



# General Assembly

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## Committee on the Peaceful Uses of Outer Space

### Activities carried out in 2022 in the framework of the workplan of the International Committee on Global Navigation Satellite Systems

#### Report of the Secretariat

#### I. Introduction

1. The field of global navigation satellite systems (GNSS) continues to develop as an instrument of international cooperation among the satellite operators of current and planned systems and their augmentations. The availability of several GNSS systems promises positioning, navigation and timing services with higher availability and improved accuracy.
2. To promote the interoperability and compatibility of all GNSS, the International Committee on GNSS (ICG) was established in 2005 under the umbrella of the United Nations. As an important vehicle in the multilateral arena, ICG contributes to the sustainable development of the world and serves to assist GNSS users with their development plans and applications by encouraging coordination and serving as a focal point for information exchange.
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 sixteenth meeting of ICG was held in Abu Dhabi, from 10 to 14 October 2022. The Providers' Forum held its twenty-sixth meeting in conjunction with that ICG meeting on 9 and 13 October 2022 (see [A/AC.105/1276](#)). The United Arab Emirates Space Agency, in cooperation with the Office for Outer Space Affairs, organized and hosted the meeting on behalf of the Government of the United Arab Emirates.
5. The present report contains a description of the activities undertaken or supported by the Office for Outer Space Affairs during 2022 and the main results achieved. Detailed information on the activities, as well as educational resources, is available on the ICG information portal.<sup>1</sup> The report has been prepared for submission to the Committee on the Peaceful Uses of Outer Space at its sixty-sixth session, to be held in 2023, and to its subcommittees.

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<sup>1</sup> Available at [www.unoosa.org/oosa/en/SAP/gnss/icg.html](http://www.unoosa.org/oosa/en/SAP/gnss/icg.html).



## **II. Activities of the International Committee on Global Navigation Satellite Systems carried out in 2022**

6. Pursuant to the ICG workplan for 2022 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 ICG information centres are hosted by the regional centres for space science and technology education, affiliated to the United Nations. The regional centres are in India and China (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). The centres focused on satellite navigation programmes, through the nine-month postgraduate courses on GNSS, and regional activities to facilitate the development of GNSS-related applications.

8. A regional workshop on GNSS and space weather was held in hybrid format at the African Regional Centre for Space Science and Technology – in French language in Rabat from 9 to 13 May 2022. The workshop was organized by the Office for Outer Space Affairs in cooperation with the Abdus Salam International Centre for Theoretical Physics (ICTP) of Italy and the Institute for Scientific Research of Boston College of the United States of America. It was held during a nine-month postgraduate course on GNSS in order to be able to also engage the students of the course carried out by the Centre.

9. The purpose of the workshop was to introduce the physics of the ionosphere and to provide basic knowledge on GNSS and their scientific and technological applications. Particular attention was devoted to space weather research using GNSS data in African countries. The workshop programme and lecture notes are available in the ICG information portal<sup>2</sup> and the ICTP website.<sup>3</sup>

10. A total of 149 specialists – 26 per cent of whom were women – from 34 countries were invited to participate in the workshop. Funds provided by the European Commission and the United States were used to defray the cost of air travel for 15 scientists from Cameroon, Côte d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Nigeria, Senegal and Uganda.

### **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. Space weather describes changing environmental conditions in near-Earth space. Studies on the effects of space weather on the Earth's ionosphere, and therefore on GNSS, have been ongoing for several years. Nevertheless, additional efforts are still needed to increase the involvement of the scientific community in this field of research, especially those from the emerging space nations.

<sup>2</sup> Available at [www.unoosa.org/oosa/en/ourwork/icg/activities.html](http://www.unoosa.org/oosa/en/ourwork/icg/activities.html).

<sup>3</sup> Available at <https://indico.ictp.it/event/9778/other-view?view=ictp timetable>.

12. The Office for Outer Space Affairs, in cooperation with ICTP, the Institute for Scientific Research of Boston College and Pwani University in Kilifi, Kenya, organized the African capacity-building workshop on space weather effects on GNSS. The workshop was held in a hybrid format in Trieste, Italy, from 3 to 14 October 2022.

