including Radio Regulations. Under Agenda Item 1.1, International Mobile Telecommunications (IMT) Spectrum Identification, Radio Navigation Satellite Systems (RNSS) spectrum is fully protected. Under Agenda Item 1.14, Continuous Reference Time scale of UTC, there was a discussion about leap seconds. It was agreed that there will no changes to the current time scale until at least 2023. Finally, under Agenda Item 8, Country Footnote, it was agreed that the frequency band 1559-1610 MHz will be kept clear for GNSS. Finally, the co-chairs reviewed ICG-10 Recommendation 1, Seminar on Spectrum Protection. It was noted that the first seminar took place in December 2015, and a second seminar will take place in December 2016, in Kathmandu, Nepal.
7. Mr. Dmitry Aronov from the Russian Federation presented on Protection of global navigation satellite systems from unwanted emissions caused by IMT systems in the frequency range 3 GHz. Mr. Aronov noted several ITU recommendations which support protection criteria for GNSS receivers. He also explained that actual experiments show that unwanted emissions could affect GNSS. Therefore ICG Recommendation 9A.2.1, GNSS Spectrum Protection from possible IMT emissions, should be updated. The Compatibility & Spectrum Sub-Working Group co-chairs reviewed the recommendation, with proposed updated language based on discussions from the June 2016 intersessional meeting. No additional comments were offered.
8. The Compatibility & Spectrum Sub-Working Group meeting continued by moving to the topic of interference detection and mitigation (IDM) standards and information exchange. Mr Weimin Zhen from China presented an Update of GNSS IDM Research. He discussed the impacts of GNSS interference to different sectors, including mobile communications, electrical power systems, transportation and precision agriculture. He linked the relative impact to the length of the interference event. Zhen also discussed the benefits of using unmanned aerial vehicles (UAV) to detect interference, using direction finding equipment.
9. Mr. Gerhard Berz from EUROCONTROL, presented on the ICAO GNSS RFI Mitigation Plan, explaining that ICAO has lots of experience with interference. The goal is to define activities for States to ensure that risks to aviation are addressed. There are three parts that form the framework of the ICAO plan: 1. Monitor Threats; 2. Assess Risk; 3. Deploy Mitigation Measures. Risk trades are needed to examine the likelihood versus the impact. Implementing mitigation barriers can prevent the transmission of interference, prevent GNSS service outages, and limit the severity of an outage. EUROCONTROL has established voluntary incident reporting, called EVAIR, which shows a steady increase in the number of GPS incidents, reported since 2013. The next step will be to include the use of ADS-B

Position Integrity Category (PIC) Reports, with a long-term goal of detecting RFI and providing information to air traffic control. A question was asked about whether EUROCONTROL has been working with manufacturers on automatic reporting. Mr. Berz responded that the idea is in its infancy and won't be seen until the next generation of receivers are in use. He suggested it would be a good idea to have a workshop with the manufacturers to discuss ideas for getting the ball rolling. The WG-S co-chair, Mr. Turner, stated that this could form an agenda for a future IDM workshop under the ICG.

