

Report of Working Group B: Enhancement of Global Navigation Satellite Systems Services Performance

1. The Working Group on Enhancement of Global Navigation Satellite Systems (GNSS) Service Performance (WG-B) of the International Committee on GNSS (ICG) held in accordance with its work plan the following annual meetings

- (a) 1st Meeting during ICG2 on 06 September 2007,
- (b) 2nd Meeting during ICG3 on 11 December 2008,
- (c) 3rd Meeting during ICG4 on 16 September 2009,
- (d) 4th Meeting during ICG5 on 20 October 2010,
- (e) 5th Meeting during ICG6 on 07 September 2011,
- (f) 6th Meeting during ICG7 on 07 November 2012.

In addition to the annual meetings, two interim meetings on dedicated subjects related to GNSS Service Performance Enhancement were conducted during 2012

- (a) WG-B interim meeting on 06 June 2012 on GNSS Space Service Volume (SSV) and New Message Broadcasts,
- (b) WG-B Application Subgroup Meeting on 12 and 13 March 2012 focusing on Multi-GNSS Mass Market, Ubiquitous Navigation and Authentication Applications.

2. At the sixth annual meeting of WG-B the following presentations were given and discussed:

(a) A briefing on the outcomes of the interim meeting of the group on “GNSS Service Performance Enhancement and Applications” that was held on 06 June 2012 in Vienna, Austria, was provided by the WG-B co-chair. The interim meeting of WG-B was dedicated to the subjects of an Interoperable GNSS Space Service Volume and on concepts for new message broadcasts. In particular the benefits of an Interoperable Space Service Volume were recognized by participants leading this to further presentations during the ICG7 session of WG-B.

(b) A report on the outcomes of the initial meeting of the newly formed WG-B Applications subgroup was given by the co-chairs of this group, X. Zhan (China) and M. Mine (Japan). The structure of the group together with its Terms of Reference as agreed on during the first Application Subgroup Meeting on 12/13 March 2012 was outlined to WG-B. A number of 25 navigation and application experts attended the first meeting of the Application Subgroup in March 2012 and discussed upon presentations stemming from the area of Multi-GNSS Mass Market, Ubiquitous Navigation and Authentication Applications. An outlook of the work to be conducted by the group until end of 2013 concluded that presentation.

(c) Continuing the work of the WG-B interim meeting the National Aeronautics and Space Administration (NASA) provided further background on the benefits an interoperable GNSS Space Service Volume will offer to all space users. GPS III will be compliant to specific minimum performance parameters applicable to space users in higher

Earth orbits. For GPS the following three parameters characterise the support of Positioning Velocity and Timing (PVT) in the SSV: Receiver power at space user level, pseudorange accuracy and signal availability. An overview on the quantitative characteristics of GPS in the SSV concluded the presentation. All GNSS service providers were encouraged to support and interoperable GNSS SSV as this is considered the key to achieve a more sufficient signal availability level at high Earth orbits.

(d) The European Space Agency (ESA) confirmed the relevance of the SSV for satellite missions, giving an overview of already deployed and future space missions that embark a GNSS space receiver. Clarification was given that the 1st generation of Galileo does not foresee the provision of a SSV, yet signal emissions originating from the secondary lobes of the Galileo L-band antenna may be exploited by space users. No guarantees on the minimum signal power and the Signal in Space Accuracy (SISA) of these secondary lobe emissions can be guaranteed for 1st generation of Galileo. The definition process of Galileo 2nd generation is currently ongoing.

(e) A presentation on MICHIBIKI (Quasi Zenith Satellite 1) and the SSV given by Japan Aerospace Exploration Agency (JAXA) completed the WG-B Session on SSV. Due to its elliptical orbit characteristics the MICHIBIKI satellite has a rather wide reference off-boresight angle. This can be exploited to provide space users with service while MICHIBIKI being close to its perigee. Quantitative characteristics of the MICHIBIKI received power levels for GEO users together with the user range error were provided by JAXA.