13. That capacity-building workshop provided an in-depth view of space weather phenomena, including their effects on technological systems. Tutorials were given about GNSS and the exploitation of their signals for ionospheric studies with the aim of enhancing the knowledge and the research capabilities of young scientists, in particular those from African countries. Group projects on GNSS data analysis to investigate the ionospheric response to space weather events were also carried out by participants during the workshop. Detailed information about the workshop is available on the ICTP website.<sup>4</sup>

14. A total of 140 specialists – 31 per cent of whom were women – from 25 countries were invited to participate in the workshop. Funds provided by the European Commission and the United States were used to defray the cost of air travel for 12 scientists from Algeria, Egypt, Ethiopia, Nigeria, Pakistan, Rwanda, South Africa, Sri Lanka and Uganda.

15. The Office for Outer Space Affairs, in cooperation with ICTP, the Institute for Scientific Research of Boston College and the National University of Tucuman of Argentina organized the workshop entitled “International workshop on machine learning for space weather: fundamentals, tools and prospects”. The workshop was held in a hybrid format in Buenos Aires from 7 to 11 November 2022.

16. The workshop was aimed at fostering space weather research through the application of machine learning and statistical techniques and, to do so, provided participants with theoretical and practical training on space weather and machine learning fundamentals, including hands-on tutorials. At the workshop, lecture courses were given on the following topics: space weather fundamentals, the ionosphere, basic concepts of machine learning, deep learning and current trends, and machine learning techniques applied to space weather and their main challenges. Hands-on and practice tutorials sessions covered the following topics: open-source tools for machine learning. Detailed information about the workshop is available on the ICTP website.<sup>5</sup>

17. A total of 82 specialists, 46 per cent of whom were women, from 28 countries were invited to participate in the workshop. Funds provided by the European Commission and the United States were used to defray the cost of air travel for 10 scientists from Brazil, Chile, Costa Rica, Mexico and Peru.

18. A session on ionospheric effects on GNSS augmentation systems, held in a hybrid format on 2 August 2022, was organized in conjunction with the twenty-first International Beacon Satellite Symposium, held in Boston, the United States, from 1 to 5 August 2022. The session addressed topics related to performance assessments of augmentation systems affected by ionospheric effects, mitigation techniques, effects on users and the programme status of navigation satellite systems.

19. Funds provided by the European Commission and the United States were used to defray the cost of air travel for four scientists from Brazil, India, Nigeria and Peru.

20. As part of the International Space Weather Initiative, the space weather school was organized, held in hybrid format in Abidjan from 17 to 28 October 2022.

21. The main objective of the school was to improve the level of expertise of young scientists from the Maghreb and West Africa. Through hands-on practice, participants familiarized themselves with solar wind data sources and solar corona images, and the modelling of the ionosphere vertical total electron content. Participants also learned about the Global Positioning System, the ionosphere and ionospheric

<sup>4</sup> Available at <https://indico.ictp.it/event/9778/>.

<sup>5</sup> Available at <https://indico.ictp.it/event/9840/>.

scintillation. The report on the summer space weather school is available on the ICG information portal.<sup>6</sup>

## 2. Global navigation satellite systems data processing

22. GNSS receivers are widely used in many applications that require position and time data. There are several applications that also require a high degree of accuracy down to the centimetre level. The increase in applications has created demand for the development of low-cost, low-power and smaller receiver systems, without any compromise to performance.

23. The Center for Spatial Information Science of the University of Tokyo and the ICG Working Group on Information Dissemination and Capacity-building (Working Group C) held a training programme on GNSS in a hybrid format in Pokhara, Nepal, from 11 to 14 January 2022.

24. The training programme focused on an introduction to GNSS and GNSS data processing. The programme consisted of the following topics: GNSS data types, GNSS errors, coordinate systems and applications; a real-time kinematic and multi-GNSS advanced demonstration tool for orbit and clock analysis to process GNSS data with high accuracy; and low-cost receiver system data. Detailed information about the programme is available on the ICG information portal.<sup>7</sup>

25. A total of 75 specialists – 16 per cent of whom were women – from 15 countries were invited to participate in the training programme.

