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Committee on the Peaceful Uses of Outer Space

Activities carried out in 2019 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) is an important platform for international cooperation and coordination in achieving compatibility and interoperability among the providers of global navigation satellite systems (GNSS). ICG also greatly contributes to the overall aim of achieving efficient interaction in one of the most important fields of space applications.

2. The Office for Outer Space Affairs, as the executive secretariat of ICG, coordinates the preparatory meetings of ICG and its Providers' Forum, as well as the intersessional meetings of the ICG working groups held in conjunction with sessions of the Committee on the Peaceful Uses of Outer Space and its subsidiary bodies. The Office also coordinates the implementation of the ICG programme on GNSS applications.

3. ICG held its fourteenth meeting in Bengaluru, India, from 9 to 13 December 2019, while the Providers' Forum held its twenty-third meeting on 8 and 12 December 2019 (see A/AC.105/1217). The Office for Outer Space Affairs assisted the co-chairs of both meetings in organizing the meetings.

4. The present report contains a description of the activities undertaken or supported by the Office for Outer Space Affairs during 2019 and the main results achieved. Detailed information on the activities is available on the ICG information portal.[1] The report has been prepared for submission to the Committee at its sixty-third session and to the Scientific and Technical Subcommittee at its fifty-seventh session, both to be held in 2020.

II. Activities of the International Committee on Global Navigation Satellite Systems carried out in 2019

5. Pursuant to the ICG workplan for 2019 and the recommendations contained therein, the Office for Outer Space Affairs, in partnership with members and associate

[1] www.unoosa.org/oosa/en/SAP/gnss/icg.html.

members of and observers to 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

6. The regional centres for space science and technology education, affiliated to the United Nations, were established on the basis of regions corresponding to the United Nations regional commissions: Africa (Morocco and Nigeria), Asia and the Pacific (India and China), Latin America and the Caribbean (Brazil and Mexico) and Western Asia (Jordan). The centres, also acting as information centres for ICG, use existing facilities and expertise already available in education and other research institutions in their respective regions to conduct short- and long-term training courses on various aspects of GNSS. The centres develop courses on GNSS that are followed by young professionals and educators from the countries in their regions. By so doing, the centres foster the development of contacts among countries and the initiation of new research, thereby facilitating the development of GNSS-related applications.

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

1. Space weather effects on global navigation satellite systems

7. Ionospheric weather forecasting, which depends strongly on the ability to forecast space weather events that reach the Earth, is increasingly needed for radiocommunications, satellite navigation and positioning operations. The current capacity to forecast ionospheric conditions lags far behind the level of accuracy reached by tropospheric weather forecasting. This is partly due to a lack of understanding of the coupling of the ionosphere with the lower regions of the atmosphere, in particular at low latitudes, where most developing countries are located.

8. A workshop on findings and challenges in ionospheric forecasting for GNSS operations in developing countries was held in Trieste, Italy, from 27 to 31 May 2019, in cooperation with the Abdus Salam International Centre for Theoretical Physics, the Institute for Scientific Research of Boston College and ICG. Participants in the workshop were introduced to GNSS operations and the impact that the ionosphere has on them. They discussed the issue of forecasting ionospheric conditions, with a focus on total electron content, and its relevance for developing countries. Detailed information about the workshop is available on the website of the Abdus Salam International Centre.[2]

9. A total of 65 experts from 36 countries participated in the workshop. Funds provided by the United States of America and the European Commission through ICG were used to defray the cost of air travel for 27 experts from Algeria, Argentina, Brazil, Chile, Costa Rica, Côte d'Ivoire, Egypt, Ethiopia, Fiji, Ghana, India, Iran (Islamic Republic of), Kenya, Nepal, Nigeria, Pakistan, Rwanda, Sri Lanka, Uganda, Ukraine and Zambia.

10. The NeQuick ionospheric electron density model was used in several assessment studies concerning space weather effects on GNSS. Particular attention was devoted

[2] http://indico.ictp.it/event/8686/.

to the mitigation of ionospheric effects in single frequency positioning applications, and a specific version of the model, NeQuick G, was adopted as the ionospheric correction algorithm in the European Union GNSS (Galileo).

