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**Committee on the Peaceful Uses of Outer Space**

# Activities carried out in 2017 in the framework of the workplan of the International Committee on Global Navigation Satellite Systems

**Report of the Secretariat**

## I. Introduction

1. The International Committee on Global Navigation Satellite Systems (ICG) was a result of the third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in July 1999, and was established in 2005 under the auspices of the United Nations to facilitate cooperation and communication among the world's providers and users of global navigation satellite systems (GNSS). In 2007, the Providers' Forum was established within ICG to promote compatibility and interoperability among current and future providers of GNSS, encouraging the development of complementary systems, and to address key issues, such as ensuring protection of the GNSS spectrum and matters related to orbital debris and orbit de-confliction.

2. In compliance with its workplan, the work of ICG is organized through its four working groups: Working Group S, formerly Working Group A, which focuses on systems, signals and services; Working Group B, on enhancement of GNSS performance, new services and capabilities; Working Group C, on information dissemination and capacity-building; and Working Group D, on reference frames, timing and applications.

3. The Office for Outer Space Affairs of the Secretariat, as the executive secretariat of ICG and its Providers' Forum, promotes the use of GNSS capabilities through its capacity-building initiatives and information dissemination, particularly in developing countries. The Office organizes seminars, training courses and workshops on various aspects of GNSS technology and applications for economic and social development.

4. The Office also oversees the ICG information centres, which are working towards the establishment of a network of institutions involved or interested in GNSS. The main objective of the information centres is to enhance the capabilities of member States in the use of GNSS and related applications at the regional and international levels so as to advance their scientific, economic and social development. The ICG information centres are hosted by the regional centres for space science and technology education, affiliated to the United Nations. The regional centres are located in India and China for Asia and the Pacific, in Morocco and Nigeria for Africa,

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in Brazil and Mexico for Latin America and the Caribbean and in Jordan for West Asia.

5. ICG holds annual meetings to review and discuss developments on GNSS. The annual meetings also address GNSS science, innovative technology applications and future commercial applications. ICG members, associate members and observers may attend the annual meetings.

6. The twelfth meeting of ICG and the nineteenth meeting of the Providers' Forum are to be held in Kyoto, Japan, from 2 to 7 December 2017 (see A/AC.105/1158). The Cabinet Office and the Ministry of Foreign Affairs are hosting and organizing the meetings on behalf of the Government of Japan. Detailed information is available on the meeting website (http://icg12.jp).

7. The present report contains a description of the activities undertaken or supported by the Office for Outer Space Affairs during 2017 and the main results achieved. Detailed information on the activities, as well as educational resources, is available on the ICG information portal (www.unoosa.org/oosa/en/SAP/gnss/icg.html).

# II. Activities of the International Committee on Global Navigation Satellite Systems carried out in 2017

8. Pursuant to the ICG workplan for 2017 and the recommendations contained therein, the Office for Outer Space Affairs, in partnership with members, associate members and observers of ICG and international entities, focused on: (a) disseminating information through the information centres hosted by the regional centres for space science and technology education, affiliated to the United Nations; (b) promoting the use of GNSS as tools for scientific applications; and (c) building the capacity of developing countries in using GNSS technology for sustainable development.

## A. Information dissemination through the information centres hosted by the regional centres for space science and technology education, affiliated to the United Nations

9. A seminar on data of the Global Positioning System (GPS) of the United States of America for ionospheric studies was held at the African Regional Centre for Space Science and Technology — in French language in Rabat from 16 to 20 January 2017. The seminar was held during a nine-month postgraduate course on GNSS and consisted of two parts. The first part of the seminar was devoted to theoretical information about the physics of space weather, continuous and transient transport of energy from the Sun to the Earth, and the ionosphere and its response to space weather. The second part consisted of four interactive sessions focused on GPS data processing using Receiver Independent Exchange format (RINEX) files; GPS measurement processing using RINEX files and differential code bias (DCB) files; GPS file processing; and global ionospheric map cartography, including ionosphere products in the Ionosphere Exchange format (IONEX). The Office for Outer Space Affairs and Telecom Bretagne (Brest, France) organized the seminar as a follow-up to the recommendations made at the United Nations/Nepal workshop on the applications of GNSS held in Kathmandu from 12 to 16 December 2016 (see A/AC.105/1149). The seminar programme and lecture notes are available from the ICG information portal (www.unoosa.org/oosa/en/ourwork/icg/activities/2017/icg2017-event.html).