26. A one-day workshop on GNSS for policymakers and decision-makers was held online on 21 January 2022. The workshop provided information on the following topics: introduction to GNSS and its applications; GNSS accuracy, errors and coordinate systems; an overview of GNSS data processing software and hardware requirements; an interpretation of GNSS specifications; and low-cost GNSS receiver systems and receiver selection guidelines. A total of 21 participants from nine countries were invited to participate in the workshop.

27. In recognition of a number of ongoing projects and initiatives to establish regional reference frame networks that meet the growing needs of industries, science programmes and the members of the general public that are using precise GNSS-positioning applications, the Commission on Positioning and Measurement (Commission 5) of the International Federation of Surveyors, the Subcommittee on Geodesy of the Committee of Experts on Global Geospatial Information Management, the International Association of Geodesy and the Association of Polish Surveyors, in cooperation with ICG, organized a technical seminar on reference frames in practice, held in Warsaw on 10 and 11 September 2022. The focus of the seminar was reference frames in general, with a specific focus on the United Nations initiatives, global and regional frames and selected national case studies. A half-day training session on international GNSS service provided an introduction to GNSS software: Spotlight on Bernese and Spotlight on GipsyX. Detailed information about the seminar is available on the website of the International Federation of Surveyors.<sup>8</sup>

28. Funds provided by the European Commission and the United States were used to defray the costs of air travel and daily subsistence allowance for five specialists from Nepal, the Philippines, Uganda and Zimbabwe.

29. The technical seminar on reference frames in practice: reference frames, kinematics and dynamic datums was held in Santiago on 10 and 11 November 2022. It was hosted by the International Federation of Surveyors. The seminar brought together researchers to share their research results and collaborate on new and

<sup>6</sup> Available at [www.unoosa.org/documents/pdf/icg/2022/GIRGEA2022/Report-IMAO5-english\\_v2.pdf](http://www.unoosa.org/documents/pdf/icg/2022/GIRGEA2022/Report-IMAO5-english_v2.pdf).

<sup>7</sup> Available at [www.unoosa.org/oosa/en/ourwork/icg/activities.html](http://www.unoosa.org/oosa/en/ourwork/icg/activities.html).

<sup>8</sup> Available at [www.fig.net/fig2022/rfip.htm](http://www.fig.net/fig2022/rfip.htm).

ongoing projects. The presentations covered the following topics: reference frames, datum transformations, and case studies.

30. Funds provided by the European Commission and the United States were used to defray the costs of air travel for five specialists from Bolivia (Plurinational State of), Uruguay and Venezuela (Bolivarian Republic of).

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

#### **International Meeting on the Applications of the Global Navigation Satellite Systems and the International Space Weather Initiative**

31. The Office for Outer Space Affairs and ICG work together to raise awareness of the important role of GNSS in our societies and to promote international collaboration in this field. To focus on GNSS technology and applications, the United Nations International Meeting on the Applications of GNSS (see [A/AC.105/1290](#)) was organized by the Office for Outer Space Affairs in cooperation with the ICG working groups. The meeting was held in a hybrid format in Vienna from 5 to 9 December 2022.

32. Consistent with the workplan of the ICG Working Group on Systems, Signals and Services (Working Group S), the experts of the Working Group's task force on interference detection and mitigation conducted a seminar on GNSS spectrum protection and held the tenth Workshop on Interference Detection and Mitigation in conjunction with the International Meeting, on 6 and 7 December 2022. The purpose of the seminar and workshop was to describe the importance of GNSS spectrum protection at the national level and explain how to reap the benefits of GNSS. The seminar lecture notes<sup>9</sup> and the workshop briefings<sup>10</sup> are available at the website of the Office for Outer Space Affairs.

33. To review the results of the operation of the instrument arrays of the International Space Weather Initiative and discuss ways and means to continue space weather research and education, the United Nations/Azerbaijan workshop on the International Space Weather Initiative: the Sun, Space Weather and Geosphere ([A/AC.105/1275](#)) was organized jointly by the Office for Outer Space Affairs and the Baku State University on behalf of the Government of Azerbaijan. The workshop was co-organized and co-sponsored by the ICG. The workshop was hosted by the Baku State University and was held in a hybrid format in Baku from 31 October to 4 November 2022. 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.