11. A workshop on the latest developments of NeQuick and the implementation of new versions of NeQuick for space applications was also held at the Abdus Salam International Centre for Theoretical Physics, in Trieste, from 8 to 11 October 2019. The workshop allowed participants to become acquainted with the new developments of the model and its implementation. Special consideration was given to NeQuick validation and its use in data ingestion and assimilation schemes adopted to retrieve global and regional 3-D ionospheric electron density specifications.

12. The workshop participants were introduced to various topics concerning the NeQuick model: from theoretical aspects of ionospheric modelling to specific problems related to the model mathematical formulation. The implementation of new versions of NeQuick was taken into account, and the performance of NeQuick G was reported on, in connection with recommendation ICG/REC/2014 of the ICG working group on enhancement of GNSS performance, new services and capabilities (Working Group B) (see A/AC.105/1083). An open discussion, aimed at elaborating on specific modelling-related topics and on specific needs of NeQuick users, allowed for the review of methodologies and data to be used for model improvements. To identify potential NeQuick improvements, a working group, to be led by the Abdus Salam International Centre for Theoretical Physics, was established by the workshop participants. The Office for Outer Space Affairs will also participate in the working group.

13. A total of 35 scientists from 16 countries participated in the workshop. Funds provided by the United States and the European Commission were used to defray the cost of air travel for nine scientists from Argentina, Brazil, Côte d'Ivoire, Egypt, India, Nigeria, Pakistan and Peru.

2. Reference frames and timing

14. The second training course on GNSS was held in Bangkok from 14 to 18 January 2019, to raise awareness of GNSS and its applications in Asia and the Pacific. The course was organized by the Geoinformatics Centre of the Asian Institute of Technology and the Centre for Spatial Information Science at the University of Tokyo, with the support of ICG. The course objectives were to provide an introduction to GNSS, provide an overview of signal processing in receiver and receiver performances (low-cost receiver versus high-end survey-grade receiver), introduce RTKLIB (an open-source GNSS-processing software) and related software for high-accuracy GNSS data processing, and conduct a field survey using a low-cost receiver for high-accuracy positioning. During the course, participants learned various methods for signal processing, including precise point positioning and post-processing or real-time kinematics for high accuracy using data from the survey and low-cost GNSS receivers.

15. A total of 85 specialists from 15 countries participated in the course. Funds provided by the United States and the European Commission through ICG were used to defray the cost of air travel for 24 specialists from Bangladesh, Bhutan, Cambodia, India, Indonesia, Maldives, Mongolia, Nepal, Pakistan, the Philippines and Sri Lanka.

16. A technical seminar on reference frames in practice was held in Hanoi on 20 and 21 April 2019. The seminar covered vertical and geometric reference frames in a general fashion, with a focus on examples from Asia and the Pacific. An overview of the work carried out by ICG and its working groups was also presented. A training course delivered by BELS+ (Building European Links towards South-East Asia in the Field of EGNSS) was completed on the second day, providing practical, hands-on training. The seminar was organized by International Federation of Surveyors Commission 5, in conjunction with the International Association of Geodesy, ICG, the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific, BELS+ and the Viet Nam Association of

Geodesy, Cartography and Remote Sensing. The seminar was run in conjunction with International Federation of Surveyors Working Week 2019, held in Hanoi from 22 to 26 April 2019. Detailed information about the seminar is available on the website of the International Federation of Surveyors.[3]

17. There were 43 participants, including presenters from 20 countries around the world. Attendees represented a mix of academic, governmental and commercial institutions. Funds provided by the United States and the European Commission through ICG were used to defray the cost of air travel for seven experts from Bangladesh, Fiji, Pakistan, the Philippines and Uganda.

18. An international workshop for the implementation of the global geodetic reference frame in Latin America was held in Buenos Aires from 16 to 20 September 2019. The workshop was focused on the status of the GNSS-based Geocentric Reference System for the Americas (SIRGAS), the existing gravity infrastructure, advances in the geoid modelling and recent regional activities related to space geodetic techniques, especially in satellite laser ranging, very long baseline interferometry and Doppler orbitography and radiopositioninig integrated by satellite. Detailed information about the workshop is available on the SIRGAS website.[4]

19. Funds provided by the United States and the European Commission through ICG were used to defray the cost of air travel for seven experts from Brazil, Colombia, Costa Rica, Ecuador, Peru, Spain and Venezuela (Bolivarian Republic of).