10. The seminar was aimed at establishing research studies using GNSS in Africa and at providing a framework for collaboration between teams of scientists in instrument operation, data collection and analysis and publication of scientific results.

A total of 19 experts from six African countries (Cameroon, Central African Republic, Morocco, Niger, Togo and Tunisia) attended the seminar.

## B. Promoting the use of global navigation satellite system technologies as tools for scientific applications

### 1. Space weather effects on global navigation satellite systems

11. A workshop on the effects of space weather on GNSS was held in Trieste, Italy, from 22 May to 2 June 2017, in cooperation with the Abdus Salam International Centre for Theoretical Physics, Boston College and ICG. The purpose of the workshop was to give theoretical and practical training on the physics of space weather and its main effects on GNSS operations, with particular emphasis on low-latitude ionospheric processes.

12. The workshop continued the series of activities in the field carried out since 2009 to provide GNSS education for scientists, engineers and students in Africa. The goals were to encourage the use of GNSS for social and economic benefits, build GNSS infrastructure, establish research studies using GNSS in Africa and establish international scientific collaborations.

13. The series of annual workshops demonstrated progress in attaining those goals. One measure of success was the number of papers reflecting the use of GNSS for space science exploration published by African scientists in journals, together with the number of doctorate degrees conferred.

14. Although the series of workshops had originally focused on African countries, the 2017 workshop brought together experts from developing nations around the world, although the focus on African nations remained.

15. The topics addressed during the workshop held in Trieste included a general introduction to GNSS and GNSS receivers, GNSS errors and differential GNSS, ionospheric and space weather monitoring using GNSS and other sensors, space weather and its effects on GNSS, and equatorial electrodynamics and other ionospheric irregularities. Participants also worked on group projects in which various space weather events were studied using GNSS. Detailed information about the workshop is available on the website of the Abdus Salam International Centre for Theoretical Physics (http://indico.ictp.it/event/7964/overview).

16. A total of 40 experts from 24 countries participated in the workshop. Funds provided by the United States of America and the European Commission through ICG were used to defray the costs of air travel for 10 experts from Argentina, Cameroon, Côte d'Ivoire, India, Indonesia, Malaysia, Nigeria, Pakistan, Peru and Rwanda. The number of women attending the workshops has increased every year; in 2017, nearly half of the participants were women.

### 2. Reference frames and timing

17. In accordance with the ICG recommendation on reference frames, the Office for Outer Space Affairs, in cooperation with the Commission on Positioning and Measurement (Commission 5) of the International Federation of Surveyors, the International Association of Geodesy, the regional committee of the United Nations Initiative on Global Geospatial Information Management for Asia and the Pacific, the Japan Federation of Surveyors and the Geospatial Information Authority of Japan, organized a technical "Reference frame in practice" seminar. The seminar was held in Kobe, Japan, on 29 and 30 July 2017, in conjunction with the Joint Scientific Assembly of the International Association of Geodesy and the International Association of Seismology and Physics of the Earth's Interior.

18. The "Reference frame in practice" seminar series has been held since 2012. The objective of the 2017 seminar was to provide fundamental geodetic reference frame

background and concepts and examine the associated data and analysis techniques, with a focus on practical implementation and application.

19. Participants in the seminar recommended providing operational or hands-on training on specific geodetic applications or techniques, such as deformation modelling and geo-hazard management. It was highlighted that there was a need for more sharing of knowledge and experiences among agencies and countries in the region with respect to geodesy.

20. A total of 68 experts from 19 countries participated in the seminar. Funds provided by the United States through ICG were used to defray the costs of air travel for four experts from Bangladesh, Fiji, the Philippines and Tonga. Detailed information about the seminar is available on the Commission 5 website of the International Federation of Surveyors (www.fig.net).

