



**Committee on the Peaceful
Uses of Outer Space****Activities carried out in 2023 in the framework of the
workplan of the International Committee on Global
Navigation Satellite Systems****Report of the Secretariat****I. Introduction**

1. A global navigation satellite system (GNSS) is a satellite configuration that provides coded satellite signals which are processed by a GNSS receiver to calculate position, velocity and time. Some common GNSS systems are the Global Positioning System (GPS) of the United States of America, the Global Navigation Satellite System (GLONASS) of the Russian Federation, the BeiDou Navigation Satellite System (BDS) of China and the European Satellite Navigation System (Galileo) of the European Union, as well as some other regional systems. The advantage of having access to multiple satellites is that it helps to ensure accuracy, redundancy and availability at all times.
2. As a unique combination of GNSS service providers and major user groups, the International Committee on GNSS (ICG) – established in 2005 under the umbrella of the United Nations – is exceptionally placed to facilitate compatibility, interoperability and transparency among all the satellite navigation systems and to promote and coordinate activities aimed at enhancing GNSS performance, recommending system enhancements and meeting future user needs.
3. The Office for Outer Space Affairs, as the executive secretariat of ICG, is actively involved in work of ICG associated with its workplan and coordinates the implementation of the ICG programme on GNSS applications.
4. The seventeenth meeting of ICG was held in Madrid from 16 to 20 October 2023. The Providers' Forum held its twenty-eighth meeting in conjunction with that ICG meeting on 15 and 19 October 2023 (see [A/AC.105/1304](#)). The European Commission organized and hosted the meeting in collaboration with the Spanish Presidency of the European Union. The meeting also received support from the Office for Outer Space Affairs in its capacity as the executive secretariat of ICG.
5. The present report contains a description of the activities undertaken or supported by the Office for Outer Space Affairs during 2023 and the main results achieved. Detailed information on the activities, as well as educational resources, is available on the ICG information portal.¹ The report has been prepared for submission

¹ Available at www.unoosa.org/oosa/en/SAP/gnss/icg.html.



to the Committee on the Peaceful Uses of Outer Space at its sixty-seventh session and for consideration by the Scientific and Technical Subcommittee at its sixty-first session, both to be held in 2024.

II. Activities of the International Committee on Global Navigation Satellite Systems carried out in 2023

6. Pursuant to the ICG workplan for 2023 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

7. The United Nations-affiliated regional centres for space science and technology education are located in China and India (for Asia and the Pacific), in Morocco and Nigeria (for Africa), in Brazil and Mexico (for Latin America and the Caribbean) and in Jordan (for West Asia). During the period, the regional centres focused on satellite navigation programmes – through the nine-month postgraduate courses on GNSS – and on regional activities to facilitate the development of GNSS-related applications.

8. The centres, which also act as information centres for ICG, coordinate their activities closely with the Office for Outer Space Affairs and GNSS providers that support the development of GNSS services and applications in the regions.

9. The African Regional Centre for Space Science and Technology – in French language, located in Rabat, hosted an intersessional meeting of the ICG Working Group on Systems, Signals and Services from 28 to 31 August 2023 in a hybrid format. Participants reviewed actions, recommendations and next steps to be taken in the implementation of Working Group's workplan on the following topics: interference detection and mitigation standards; signal compatibility and spectrum protection; and open services standards.

10. With a view to enhancing the effectiveness of GNSS-related learning and teaching in the Centre's nine-month postgraduate courses, a booklet on ancient Chinese navigation technology – produced by the National Time Service Centre of the Chinese Academy of Sciences – was presented to the Centre by experts from China.

11. The African Regional Centre for Space Science and Technology Education – in English language, located in Ile-Ife, Nigeria, organized an international colloquium on equatorial and low-latitude ionosphere in a hybrid format in Ilorin, Nigeria, from 4 to 8 September 2023. The colloquium, which is an annual capacity-building event, was geared towards gaining a greater understanding of the Sun and space weather; the dynamics of the equatorial ionosphere, its complexities and high level of dynamics, which results in phenomena such as ionospheric anomaly, equatorial electrojet, equatorial plasma fountain; and how space weather impacts satellite operations and other space-based technologies. A representative of the Office for Outer Space Affairs made a presentation on the activities of ICG related to space weather and GNSS capacity-building.

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

1. Space weather effects on global navigation satellite systems

12. Space weather is a relatively new discipline of space science that investigates the effects of the Sun's activity on and interactions with technology, life and health. It is defined as the variations in the space environment induced by different phenomena occurring on the Sun's surface, such as coronal mass ejections and solar flares, and disturbances resulting from interactions between the ionosphere-thermosphere system.

13. The Office for Outer Space Affairs, in cooperation with the Abdus Salam International Centre for Theoretical Physics (ICTP) of Italy, organized a workshop on the predictability of variable solar-terrestrial coupling. The workshop was held in Trieste, Italy, from 29 May to 2 June 2023, and was co-organized and co-sponsored by the Scientific Committee on Solar-Terrestrial Physics, the National Aeronautics and Space Administration (NASA) of the United States and Boston College (United States).