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

1. Regional workshop on global navigation satellite systems applications

20. A workshop on the applications of global navigation satellite systems was organized by the University of the South Pacific, with support from the Office for Outer Space Affairs. The workshop, held in Suva from 24 to 28 June 2019, was co-sponsored by the European Commission and the United States through ICG (see A/AC.105/1216).

21. The workshop was focused on the use of GNSS for various applications that could provide sustainable social and economic benefits, in particular to developing countries. Many presentations and key messages were relevant to the workplans of the ICG working groups and the ICG programme on GNSS applications implemented by the Office for Outer Space Affairs. The main salient point was that GNSS had become an essential part of positioning, time and navigation aspects of ground, marine, aviation and space applications. While GNSS modernization programmes were ongoing, all the GNSS systems were significantly expanding their global component capabilities to provide GNSS services that benefited users worldwide. Detailed information about the workshop is available on the website of the Office for Outer Space Affairs.

22. Funds provided by ICG and the Office for Outer Space Affairs were used to defray the cost of air travel for 22 specialists from Australia, India, Indonesia, Kiribati, Malaysia, Mongolia, Myanmar, Nauru, Nepal, New Zealand, Pakistan, the Philippines, Samoa, Thailand, Tonga and Tuvalu.

2. Regional workshop on the International Space Weather Initiative

23. To review the results of the operation of the space weather instrument arrays and discuss ways and means to continue space weather research and education, a workshop on the International Space Weather Initiative was held at the Abdus Salam International Centre for Theoretical Physics from 20 to 24 May 2019. The workshop was jointly organized by ICG, the Abdus Salam International Centre, Boston College

[3] www.fig.net/fig2019/rfip.htm.
[4] www.sirgas.org/en/ggrf/.

and the National Aeronautics and Space Administration (NASA) (see A/AC.105/1215).

24. The purpose of the workshop was to raise awareness among Member States of the impact of space weather and to discuss methods for analysing space weather data. Participants in the workshop highlighted that GNSS technology was a relatively convenient means for monitoring the activity of the ionosphere. Consequently, the aggregation and standardized reduction of data on the ionosphere across regions represented a goal. Participants underscored the need for consolidated, accessible standardized GNSS data archives, such as the solar data sets available through the coordinated data analysis workshops.

III. Technical advisory services

25. In order 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 in 2019:

(a) Munich Satellite Navigation Summit 2019, held in Munich, Germany, from 25 to 27 March;

(b) Thirteenth International Navigation Forum, held in Moscow on 23 and 24 April;

(c) Fifty-ninth meeting of the Civil Global Positioning System Service Interface Committee at the Institute of Navigation GNSS+ 2019 Conference, held in Miami, United States, on 16 and 17 September;

(d) Twenty-fourth meeting of the National Space-based Positioning, Navigation and Timing Advisory Board, held in Cocoa Beach, United States, on 20 and 21 November.

26. The Office for Outer Space Affairs held two preparatory meetings for the fourteenth meeting of ICG. Chaired by India, the meetings were held in Vienna on 18 February 2019, on the margins of the fifty-sixth session of the Scientific and Technical Subcommittee, and 11 June, on the eve of the sixty-second session of the Committee.

27. The Office for Outer Space Affairs also organized the twenty-second meeting of the Providers' Forum, which was held in Vienna on 10 June 2019 and co-chaired by China and India. The meeting was focused on issues related to open-service information dissemination, service performance monitoring, spectrum protection and interference detection and mitigation. A summary of the activities undertaken by the ICG information centres was provided by the ICG executive secretariat. A report on a multi-GNSS demonstration project carried out in Asia and Oceania was presented by the representative of Japan. The representatives of China presented their work on the BeiDou Navigation Satellite System (BDS-3)/synthetic aperture radar services and GNSS space debris status. The representative of the United States briefed participants on the concept of autonomous flight termination system that made flight termination decisions using configurable software-based rules implemented on redundant flight processors. One of the system applications is a crew advisory system for human space flight.