## C. Building the capacity of developing countries in using global navigation satellite system technology for sustainable development

### Regional workshop on the International Space Weather Initiative

21. The International Space Weather Initiative (ISWI) has proven to be a valuable framework for international collaboration between teams of scientists on instrument operation, data collection, analysis and publication of scientific results. ICG has played an important role in ISWI, given the important role of GNSS receivers in better comprehending the dynamic processes in the Earth's atmosphere caused by severe space weather.

22. The United Nations/United States workshop entitled "International Space Weather Initiative: the decade after the International Heliophysical Year 2007" was organized jointly by the Office for Outer Space Affairs and the National Aeronautics and Space Administration (NASA) on behalf of the Government of the United States. The workshop was co-organized and co-sponsored by the Scientific Committee on Solar-Terrestrial Physics, ICG, the National Science Foundation and the Universities Space Research Association of the United States. It was hosted by Boston College and held in Boston, United States, from 31 July to 4 August 2017 (see A/AC.105/1160).

23. Presentations by and discussions among a wide range of space weather stakeholders, service providers and users demonstrated an extensive network of space weather services and capabilities, underpinned by an increased understanding of space weather science, impact and risks. Workshop participants agreed, however, that international coordination was essential to mitigate the threat posed by space weather to today's interconnected and interdependent society. Participants noted the success of ICG as a model for targeted cooperation and interoperability and for the avoidance of duplication of effort at the global, intergovernmental level.

24. The presentations made at the workshop, abstracts of the papers given, the workshop programme and background materials are available on the website of the Office for Outer Space Affairs (www.unoosa.org).

# III. Technical advisory services

25. To inform a wide audience about the current status and future role of ICG in a multi-GNSS arena, and to receive feedback from the entire GNSS community, the Office for Outer Space Affairs participated in and contributed to the following international conferences and symposiums:

(a) Munich Satellite Navigation Summit 2017, held in Munich, Germany, from 14 to 16 March 2017;

(b) Eleventh International Satellite Navigation Forum, held in Moscow from 25 to 28 April 2017;

(c) Pacific Positioning, Navigation and Timing Conference of the Institute of Navigation, held in Honolulu, United States, from 1 to 4 May 2017;

(d) Fifty-seventh Meeting of the Civil GPS Service Interface Committee at the Institute of Navigation GNSS+2017 Conference, held in Portland, Oregon, United States, on 25 and 26 September 2017.

26. The Office participated in and contributed to the third International Civil Aviation Organization/Office for Outer Space Affairs Aerospace Symposium, held in Vienna from 29 to 31 August 2017. Presentations made during the panel entitled “The way ahead: concepts for evolution in aerospace regulation and operation — looking ahead towards a broader aerospace community” outlined trends in the aerospace sector, including through the sharing of experience on the protection of communication and navigation systems and critical infrastructure, in order to assess where further efforts within the broader aerospace community were required. Of particular interest was the work of ICG Working Group S on spectrum protection and interference detection and mitigation. The presentation by the representative of the ICG executive secretariat highlighted the importance of GNSS spectrum protection at the national level in order to gain the maximum benefit from the many uses of GNSS. The presentation was made based on an ICG conference room paper on voluntary reporting on national radionavigation satellite service spectrum protection practices and global navigation satellite systems interference detection and mitigation capabilities.

27. The Office participated in and contributed to the thirty-seventh session of the United Nations Inter-Agency Meeting on Outer Space Activities (UN-Space) and its thirteenth informal open session, both held in Geneva on 24 August. At the open session, a wide range of applications of space science and technology was highlighted by United Nations entities. Those applications included the use of satellite communications, GNSS, remote sensing and space-based research in the health sector; space programmes relating to meteorological observations and space weather; frequency regulations in relation to satellites; and navigation, positioning and tracking systems.

28. The Office also participated in and contributed to the United Nations Expert Meeting on Space for Women held in New York from 4 to 6 October. There was a presentation on the ICG education and outreach programme, which is a framework for scientific research enabled by GNSS.