10. The co-chair of the IDM Task Force, Mr. Rick Hamilton from the U.S., provided a short summary of the 5<sup>th</sup> IDM Workshop, which was held in May 2016 in Changsha, China. He reviewed the conclusions and noted that the 6<sup>th</sup> IDM Workshop will take place in conjunction with the Baska Conference in Croatia, May 2017, with a focus on member state capabilities (site and network-based IDM) and receiver-based implementation (crowd sourcing). On behalf of Stanislav Kizima of the Russian Federation, Mr. Hamilton continued with a presentation on implementation of Recommendations for Estimation of Electromagnetic Environment and Interference Environment in GNSS frequency bands. The proposal provided several ideas for the content of chapters and a suggestion to have the first version of the recommendations out to the members of WG-S before the end of February 2017.
11. The co-chairs reviewed the status of implementing Recommendation 10S.2, calling for a presentation on spectrum protection and IDM to the UN COPUOS STSC. The presentation in February 2016 did not happen because it was not possible to get an agenda slot at the COPUOS STSC meeting. At the same time the U.S. and Russian delegations supported the proposed idea in their statements during the session. Finally, in the STSC report the statement # 145 was presented dedicated to the IDM issue. The co-chairs presented a revised version of the recommendation (new proposed recommendation), which calls for developing a communication from the ICG Secretariat that would include ICG activities, background, and worldwide IDM capability. This would be circulated to select COPUOS member states before end of 2016, to allow them time to respond at the 2017 COPUOS STSC meeting in February 2017. There were no objections to this revised recommendation.
12. The meeting continued with a session of the **Interoperability and Service Standards Sub-Working Group**. Mr. Alexey Bolkunov, Russian Federation, began with a presentation titled "GNSS Performance Standard Template: Challenges and Way Forward". Mr. Bolkunov began by explaining the purpose of the GNSS performance standard template, explaining that it can be used by all GNSS to harmonize the documents among the ICG Providers. He offered six recommendations for the way forward: 1) Periodic updating of GNSS performance standard template and calculation method; 2) Coordinate with international organizations 3) Joint discussion on performance standard issues; 4) Periodic status updates; 5) Harmonize GNSS PS template and calculation methods; 6) Adopt a roadmap. A draft roadmap was then displayed.
13. Mr. Frank Clark from the U.S. followed with a presentation on the U.S. GPS Service Performance Standard Assessment. He explained that the U.S. report on performance from 2013 has been completed and is available for download. This is a document which provides metrics for how the U.S. GPS performed relative to its performance standard. Mr. Clark

noted that the U.S. plans to publish a yearly report on performance, and the 2014 and 2015 reports are currently being developed.

14. The Interoperability and Service Standards Sub-Working Group co-chairs, Mr. Jeff Auerbach, from the U.S., and Dr. Xiaochun Lu, from China, presented the Subgroup report on GNSS performance standards. They reviewed the latest status of the Interface Control Documents (ICD) from the GNSS Providers, and the previously agreed upon way forward, which calls for Providers to create a Performance Standard Template for all GNSS, which defines a set of parameters to be used for monitoring and assessment.
15. The meeting continued with the session on **System and Service Interoperability**. Sergey Silin from the Russia Federation presented on GNSS Interoperability Solution at the User Level. He explained that GNSS interoperability at the user level can be resolved with the user receiver equipment, and at the augmentation systems level. It is important to comply with international and interstate standards, such as those from RTCA, RTCM, RTK/PPP and NMEA. Mr. Silin discussed a test project to monitor GNSS open service characteristics, and suggested that the subgroup could make this a priority in 2017.
16. Mr. Vladimir Pasnykov from the Russian Federation, presented Results of the PZ-90.11 reference frame implementation to GLONASS. The Russian Government Executive Order No.797-r from 2007, established the PZ-90.02 system of the earth geodetic parameters. The more accurate PZ-90.11 was introduced in 2012, replacing PZ-90.02, and GLONASS was directed to upgrade to PZ-90.11 by January 2014. Geodetic parameters have been updated, which significantly improved ephemeris for GLONASS. Since the transition, the coordinate conversion accuracy for GLONASS has improved from 3 m to around 30 cm.
17. Mr. Clark from the U.S. provided an update on the GPS Time Offset issue. He explained that the GPS Master Control Station uploaded incorrect UTC offset parameters to part of the GPS constellation during a 14 hour window in January 2016. Fifteen GPS satellites were affected before a correction was identified and implemented. The U.S. is looking into increased monitoring of UTC offset parameters and follow on software updates to prevent this type of situation from happening again.
18. Mr. Hayes from the EU followed with a presentation titled “Towards Achieving Interoperability”. He explained that receiver level interoperability is routine today, and is the current preferred Galileo position on achieving interoperability between systems. System level interoperability allows each system to transmit the timing offset in its signal to achieve tighter interoperability. This method is much more complex. Mr. Hayes offered a proposed recommendation for system level interoperability that would be less complex. This would be done by using an existing common timing reference or source, which would allow systems to achieve interoperability. We should consider whether combining existing timing offsets would allow system level interoperability between all GNSS, keeping in mind that receiver level interoperability is always available as the backup. The co-chairs noted that an ICG timing workshop is being planned for July 2017, and this would be an ideal place to discuss the recommendation further.