14. The workshop was organized to bring together scientists from the fields of solar, magnetospheric, ionospheric and atmospheric physics in order to deliberate on the effects of space weather on the Earth's ionosphere, thermosphere and magnetosphere, including technological infrastructure; solar impacts on the atmosphere and climate; and predictability of the solar cycle. Tutorials were given about GNSS and the exploitation of their signals for ionospheric studies.

15. Funds provided by the European Commission and the United States were used to defray the cost of air travel for 12 scientists – 69 per cent of whom were women – from Argentina, Brazil, Côte d'Ivoire, Egypt, Ghana, India, Kazakhstan, Nepal, Nigeria, Pakistan, Türkiye and Uganda.

16. Modern technological infrastructures, such as GNSS and high-frequency communication facilities, are susceptible to the adverse impacts of space weather, which can induce large errors in single-frequency GNSS positioning and even radio signal black-outs. Many developing countries in Africa are located in equatorial and low latitudes, where the effects of space weather make the ionosphere more variable and highly unpredictable. However, owing to the lack of the required infrastructure, only limited efforts have been made to study the impact of space weather in these regions.

17. The Office for Outer Space Affairs, in cooperation with ICTP, the National Institute of Geophysics and Vulcanology (Italy), Boston College, Pwani University (Kenya) and the Italian Space Agency, organized a capacity-building workshop for Eastern Africa on space weather and the low-latitude ionosphere. The workshop was held at the Luigi Broglio-Malindi Space Centre in Malindi, Kenya, from 3 to 12 October 2023.

18. The workshop included lectures and hands-on training on the following topics: space weather and Sun-Earth coupling; GNSS fundamentals; the low-latitude ionosphere; ionospheric monitoring, modelling and forecasting; and space weather data-sharing platforms. Interactive discussion sessions provided participants with an opportunity to focus on specific problems and projects related to space weather research and use of space weather data. The workshop participants recognized that many of the research outputs (data, models and algorithms) produced by the space weather research community were key elements for a future space weather forecast model.

19. Funds provided by the European Commission and the United States were used to defray the cost of air travel for 13 scientists – 53 per cent of whom were women – from Côte d'Ivoire, Egypt, Ethiopia, Ghana, India, Nigeria, Pakistan, Rwanda and Uganda.

2. Global navigation satellite systems data processing

20. GNSS receivers collect signals from orbiting satellites to determine their location in three dimensions and calculate precise times. GNSS receivers detect, decode and process both pseudo-range (code) and phase transmitted by GNSS satellites. The satellites transmit the ranging codes on two or more radio-frequency carriers, allowing the locations of GNSS receivers to be determined with varying degrees of accuracy, depending on the receiver and post-processing of the data. The receivers also calculate current local time to high precision, thus facilitating time synchronization applications.

21. In the framework of the ICG Working Group on Information Dissemination and Capacity-Building, the Office for Outer Space Affairs and the Center for Spatial Information Science of the University of Tokyo conducted a training programme on GNSS in a hybrid format in Pokhara, Nepal, from 3 to 6 January 2023.

22. The training focused on providing an introduction to GNSS and GNSS data processing. For hands-on training of the on-site participants, arrangements were made to allow access to several units of different types of GNSS receivers including continuously operating reference stations for various types of data processing. The online participants received the sample data. Detailed information about the programme is available on the ICG information portal.²

23. A total of 352 specialists, 26 per cent of whom were women, from 57 countries were invited to participate in the training programme.

24. A one-day workshop on GNSS for policymakers and decision-makers was held online on 9 January 2023. The workshop was focused on providing a basic introduction to GNSS systems and how they could be used in various applications. Detailed information was shared on GNSS data processing software and hardware requirements; an interpretation of GNSS specifications; and low-cost GNSS receiver systems and receiver selection guidelines.

25. In the framework of the ICG Working Group on Reference Frames, Timing and Applications workplan, the Commission on Positioning and Measurement (Commission 5) of the International Federation of Surveyors, the National Society of Professional Surveyors, the International Association of Geodesy and the International GNSS Service, in cooperation with the ICG executive secretariat, organized a technical seminar on reference frames in practice, held in Orlando, United States, on 27 and 28 May 2023.

26. The focus of the seminar was on reference frames in general, with a specific focus on United Nations initiatives and global and regional frames, as well as selected national case studies. A demonstration was provided of the Ginan processing package being developed by the GNSS Analysis Centre Software of Geoscience Australia to process GNSS observations for geodetic applications. The case studies addressed the following topics: “one Pacific, one map”; national geodetic datums; and exploring the lunar reference frame.

27. Funds provided the United States were used to defray the costs of air travel for four specialists from Australia, Fiji, the Philippines and Uruguay.