29. The Office, in cooperation with the International Union of Radioscience and the Abdus Salam International Centre for Theoretical Physics, organized a “school on radio physics”, held in Trieste, Italy, from 27 to 31 March. A total of 35 participants from 18 countries attended the school. Funds provided by the United States through ICG were used to defray the costs of air travel for seven scientists from Armenia, Bangladesh, China, India, Nigeria and Ukraine. Radiophysics training was provided to young scientists from around the world. The lectures on GNSS covered the following topics: space physics and introduction to the ionosphere and plasmasphere in the context of communications, navigation and remote sensing; space weather and its effects on radio systems; and environmental applications of remote sensing techniques.

30. The Office organized two preparatory meetings for the twelfth meeting of ICG. Chaired by Japan, they were held in Vienna on 6 February and 6 June 2017, on the margins of the fifty-fourth session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space and the sixtieth session of the Committee, respectively. It was emphasized that ICG was progressing significantly in establishing an interoperable GNSS space service volume, and that by exploiting the interoperability of all systems, a GNSS signal availability of nearly 100 per cent had been achieved.

31. The Office also organized the eighteenth meeting of the Providers' Forum. It was held in Vienna on 6 June 2017 and co-chaired by Japan and the Russian Federation. The meeting focused on issues related to open service information dissemination, service performance monitoring, spectrum protection and interference detection and mitigation, and space weather. A summary of the activities undertaken by the ICG information centres was provided by a representative of the ICG executive secretariat. A representative of the secretariat of Multi-GNSS Asia provided a report on a multi-GNSS demonstration project carried out in Asia and Oceania. The agenda of the meeting and detailed information about the presentations are available on the ICG information portal.

32. The Office organized intersessional meetings of ICG working groups. Those meetings formed the basis for the views and recommendations on spectrum protection, open service performance, the monitoring of open services, the review of existing user position integrity concepts and further action. The following intersessional meetings and workshops were held in 2017:

(a) Sixth workshop on GNSS spectrum protection and interference detection and mitigation, held in Baška, Croatia, on 9 May, in conjunction with the eleventh annual Baška GNSS Conference, held from 7 to 9 May. The workshop was focused on the following topics: GNSS interference effects on infrastructure and applications and typical interference cases; and interference detection and geo-location capabilities and technologies. On 10 May, following the workshop, an intersessional meeting of the compatibility and spectrum subgroup of Working Group S was held;

(b) The International GNSS Monitoring and Assessment (IGMA) Task Force workshop on performance monitoring held in Shanghai, China, on 22 May, in conjunction with the China Satellite Navigation Conference held from 20 to 23 May. The workshop addressed the Task Force's activities and the status of its trial project with the International GNSS Service; and the need for and benefit of GNSS signal quality monitoring and the feasibility of establishing it within ICG in the future;

(c) An expert workshop to discuss GNSS time offsets among systems held in Paris on 7 July in conjunction with an IGS workshop held from 3 to 7 July;

(d) Meeting of Working Group B held in Vienna on 7 and 8 June. The meeting was focused on the status of current work and the following topics were discussed: (i) progress of the Working Group recommendations; (ii) approach to space weather aspects; and (iii) space service volume.

# IV. Voluntary contributions

33. In 2017, ICG activities were successfully implemented thanks to support and voluntary contributions, financial and in-kind, provided by member States:

(a) The Government of the United States provided $370,000 to support capacity-building and technical advisory services, and arranged for experts to make technical presentations and participate in discussions during activities described in the present report;

(b) The European Commission provided 100,000 euros to support capacity-building and technical advisory services, and arranged for experts to make technical presentations and participate in discussions as part of activities described in the present report;

(c) The Government of Japan provided financial support for two staff members of the Office for Outer Space Affairs to participate in and contribute to the twelfth meeting of ICG and its planning meetings;

(d) The Government of the Russian Federation and the Government of China provided financial support for experts to make technical presentations and participate in discussions as part of activities described in the present report.