28. In order to make further progress with the workplans and recommendations of the ICG working groups, the Office for Outer Space Affairs held the following intersessional meetings of the working groups and their subgroups in 2019:

(a) An interim meeting of Working Group B was held in Vienna on 12 June. Participants in the meeting reviewed the progress in the implementation of the recommendations made at the thirteenth meeting of ICG, in 2018, and discussed additional recommendations for further consideration by ICG;

(b) Also on 12 June, the subgroup on interoperability and service standards of the working group on systems, signals and services (Working Group S) held a workshop on defining guidelines for developing open service performance standards. The main emphasis was on defining and expanding the list of parameters beyond those laid out in the initial performance standard guidelines adopted at the thirteenth meeting of ICG. The subgroup's guidelines for developing global and regional navigation satellite systems performance standards (version 1.0) are available on the ICG information portal;[5]

(c) A joint timing workshop of Working Group S and of the working group on reference frames, timing and applications (Working Group D) was held in Vienna on 14 June. The Working Groups agreed to continue discussions by holding another workshop in conjunction with the meetings of Working Groups B and D in 2020, with a focus on input from GNSS receiver manufacturers and users of different categories;

(d) Consistent with the relevant workplan, the experts of the interference detection and mitigation task force of Working Group S conducted a seminar on GNSS spectrum protection and interference detection and mitigation. The purpose of the seminar was to describe the importance of GNSS spectrum protection at the national level and explain how to reap the benefits of GNSS. The seminar was held in conjunction with the regional workshop in Suva, on 25 and 26 June;

(e) A special technical session on standards and interoperability of precise point positioning services was held and moderated by the representatives of Working Groups B and D. The purpose of the session was to increase awareness of the systems-provided precise point positioning services and to encourage their standardization and interoperability. The session was held in conjunction with the regional workshop in Suva, on 27 June.

29. On 5 July, the Office for Outer Space Affairs held a meeting at the South African National Space Agency, in Hermanus, South Africa, with researchers and postgraduate students. A lecture on outreach and capacity-building activities related to space weather was given at the International Space Weather Camp, which was attended by natural science and engineering postgraduate and senior undergraduate students from various universities in South Africa, Germany and the United States. The meeting was aimed at promoting career opportunities in space science and space weather research or operations. During a question-and-answer session, participants looked at possible ways for easily and efficiently sharing and having access to the various types of data between individual space weather research groups and across the different techniques and domains.

30. The Office for Outer Space Affairs, in cooperation with the Beacon Satellite Studies Group of Commission G of the International Union of Radio Science, co-held and co-sponsored the twentieth International Beacon Satellite Symposium, in Olsztyn, Poland, from 19 to 23 August 2019. The Symposium provided a great opportunity for ionosphere scientists from all over the world to meet and discuss topics related to ionospheric effects on radio propagation, which are of interest to the ICG working group on information dissemination and capacity-building (Working Group C). Funds provided by the United States and the European Union were used to defray the cost of air travel for six scientists from Argentina, Bolivia (Plurinational State of), Ethiopia, India and Nigeria.

31. The Office for Outer Space Affairs participated in and contributed to the fourth International Space Forum at Ministerial Level – The Mediterranean Chapter under the theme "Space technology and applications meet Mediterranean needs", held in Reggio Calabria, Italy, on 5 September 2019. The Office delivered a keynote speech on the topic of space and the blue economy that focused on the role of space technology, using both Earth observation satellite data and GNSS for marine monitoring. The relation between the marine environment, Sustainable Development

[5] See www.unoosa.org/oosa/en/ourwork/icg/working-groups/s/PSindex.html.

Goal 14 and other Sustainable Development Goals, in particular Goals 1, 2 13 and 17, was highlighted.

32. The Office for Outer Space Affairs also participated in the meeting of the Baška GNSS Conference Organizing Committee held in London on 22 February 2019, to contribute to the structure and agenda of the conference and develop activities to be carried out in cooperation with the International Association of Institutes of Navigation in the context of the work of ICG Working Group C on GNSS education and training.

IV. Voluntary contributions

33. In 2019, ICG activities were successfully implemented thanks to support and voluntary contributions, financial and in kind, provided by member States, namely:

(a) The Government of the United States provided $300,000 to support capacity-building and technical advisory services, and arranged for experts to make technical presentations and participate in discussions at events 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 at events described in the present report;

(c) The Government of India supported the participation of one staff member of the Office for Outer Space Affairs in the fourteenth meeting of ICG and its preparatory meeting;

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