## Report of Working Group A: Compatibility and Interoperability

1. The International Committee on Global Navigation Satellite Systems (ICG) Working Group on Compatibility and Interoperability held its second meeting on Wednesday, December 10 and Thursday, December 11, 2008 under the co-chairmanship of Sergey Revnivykh of the Russian Federation, and David Turner of the United States of America.

2. After brief introductory remarks, the Co-Chairs invited presentations on compatibility and interoperability from the perspectives of the United States, the Russian Federation, the European Union, and the U.S. Federal Aviation Administration.

(a) The U.S. view of interoperability, as explained by Patrick Harrington of the Office of the Under Secretary of the Air Force, includes characteristics such as: common time and reference frames or broadcast offsets; common carrier frequencies; similar spreading modulation spectra; common spreading code lengths and a common code family; and common data message structures and encoding. He also noted that common Min/Max signal power levels is another dimension of interoperability that could be considered a necessary addition to the principle of interoperability. Information on all of these characteristics should be found in specifications for open signals. Regarding the compatibility of authorized services, he explained that it protects the full utility of each system. For example, spectral separation from M-code not only protects utility of M-code, but also protects other systems signals by avoiding interference from higher power M-code and a large Global Positioning System (GPS) constellation. Finally, recognizing that system compatibility is essential and civil interoperability benefits both civil users and providers, Mr. Harrington suggested that the establishment of documented performance commitments by every global navigation satellite system (GNSS) provider could be considered as a new ICG principle;

(b) The Russian Federation ideas on compatibility and interoperability were presented by Grigory Stupak of the Russian Institute of Space Device Engineering. He outlined rising levels of GNSS integration beginning with compatibility, then interoperability, interchangeability, and finally a single worldwide GNSS. He recommended that system collaboration be pursued on different integration levels and that an investigation of a quantitative evaluation of GNSS interoperability should be initiated. The Russian presentation also questioned whether compatibility among authorized service signals could truly be achieved if it is defined by adequate spectral separation, since frequency spectrum is very wide when sidelobes are included and there are already some cases of spectral overlap between authorized service signals. It has been concluded that in order to achieve common understanding, the Working Group should pursue further refinement of compatibility and interoperability principles and definitions;

(c) The presentation by Frederic Bastide of the European Commission explained that spectral separation between Public Regulated Service (PRS) and other signals is a very important aspect of compatibility from their perspective. With respect to interoperability, he pointed out that both technical characteristics (same center frequency, same modulation, limitations on maximum power level, geodetic reference frames realization and system time reference) and non-technical characteristics (availability of open information on system architecture, performance standards and actual performance, availability of open information on signals) are important. Therefore, the ICG should work on a consolidated definition of interoperability for signals and systems based on both types of characteristics. In this context he pointed out the opportunities of emitting compatible and interoperable signals and services in frequency bands L1, E6 and E5a/E5b;

(d) From the perspective of the U.S. Federal Aviation Administration, Leo Eldredge explained that interoperability should be a goal not just for GNSS signals, but also for integrity provision. With multiple constellations potentially available in the future, receiver autonomous integrity monitoring (RAIM) could provide integrity without the need for augmentation. To make this possible, open signals from new global or regional navigation satellite systems should provide the following: good nominal signal accuracy on the order 1 m ranging accuracy; a fault modes and effects analysis in order to understand and make transparent potential faults and their effects; assurance of low fault rates on the order of $10^{-5}$/SV/Hour; good continuity of signals that is less than $10^{-5}$/hour probability of unexpected outages; and the assurance of good signal availability.

3. In the Working Group's next session, China also provided its views on interoperability, stating that the principle is the ability of multiple satellite navigation system services to be used together to provide better capabilities at the user level than would be achieved by relying solely on one service or signal, without significantly increasing the complexity of receivers. With respect to compatibility, their focus was on the ability of multiple satellite navigation system services to be used separately or together, without generating interference that affects the navigation performance of each system. The concept of spectral separation between authorized service signals and other signals was not included in the Chinese version of the compatibility principle.