(f) The session on performance enhancement started with a presentation from the University of the Federal Armed Forces Munich on the subject of Receiver Autonomous Integrity Monitoring (RAIM) for Automatic Identification System (AIS) position integrity in the maritime domain. An overview on present Navigation solutions for maritime applications was given. The core focus of the presentation was to provide insight to which extent classical RAIM, when applied to dual frequency signals and multiconstellation GNSS scenarios, can provide integrity services for maritime users. The integrity requirements for port approach and restricted waterways were used as reference. Simulations showed that very good availability figures can be reached for these applications. Due to shortcomings of GNSS (e.g. interference, spoofing, iono effects), alternative systems may be recommendable for fusion with GNSS at user side.

(g) Following up the discussions at the WG-B interim meeting JAXA provided an evaluation of the Cyclic Shift Keying (CSK) performance. A comparison between the theoretical and the experimental Frame Error Rate (FER) was presented, showing a good level of correlation.

(h) The relevance of signal design in order to reduce the multipath error was addressed by the Technical University of Moscow. The multipath error can be fought against at various instances, starting at the signal design level, specific antenna features and last but not least at the digital part of the receiver. The link between signal bandwidth and multipath error was re-confirmed. The results of a measurement campaign showed the similar accuracy can be achieved with GPS and GLONASS for high-precision applications.

(i) The status, progress and future plans of the BeiDou Application, Demonstration and Experience Campaign (BADEC) was presented by the International Cooperation Research Center (CSNO). BADEC aims to advocate international users to learn about and apply BeiDou/GNSS, to encourage all stakeholders to jointly carry out multi-GNSS Application Demonstration & Experience Campaign, and to survey and collect requirements from international users. An overview on the BADEC activities in Pakistan and Korea and its cooperation with international bodies (Asia-Pacific Space Cooperation Organization (APSCO), International GNSS Service (IGS), United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), etc.) was outlined. Future plans of BADEC were presented, including the launch of international application pilot projects, the establishment of regional, academic symposia and GNSS education and training initiatives.

3. WG-B members were invited to propose recommendations enabling the enhancement of GNSS service performance. The status of previous WG-B recommendations was considered. A number of four recommendations were presented and adopted by the ICG Plenary on 09 November 2012. The endorsed recommendations of WG-B at ICG7 are listed in Attachment 1.1 – 1.4 of this report.

4. The work plan of WG-B as endorsed by the Plenary Meeting during ICG6 was reviewed and the existing actions were confirmed

ATTACHMENT 1.1

WG-B Recommendation 1 Endorsed by Committee Decision

Prepared by: WG-B

Date of Submission: 08 November 2012

Issue Title: Statement of Interest in GNSS Space Service Volume

Background/Brief Description of the Issue:

WG-B has followed in the last year Recommendation 6 of ICG6 entitled “Interoperable GNSS Space Service Volume”. WG-B has addressed this topic at a technical level at its interim Meeting in June 2012 in Vienna and has identified the advantages of an Interoperable GNSS SSV for the Space user community.

Discussion/Analyses:

In order to progress further towards an interoperable GNSS Space Service volume the contribution of the different system providers is an essential element. Only with their direct involvement in a Space Service Volume definition process it is possible to achieve a harmonization of the qualitative and quantitative characteristics of such an interoperable GNSS Space service volume.

Recommendation of Committee Action:

Recognizing the advantages of an Interoperable GNSS SSV for the Space user community, ICG is invited to take notice that WG-B encourages all system providers to identify their interest in contributing to a future interoperable GNSS space service volume. The qualitative and quantitative specification of such a future, interoperable GNSS space service volume is recommended to be coordinated through the on-going GNSS Space Service Volume initiative within ICG WG-B. This process will need the involvement of the system providers in order to allow for a high level of interoperability in the Space Service Volume.

The committee recommends that a definition of an interoperable GNSS SSV be introduced into the ICG Glossary of Terms.

