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Report on the United Nations/Philippines workshop on the applications of global navigation satellite systems

(Manila, 22–26 April 2024)

I. Introduction

1. The term “global navigation satellite system” (GNSS) is used to refer to navigation systems using constellations of satellites, space- and ground-based augmentation systems and related user equipment. Satellite navigation systems in use around the world 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. Regional systems that provide additional signals from satellites operating over a given geographical area include the Navigation with Indian Constellation (NavIC) system of India and the Quasi-Zenith Satellite System (QZSS) of Japan, which are also compatible with one or more GNSS. These systems are being further developed and improved to ensure the continued provision of reliable and accurate positioning, navigation and timing services, thereby enabling new possibilities and applications.

2. Pursuing a GNSS “system-of-systems” to provide GNSS services that benefit users worldwide, the International Committee on Global Navigation Satellite Systems (ICG), established in 2005 under the umbrella of the United Nations, continues to promote the use of GNSS and their integration into infrastructures, particularly in developing countries, and to encourage compatibility and interoperability among global and regional systems. More detailed information about ICG is available on the ICG information portal (www.unoosa.org/oosa/en/ourwork/icg/icg.html).

3. The United Nations/Philippines workshop on the applications of global navigation satellite systems was organized by the Office for Outer Space Affairs in cooperation with the National Mapping and Resource Information Authority (NAMRIA) of the Philippines on behalf of the Government of the Philippines. The workshop was held in Manila from 22 to 26 April 2024. It was co-organized and co-sponsored by ICG and the Philippine Space Agency.

4. The present report describes the background, objectives and programme of the workshop and provides an overview of the highlights of each session and the observations made by the participants. It has been prepared for submission to the Committee on the Peaceful Uses of Outer Space at its sixty-seventh session, to be held in 2024.

A. Background and objectives

5. Since 2006, the Office for Outer Space Affairs, in its capacity as the executive secretariat of ICG and its Providers' Forum, has been organizing regional workshops focusing on a wide array of GNSS applications for socioeconomic benefits. The workshops have addressed, inter alia, the use of GNSS technology for aviation, marine and land-based activities, intelligent transport systems and search and rescue operations, and the impact of space weather on precise positioning applications of GNSS. The overall objective of the workshops is to define the needs and requirements of end users of GNSS and to provide a framework for scientific research enabled by GNSS.

6. In line with the consideration by the Scientific and Technical Subcommittee at its sixty-first session of the agenda item entitled "Recent developments in global navigation satellite systems" (see A/AC.105/1307, paras. 119–131), the main objectives of the workshop were as follows: (a) to reinforce the exchange of information between countries and scale up capacities in the region for pursuing the application of GNSS solutions; (b) to share information on national, regional and global projects and initiatives that could benefit regions; and (c) to enhance cross-fertilization among those projects and initiatives. The discussions at the workshop were also linked to the Sustainable Development Goals.

7. The specific objectives of the workshop were as follows: (a) to introduce GNSS-based technology and its applications; (b) to promote the greater exchange of actual experiences with specific applications; (c) to focus on appropriate GNSS applications projects at the national and/or regional levels; and (d) to define recommendations and findings to be forwarded as a contribution to the work of the Office for Outer Space Affairs and the ICG working groups, in particular with regard to forging partnerships to strengthen and deliver capacity-building on satellite navigation science and technology.

B. Programme

8. At the opening of the workshop, introductory and welcoming statements were made by the Administrator of NAMRIA and by the Director General of the Philippine Space Agency. The representative of the Office for Outer Space Affairs also made opening remarks.

9. In total, 44 presentations were made during the following technical sessions covering a wide range of topics related to GNSS-based technology and its applications: (a) current and planned GNSS and satellite-based augmentation systems; (b) GNSS reference stations and applications; (c) space weather: ionospheric monitoring with GNSS; (d) precise point positioning services; (e) applications of GNSS: case studies and national programmes; (f) GNSS technology and applications; and (g) the use and implementation of GNSS technology. Two discussion sessions allowed for exchanges on structured topics, such as capacity-building and institutional strengthening, and specific GNSS applications, and led to the development of an action plan for forming partnerships in the region and initiating proposals for pilot projects.

10. An informative technical tour of NAMRIA was organized for the workshop participants. The tour included a presentation on the NAMRIA positioning infrastructure, which comprised continuously operating geodetic reference stations used to support various positioning, navigation and timing applications in the Philippines. The tour also included a visit to a roof-based installation consisting of geodetic control points.

11. The programme of the workshop was developed by the Office for Outer Space Affairs and NAMRIA. The presentations made at the workshop, abstracts of the

papers presented and the programme of the workshop are available on the website of the Office for Outer Space Affairs (www.unoosa.org).

C. Attendance

12. A total of 107 specialists representing national space agencies, academia, research institutions, international organizations and industry from developing and developed countries concerned with the development and use of GNSS for practical applications and scientific exploration were invited to participate in the workshop.

13. Funds provided by the United Nations, ICG and NAMRIA were used to defray the costs of air travel and the daily subsistence allowance for 25 participants.