4. Before continuing with discussions on the principles of compatibility and interoperability and their definition, the Co-Chairs reviewed the status of the Working Group assigned actions and activities (attached), focusing on Action A2 and A3 from the original ICG Work Plan. It has been suggested to postpone action A4 to future Working Group meetings in order to focus efforts on the core issue of compatibility and interoperability among systems. Actions A2 and A3, that call for workshops on measures being taken to survey and enhance compatibility and interoperability for global and regional space-based systems and regional ground-based Differential GNSS (DGNSS), are now being addressed by the more specific tasks identified at ICG-2 (see A/AC.105/901). For example, the International Federation of Surveyors (FIG) has completed a first draft framework for a paper on the relative importance of different aspects of interoperability from the perspective of various user applications, and an Agenda was developed for the ICG Experts Meeting in Montreal where presenters discussed interoperability in detail from the perspective of industry. Furthermore, a definition of interoperability among ground-based DGNSS was completed by European Position Determination System (EUPOS) for future consideration by the working group. As for the new activities, the Co-chairs proposed moving the new activity NA1 to Working Group D and proceeding and expanding studies and research within activity NA2 under the overall coordination of India.

5. Returning to the Principles of Compatibility and Interoperability agreed upon by the Providers Forum at ICG-2 in Bangalore, India, September 2007, China and the Russian Federation proposed the revision of these principles and their definition. After lengthy discussion, the Working Group reached consensus on the following working principle of interoperability:

*Interoperability refers to the ability of global and regional navigation satellite systems and augmentations to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system.*

*(i) Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity;*

*(ii) For many applications, common center frequencies are essential to interoperability, and commonality of other signal characteristics is desirable;*

*(iii) For some applications, signal diversity is preferable;*

*(iv) Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end user accuracy everywhere and*

*improving service availability in environments where satellite visibility is often obscured;*

*(v) Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical;*

*(vi) Any additional solutions to improve interoperability are encouraged.*

The Working Group noted that the working principle of interoperability and its definition is subject to future modifications and revisions by the Working Group.

6. After presentation to the full committee, the text of this principle and its definition was further modified by the Providers Forum as documented in their approved work plan. The Working Group could not reach consensus on the revised text for the principle and definition of compatibility. However, consensus was eventually reached by the Providers, and this text can be found in the approved Providers Forum Work Plan.

7. The Working Group also recommended to the ICG that WG-A should convene at least two interim meetings with system providers and industry before ICG-4 to continue collecting user/manufacturer perspectives on interoperability and to evaluate various levels, concepts, and dimensions of interoperability as described by the presenters to the Working Group at ICG-3.

## ATTACHMENT

### Working Group A- Compatibility and Interoperability

### Status of Assigned Actions & Activities

### Actions from the ICG Work Plan*

**Action A1:** Establish a Providers Forum to enhance compatibility and interoperability among current and future global and regional space-based systems.

Status: Complete.

**Action A2:** Organize a workshop(s) on measures being taken by Members, Associate Members and Observers to enhance interoperability and compatibility of 1) global and regional space-based systems and 2) regional ground-based DGNSS.

Status: Activities are underway (see new action 4).

**Action A3:** Survey the level of interoperability and standardization among GNSS constellations and augmentations in order to identify concrete steps that can be taken at different levels (regulatory, system implementation, user algorithms) to improve interoperability and standardization. It is expected that the situation is well advanced in civil aviation and maritime, therefore, the effort would probably need to concentrate on land-based applications and users.

Status: Activities are underway (see new actions 3 through 5).

**Action A4:** Consider guidelines for the broadcast of natural disaster alarms via GNSS.

Status: currently no activity. Deferred for future consideration.

**Action A5:** Develop a strategy for ICG support of mechanisms to detect and mitigate sources of electromagnetic interference, taking existing regulatory mechanisms into consideration.

Status: Discussed at ICG-2 (see new action 2.) and now incorporated into the Providers Forum work plan as of ICG-3 (see A/AC.105/928).

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***** UN General Assembly Document A/AC.105/879, 29 December 2006, Meeting of the International Committee on Global Navigation Satellite Systems (Vienna, 1 and 2 November 2006).

## New Actions

**New Action NA1.** International Bureau of Weights and Measures (BIPM) participants volunteered to draft a paper recommending the elimination of the leap second from Coordinated Universal Time (UTC) to submit to the International Telecommunication Union (ITU) timing subcommittee after review by the ICG .

Status: Transferred to Working Group D at ICG-3 for further consideration.

**New Action NA2.** India volunteered to develop a paper on examples of interference to GNSS receivers from other radiocommunications services that occur despite compliance with ITU or domestic spectrum management regulations.