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

Regional workshops on applications of global navigation satellite systems and the International Space Weather Initiative

28. To demonstrate the value of GNSS to the global community and to encourage the integration of GNSS technology into the basic infrastructure of developed and

² Available at www.unoosa.org/oosa/en/ourwork/icg/activities.html.

developing countries, the United Nations/Finland workshop on the applications of global navigation satellite systems was held in Helsinki from 23 to 26 October 2023 (see [A/AC.105/1303](#)). It was co-organized by the Office for Outer Space Affairs and ICG in cooperation with the National Land Survey of Finland, and was attended by a total of 118 specialists from 31 countries. Funds provided by the European Commission and the United States were used to defray the cost of air travel and the daily subsistence allowance for four experts from Croatia, Cyprus, France and Poland.

29. Through the presentations made and views exchanges during the workshop, participants raised awareness of issues and opportunities in the use of GNSS for various applications that could provide sustainable social and economic benefits, in particular for developing nations.

30. The United Nations workshop on the International Space Weather Initiative: the Way Forward was organized and hosted by the Office for Outer Space Affairs. The workshop was co-sponsored by ICG, the European Space Agency and NASA. The workshop, which was held in a hybrid format in Vienna from 26 to 30 June 2023, was attended by a total of 228 specialists, including 61 speakers from 37 countries. Funds provided by the European Commission and the United States were used to defray the cost of air travel and the daily subsistence allowance for six experts from Ethiopia, Italy, Nepal, Poland, Switzerland and Zambia.

31. The presentations given at the technical sessions covered topics in the areas of space weather instrumentation and data; magnetosphere-ionosphere-thermosphere coupling; space weather monitoring using low-cost receiver systems; space weather modelling; space weather effects on technology; space weather research; national and regional space weather programmes; and space weather case studies.

III. Technical advisory services

32. In order to inform a wide audience about the current status and future role of ICG in the 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 held in person or online in 2023:

(a) Munich Satellite Navigation Summit, with the theme “Empowering mobility for air, land, sea and beyond”, held in Munich, Germany, from 13 to 15 March;

(b) 35th General Assembly and Scientific Symposium of the International Union of Radio Science, held in Sapporo, Japan, from 19 to 26 August;

(c) 63rd Meeting of the Civil GPS Service Interface Committee at the Institute of Navigation GNSS+2023 Conference, held in Denver, United States, on 11 and 12 September;

(d) Second International Summit on BDS Applications, held in Zhuzhou, China, from 26 to 28 October;

(e) Meeting of the National Space-based Positioning, Navigation and Timing Advisory Board, held in Houston, United States, on 6 and 7 December.

33. The Office for Outer Space Affairs held two preparatory meetings for the seventeenth meeting of ICG. Chaired by the European Commission, the meetings were held in a hybrid format in Vienna on 13 February 2023, on the margins of the sixtieth session of the Scientific and Technical Subcommittee, and on 6 June 2023, on the margins of the sixty-sixth session of the Committee on the Peaceful Uses of Outer Space.

34. The Office for Outer Space Affairs also organized the twenty-seventh meeting of the Providers’ Forum, which was held in Vienna on 6 June 2023 and chaired by the European Commission. The meeting 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 Forum took note of the report on the Tenth Interference Detection and Mitigation Workshop, which had been organized in Vienna, in December 2022, by the task force on interference detection and mitigation of the ICG Working Group on Systems, Signals and Services, in accordance with the task force's workplan. The report described the importance of GNSS spectrum protection at the national level.

35. 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 2023:

(a) An intersessional meeting of the Working Group on Systems, Signals and Services was held in a hybrid format from 7 to 9 June in Vienna. Participants in the meeting reviewed the progress in the implementation of the recommendations made at the sixteenth meeting of ICG, in 2022, and discussed additional recommendations for further consideration by ICG;

(b) An intersessional meeting of the Working Group on Enhancement of GNSS Performance, New Services and Capabilities was held online on 19 July to review the progress in the implementation of the recommendations made at past meetings of ICG and discuss additional recommendations for further consideration by ICG;

(c) An intersessional meeting of the Working Group on Information Dissemination and Capacity-building was held in a hybrid format from 20 to 24 March, in Paris, to further explore the possibility of using low-cost receiver systems for space weather monitoring and implementing a prototype system. Experts representing ICTP, Boston College and the University of Tokyo, who comprised a Working Group project team on space weather monitoring using low-cost GNSS receiver systems, met on 25 August in Sapporo, Japan, to discuss the software to be used for total electron content data processing and analyse results on the usability of low-cost GNSS receiver modules for ionospheric studies.

36. In cooperation with the International Space Weather Initiative Steering Committee, the Office for Outer Space Affairs organized a webinar series on topics relevant to the Initiative. The webinars were held monthly on a variety of topics that included space weather, ionospheric physics, instrumentation and national activities. Recordings of the webinars can be accessed through the website of the Office for Outer Space Affairs.³

37. In 2023, ICG activities were successfully implemented thanks to the support and voluntary contributions, both financial and in-kind, provided by ICG members. In addition, ICG members, associate members and observers provided technical advisory services and arranged for experts to make technical presentations and participate in discussions during activities described in the present report.

³ Available at www.unoosa.org/oosa/en/ourwork/psa/bssi/iswi_webinars.html.