19. The Sub-working Group co-chairs, Mr. Auerbach and Dr. Lu, concluded the session by reviewing two recommendations that were drafted during the Intersessional Meeting in June 2016. The recommendation on signal patents was reviewed and a minor wording modification was proposed. Concurrence on the recommendation was noted. The recommendation to hold a timing workshop in Paris in conjunction with the IGS Workshop in July 2017 was also reviewed. The details still need to be worked out with the IGS Governing Board, but there was concurrence on this recommendation. Finally, the co-chairs returned to the discussion on the way forward with the Service Standards and Open Service Performance Standards. Agreement was reached on having this activity continue under the Sub-Working Group, led by a team of experts (“group of enthusiasts”). The Russian Federation agreed to take the lead on organizing this activity.
20. A joint session with Working Groups B, C and D was held on 09 November 2016, which included **Open Service Information Sharing and Service Performance Monitoring (International GNSS Monitoring and Assessment)**. Starting off the session, Mr. Bolkunov, Russian Federation, presented “Current Challenges and Way Forward”. Mr. Bolkunov noted the good progress made by the IGMA Task Force over the past year and offered two recommendations to consider. The first is to organize cooperation with GNSS monitoring and assessment systems created by various use groups. The second is to create and adopt an IGMA Terms of Reference, using the draft proposed by Russia as a base. This would be a high level document defining all possible activities of IGMA. Mr. Kogure noted that the Terms of Reference for the trial project is different from the IGMA Terms of Reference.
21. Mr. Jianwen Li from China presented on Monitoring and Assessment Algorithms on GNSS, iGMAS Workgroup. He explained that iGMAS has established a monitoring & assessment system, which includes parameters and calculation methodologies such as constellation status, signal-in-space quality, signal-in-space accuracy and service performance. China proposed to research this methodology further. Ms. Juan Du from China followed this with a presentation on GNSS Signal in Space Quality Evaluation and Monitoring. Ms. Du discussed China’s Haoping Radio Observatory, which is an independent monitoring station used for analysis and assessment of GNSS signals. She explained the process for the Signal Monitoring and Assessment System, and highlighted seven parameters that have been identified by China for monitoring under iGMAS. She proposed that this could be discussed during the next IGMA Workshop.
22. The session on International GNSS Monitoring and Assessment continued with a presentation by Mr. Igor Silvestrov, on GNSS Monitoring in the Russian Federation. The presentation explained that the main goals of monitoring in Russia are to monitor and predict main GNSS characteristics, calculate initial data for GLONASS certification, and independently confirm GLONASS characteristics at the international level. He described the details of how the monitoring is done, and provided some results for GLONASS, GPS, BDS and Galileo.
23. The Report of the IGMA Task Force was given by Mr. Kogure from Japan. He explained the latest status of the IGMA-IGS Trial Project, noting that a terms of reference has been established and a call for participants has gone out. The initial phase of the project will

involve monitoring of all GNSS with a limited set of parameters being evaluated using the existing monitoring network. The next steps will be to launch the project in early 2017, and hold a workshop in May 2017, in conjunction with the China Satellite Navigation Conference (CSNC) in Shanghai. The IGS will also be invited to participate in the Workshop.