ATTACHMENT 1.2**WG-B Recommendation 2 for Committee Decision**

Prepared by: WG-B

Date of Submission: 08 November 2012

Issue Title: Dual Frequency Multi Constellation RAIM for Maritime Integrity

Background/Brief Description of the Issue:

The deployment of interoperable, dual frequency signals provided by multiple satellite navigation systems opens up new possibilities to provide users with new integrity solutions.

Discussion/Analyses:

Initial results presented to WG-B show that integrity for Maritime applications could be provided by Dual Frequency Multi Constellation (DFMC) Receiver Autonomous Integrity Monitoring (RAIM). DFMC might be a solution to provide Maritime integrity (down to coastal and port approach operations) without additional infrastructure investment at system provider side over wide area, thus including polar regions that are expected to gain in importance in the Maritime Community as well as regions where so far there is no SBAS service available. In order to enhance the robustness of DFMC RAIM the fusion of the GNSS solution with other sensors (e.g. inertial and/or present e-Navigation means) can be considered.

Recommendation of Committee Action:

ICG is invited to take notice that WG-B plans to involve an International Maritime Organization (IMO) representative in order to propose the consideration of Multi-constellation Dual Frequency classical RAIM solutions to provide integrity to these users allowing for coastal and port approach maritime operations in regions where SBAS service is not provided. Fusion of the GNSS RAIM solution with backup sensors may be recommended to enhance the robustness of the positioning solution.

ATTACHMENT 1.3**WG-B Recommendation 2 for Committee Decision**

Prepared by: WG-B

Date of Submission: 08 November 2012

Issue Title: Environmental Warning Service as New Message Broadcast

Background/Brief Description of the Issue:

In relation to WG-B workplan item B6 and in view of WG-B recommendation 3 of ICG6, WG-B addressed in its interim meeting in Vienna possible new message broadcasts to enhance and/or extend the outreach of GNSS services. During that meeting the Environmental Warning Service (EWS) was identified as a most promising candidate that can be enabled through additional message broadcasts within satellite navigation signals.

Discussion/Analyses:

At present the definition of new navigation/augmentation signals is ongoing, e.g. the SBAS L5 signal. Potentially available spare data capacity of new signals could be made use of to implement additional services, where an Emergency Warning Service (EWS) and the dissemination of ARAIM related Integrity Support Message (ISM) has attracted the particular interest of ICG WG-B.

Recommendation of Committee Action:

ICG is invited to take notice that WG-B plans to propose to SBAS IWG the consideration of an Emergency Warning Service (EWS) as new message broadcast within the new SBAS L5 signals currently under definition. As the ARAIM concept and the related ISM definition materializes, ISM dissemination through this signal may be also considered in the future and brought to the attention of SBAS IWG.

ATTACHMENT 1.4

WG-B Recommendation 3 for Committee Decision

Prepared by: WG-B

Date of Submission: 08 November 2012

Issue Title: Environmental Warning Service as New Message Broadcast

Background/Brief Description of the Issue:

The WG-B Application Subgroup was established at ICG6 in order to support Action B4 of the Work Plan of WG-B. The group held its first meeting on “LBS and Mass Market Applications” on 12/13 March, 2012 in Munich, Germany. Several core application areas shall be monitored by this group in the future.

Discussion/Analyses:

Until ICG8 WG-B agreed that the WG-B Application Subgroup shall dedicate a particular focus on Personal Navigation and Transportation (road, rail, water) applications. The group will continue to investigate together with users representing the identified applications areas to which extent their application needs are already served today by the different satellite navigation systems and about the enabling techniques in order to provide them with better service in the future.

Recommendation of Committee Action:

In order to promote the global multi-GNSS applications in the area of Personal Navigation and Transportation (road, rail, water) and to understand on their additional demands, ICG participants are invited to identify appropriate users and/or institutions representing the before mentioned application sectors by end of Dec. 2012. The 2nd Application SG meeting focusing on Personal Navigation and Transportation applications will be held on Feb. 26, 2013 [tbc] in the margin of the Munich Satellite Navigation Summit.