## **III. Technical advisory services**

34. 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 and/or online in 2022:

(a) Munich Satellite Navigation Summit, with the theme "Artificial intelligence in GNSS: intelligence brought to navigation", held in Munich, Germany, on 7 and 8 March;

(b) International Colloquium on Equatorial and Low-latitude Ionosphere, held in Abuja, from 18 to 23 September;

<sup>9</sup> Available at [www.unoosa.org/oosa/en/ourwork/psa/schedule/2022/un-international-meeting-gnss\\_gnss-spectrum-protection.html](http://www.unoosa.org/oosa/en/ourwork/psa/schedule/2022/un-international-meeting-gnss_gnss-spectrum-protection.html).

<sup>10</sup> Available at [www.unoosa.org/oosa/en/ourwork/icg/working-groups/s/idm10.html](http://www.unoosa.org/oosa/en/ourwork/icg/working-groups/s/idm10.html).

(c) First BeiDou/GNSS Global Partner High-level Forum, held in Beijing on 26 May;

(d) BDS Applications Conference, held in Zhengzhou, China, from 20 to 22 September.

35. The Office for Outer Space Affairs held two preparatory meetings for the sixteenth meeting of ICG. Chaired by the United Arab Emirates Space Agency, the meetings were held in a hybrid format in Vienna on 14 February 2022, on the margins of the fifty-ninth session of the Scientific and Technical Subcommittee, and on 7 June 2022, on the eve of the sixty-fifth session of the Committee on the Peaceful Uses of Outer Space.

36. The Office for Outer Space Affairs also organized the twenty-fifth meeting of the Providers' Forum, which was held in Vienna on 6 June 2022 and chaired by the Office for Outer Space Affairs. 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 Forum took note of the report about the Interagency Operations Advisory Group and ICG liaison presented by the representatives of the United States and the European Space Agency. The report described the contribution of the space use subgroup work packages of the ICG Working Group on the Enhancement of GNSS Performance, New Services and Capabilities (Working Group B) to international organizations.

37. 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 2022:

(a) An intersessional meeting of Working Group S on Systems, Signals and Services was held virtually on 16 August. Participants in the meeting reviewed the progress in the implementation of the recommendations made at the fifteenth meeting of ICG in 2021 and discussed additional recommendations for further consideration by ICG;

(b) Additionally, an interoperability and service provision subgroup of Working Group S held a meeting on 16 August to discuss matters related to precise point positioning interoperability; performance standards; a status update on work on the international GNSS monitoring and assessment; and system time interoperability;

(c) Also on 16 August, the compatibility and spectrum subgroup of Working Group S held a meeting to discuss matters related to interference detection and monitoring and follow-up on activities for the subgroup recommendations on "the campaign on protection of radionavigation satellite service (RNSS) operations" (ICG/REC/2015<sup>11</sup>) and the "booklet on GNSS/RNSS spectrum protection" (ICG/REC/2019<sup>12</sup>);

(d) A project team on "space weather monitoring using low-cost GNSS receiver systems" of the ICG Working Group on Information Dissemination and Capacity-building (Working Group C) met once a month prior to the sixteenth meeting of ICG. The team focused on the Fleury software to test and understand how to compute total electron content from Receiver Independent Exchange Format (RINEX) observation data.

38. 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 including space weather, ionospheric physics, instrumentation, and national activities.

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<sup>11</sup> Available at [www.unoosa.org/pdf/icg/2015/icg10/icg10-wga.pdf](http://www.unoosa.org/pdf/icg/2015/icg10/icg10-wga.pdf).

<sup>12</sup> Available at [www.unoosa.org/documents/pdf/icg/2019/icg14/WGS/Recommendation\\_1\\_WGS.pdf](http://www.unoosa.org/documents/pdf/icg/2019/icg14/WGS/Recommendation_1_WGS.pdf).

The recording of the Initiative webinars can be accessed through the YouTube channel<sup>13</sup> of the Office for Outer Space Affairs.

39. In 2022, 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.

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<sup>13</sup> Available at <https://youtube.com/playlist?list=PLaOqa4cng0GF3cKuj6Yz5kqG1BQ-Akkhr>.