24. The WG-S meeting continued with the session on **Performance Monitoring and International GNSS Monitoring and Assessment**. The co-chairs reviewed the status of recommendations that were adopted at ICG-10. This was followed by a presentation from Mr. Patrizio Vanni from the EU, on GNSS Performance Assessment and Data Recording Guidelines in Aviation. Mr. Vanni explained that in November 2013, a GNSS Monitoring Drafting Group was formed in ICAO. The GNSS monitoring concept consists of GNSS performance assessment, GNSS data recording, and GNSS operational status monitoring. The proposed approach for today involves using public reports from GNSS Providers to implement solutions. The future approach will be to get global periodic performance reports with relevant SPS parameters from the GNSS Providers, and use this data to implement solutions.
25. Mr. Yury Iovenko from the Russian Federation presented on the Development of the GNSS Monitoring System in Civil Aviation of Russia. He described the network of GBAS and local control-correcting stations in Russia and the services for RAIM prediction. A GNSS real-time monitoring center operates continuously and provides relevant information for interested aviation services. Mr. Roman Fatkulkin of the Russian Federation provided a final presentation on exchanging data related to GNSS operational failures. The presentation discussed a scheme for exchanging satellite health data to provide the probability of failure. Two recommendations were posed in the presentation: 1. Review the proposal for organizing a reliable and robust monitoring service; 2. Develop a data structure template for further discussion.
26. The co-chairs continued with a review of new Recommendation 3, proposing a Workshop on Performance Monitoring in May 2017, in conjunction with the CSNC in Shanghai. A proposal to reword the recommendation to eliminate the discussion on the IGMA trial project was adopted. This will be discussed separately in an IGMA Task Force meeting. Finally, the co-chairs reviewed the status of the IGMA concept, noting that there still is not consensus on parameters for performance standards. The goal of the trial project is to flush out details of the monitoring process, and should not be focused on the selected parameters. The trial project road map lays out a plan to expand the monitoring in the future.
27. The **Concluding Session** was held on 10 November 2016. The Working Group co-chairs began by reviewing the recommendations, noting that the objective was to reach consensus for presentation to the full ICG at the Plenary session. No objections were noted to any of the recommendations. There was also consensus that System-of-System Operations should be added as a new part of the WG-S workplan. The co-chairs also reviewed and refined the WG-S Report to the Committee and Providers Forum
28. The meeting concluded with a brief discussion about intersessional meetings of the Working Group and future subgroup/task force meetings and workshops. The Working Group agreed that they will make an attempt to combine meetings where possible and noted a proposal to

hold the compatibility intersession meeting in Croatia at the Baska Conference in May 2017. It was already agreed that the next IDM Workshop will take place as part of this conference. A proposal was also made to hold the interoperability intersession meeting in Paris in conjunction with IGS Workshop and the Timing Workshop. No objections were noted to these proposals.

The full set of WG-S recommendations, as adopted by the Committee at ICG-11, are enclosed.

## **Recommendation 11S.1 for ICG Decision**

**Prepared by:** Working Group S

**Date of Submission:** 10 November 2016 (Original submission in November 2012, revised in November 2013 and 2014)

**Issue Title:** International Mobile Telecommunications (IMT)-GNSS Compatibility

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

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

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

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

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

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



frequency band 1427 – 1518 MHz. In the GNSS frequency band 1164 – 1300 MHz impact of the second harmonic of IMT stations that use frequency band 470 – 694 MHz is possible, as well as impact of spurious emissions from IMT stations that operate in the frequency band 1427 – 1518 MHz.

### **Discussion/Analyses:**

At the 9th meeting of International Committee on Global Navigation Satellite Systems (Prague, Czech Republic 9 – 14 November 2014) theoretical estimations on this matter were presented. Theoretical estimations showed that there is a possible adverse impact of unwanted emission levels (including out-of-band, spurious and harmonic interference) from base/mobile IMT stations on the frequency bands of global navigation systems (1164 – 1300 MHz and 1559 – 1610 MHz). At the inter-sessional meeting of WG-S (Vienna, Austria, 7-10 June 2016), experimental estimations were presented. These experimental estimations confirmed the results of previously presented theoretical estimations.

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

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

### **Recommendation:**

- *ICG members are encouraged to actively participate in the ITU-R and regional work on new IMT spectrum allocations to ensure that proposals do not impact existing and future GNSS operations.*
- *The ICG members are recommended to encourage their administrations to ensure the protection of RDSS/RNSS from the unwanted emissions of new IMT spectrum allocations including adjacent band interference, spurious interference and harmonic interference, as a result may require the implementation of more stringent limits for IMT unwanted emissions levels in RDSS/RNSS bands.*
- *Members may also consider forming links with other satellite groups already defending satellite spectrum.*

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

**Prepared by:** Working Group S

**Date of Submission:** 10 November 2016

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

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

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

**Discussion/Analyses:**

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

**Recommendation:**

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

## Recommendation 11S.3 for ICG Decision

**Prepared by:** Working Group S

**Date of Submission:** 10 November 2016

**Issue Title:** Workshop on Performance Monitoring

### Background/Brief Description of the Issue:

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

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

### Discussion/Analyses:

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

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

### Recommendation:

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

*The Workshop will address the following:*

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

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

**Prepared by:** Working Group S

**Date of Submission:** 10 November 2016

**Issue Title:** Timing Workshop

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

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

**Discussion/Analyses:**

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

**Recommendation:**

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