Status: A study is currently in progress within India. WG-A participants at ICG-3 were encouraged to provide inputs to India for inclusion in their report.

**New Action NA3.** FIG and the International GNSS Service (IGS, formerly International GPS Service) to draft a paper on the relative importance of different aspects of satellite navigation system interoperability from the perspective of various user applications.

Status: A draft outline of a paper was provided at ICG-3. This paper and other inputs will be used to develop a survey/questionnaire to be used by the Working Group to collect detailed user/manufacturer perspectives on compatibility and interoperability.

**New Action NA4.** The Russian Federation, the United States, India, and FIG to form a subgroup to develop an agenda for an exchange of views on interoperability between system providers and representatives for various user applications, to include industry -- Session may occur during regional GNSS workshops being planned by the ICG Secretariat (United Nations Office for Outer Space Affairs).

Status: An Agenda was developed for the ICG Experts Meeting in Montreal and presentations were made focused on compatibility and interoperability from the aviation/transportation, and consumer mass market perspectives. The working group will now use this model to conduct at least two interim meetings with system providers and industry before ICG-4.

**New Action NA5.** EUPOS and IGS to draft a definition of interoperability applicable to ground-based DGNSS networks to provide to the working group for consideration.

Status: A draft definition was submitted to the working group at ICG-3 for further consideration.

## Recommendation for Committee Decision

**Prepared by:** Working Group A

**Date of Submission:** 12/11/08

**Issue Title:** Interim Meetings/workshops focused on Interoperability

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

New Action 4 (ICG-2). The Russian Federation, the United States, India, and FIG to form a subgroup to develop an agenda for an exchange of views on interoperability between system providers and representatives for various user applications, to include industry -- Session may occur during regional GNSS workshops being planned by the ICG Secretariat (UN OOSA).

Status: An Agenda was developed for the ICG Experts Meeting in Montreal and presenters discussed interoperability in detail from the perspective of industry. Further meetings should be organized and conducted.

**Discussion/Analyses:**

At ICG-3, Working Group A received additional inputs from presenters regarding various views on interoperability. In support of Action 4, and in light of the discussions at ICG-3, further viewpoints from users and manufacturers with expertise in all areas of GNSS applications should be presented to the working group in cooperation with the Providers Forum prior to ICG-4.

**Recommendation of Committee Action:**

WG-A should convene at least two interim meetings with system providers and industry before ICG-4 to continue collecting user/manufacturer perspectives on interoperability, including evaluation of various levels, concepts, and dimensions of interoperability.

The Working Group Co-chairs propose conducting the first interim WG-A meeting/workshop on March 2-3, 2009 in Munich, Germany, immediately preceding the Munich Satellite Navigation Summit scheduled for March 3-5, 2009.

## Recommendation for Committee Decision

**Prepared by:** Working Group A

**Date of Submission:** 12/11/08

**Issue Title:** Providers Working Principles of Compatibility and Interoperability

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

Wording changes proposed by various members of WG-A both at ICG-2, in Bangalore, and this meeting were discussed at length, leading to changes to the Principles of Compatibility and Interoperability and their definition included in the Conclusions of the First Providers Forum Meeting (A/AC.105/901).

**Discussion/Analyses:**

Working Group A recommends that the consensus language for the Principles be included in the Providers Forum work plan as working text subject to future modification.

**Recommendation of Committee Action:**

Global and regional system providers agreed that at a minimum, all GNSS signals and services must be compatible. To the maximum extent possible, open signals and services should also be interoperable, in order to maximize benefit to all GNSS users. For many applications, common carrier frequencies are essential to interoperability, and commonality of other signal characteristics is desirable. In some cases, carrier frequency diversity may be preferable to improve performance. The Providers Forum will continue to investigate the benefits of carrier frequency commonality and diversity, as well as compatibility and interoperability, as these latter terms are defined below.

***Interoperability*** refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system.

(i) Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity;

(ii) Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured;

(iii) Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical;

(iv) Any additional solutions to improve interoperability are encouraged.

***Compatibility*** refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service.

(i) The International Telecommunication Union (ITU) provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals;

(ii) Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among providers concerned will establish the framework for determining a mutually-acceptable solution;

(iii) Any additional solutions to improve compatibility should be encouraged.