14. The following 23 Member States were represented at the workshop: Algeria, Armenia, Bangladesh, Bolivia (Plurinational State of), China, Croatia, Egypt, Estonia, India, Indonesia, Japan, Kyrgyzstan, Lao People's Democratic Republic, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Russian Federation, Thailand, Tunisia, United States and Uzbekistan. The European Union was also represented. Representatives of the Office for Outer Space Affairs also participated.

II. Summary of discussions, observations and concluding remarks

15. The observations and recommendations of the participants in the workshop, which have been drawn from the reports submitted by the rapporteurs of the technical sessions and the working group discussion sessions, are summarized below.

16. Participants noted that the United States had continued to upgrade the capability of and service provided by GPS through the integration of the newest generation of satellites. The GPS Block IIIF satellites would host a laser retroreflector array to enable the precise optical laser ranging of GPS satellites and a search-and-rescue repeater to relay distress signals to rescuers.

17. Participants noted that the service provided by GLONASS of the Russian Federation operated on the basis of open access navigation signals in the L1 and L2 radio frequency bands and that the fourth generation of the GLONASS constellation, the GLONASS-K2 satellites, would facilitate the registration of emergency signals and thus improve the efficiency of search and rescue operations.

18. Participants noted that the BDS constellation of China had been further improved and provided both radionavigation satellite services and mobile satellite services, and that BDS satellites were included in the space segment of the International Cospas-Sarsat Programme, a satellite-aided search and rescue initiative, forming a part of the Programme's Medium Earth Orbit Search and Rescue system.

19. Participants noted that the Galileo system of the European Union had been providing a precise satellite navigation service through its open service, offering metre-scale accuracy, and that Galileo services had been expanded with many new capabilities that were unique with respect to other GNSS. The new Emergency Warning Satellite Service had been designed to complement existing warning systems, particularly in remote and rural areas or where networks were congested.

20. Participants noted that the QZSS system of Japan was currently providing three types of services: a service complementing GPS that transmitted ranging signals from satellites; a high-accuracy service that augmented GNSS by providing error corrections through QZSS; and a messaging service that contributed to disaster risk reduction efforts. A QZSS emergency warning satellite service for the Asia-Pacific region using L1S-band signals would be established in 2025.

21. Participants noted that the Algerian satellite-based augmentation system (AL-SBAS) was aimed at improving the accuracy and integrity of positioning

information in Algeria and the surrounding areas, providing services for users in many fields, such as surveying, transportation, aviation, rail transport and maritime navigation. The system was compatible with International Civil Aviation Organization standards and based on the first communications satellite of Algeria, Alcomsat-1.

22. Participants noted that satellite-based navigation was a key enabling technology and innovation driver for the modern economy, and that ICG was an important platform for communication and cooperation in the field of GNSS, especially in the areas of compatibility and interoperability among the different systems and GNSS spectrum protection and interference detection.

23. During the technical sessions on space weather-related physical phenomena, such as solar flares, coronal mass ejections and geomagnetic storms, participants discussed how space weather could have detrimental effects on modern technological infrastructures and how scientific understanding could help to mitigate those effects. It was noted that the effects of the ionosphere, in particular during severe space weather events, remained one of the main factors affecting the precision and reliability of many GNSS. The main findings of research in that area underscored the intricate relationship between geomagnetic storms and variations in ionospheric plasma density and pointed to the importance of comprehensive GNSS total electron content measurements in understanding and forecasting such events over low-latitude GNSS stations in the South-East Asian region.

24. It was noted that there had been interest in developing machine learning models to understand ionospheric variability in space weather and predict disturbances. Of particular interest were low-cost GNSS receivers, which could be used for ionospheric research and which had the distinct advantages of low cost, small size and low power requirements. The use of low-cost receivers would help in developing a networked GNSS-based ionospheric monitoring system operating over a given geographical area.

25. Participants noted that the application of precise point positioning, specifically the technique known as Multi-GNSS Advanced Orbit and Clock Augmentation – Precise Point Positioning (MADOCA-PPP), represented a significant advancement in the field of geospatial science. It offered a practical solution for establishing reliable and accurate reference points in remote areas, thereby enhancing the capabilities of mapping, surveying and navigation in those challenging environments. The continued development and adoption of MADOCA-PPP would likely play a crucial role in the global geospatial infrastructure in the future.

26. The sessions on GNSS reference stations, case studies and national programmes, and the use and implementation of GNSS technologies gave participants an additional opportunity to share their experiences in the use and applications of GNSS. The main conclusions reached at those sessions were the following:

(a) Some GNSS applications, such as autonomous vehicles, required high reliability, including high accuracy, integrity and availability, thus they depended crucially on the monitoring of integrity;

(b) With regard to GNSS spoofing, which was considered to be a major threat to existing technology and one that was difficult to detect, much attention needed to be given to the development and implementation of GNSS signal security and to collaborative action to implement robust countermeasures against emerging threats;

(c) The upcoming solar maximum of solar cycle 25 could cause adverse space weather events that degrade GNSS signals;

(d) The integration of GNSS with other enabling technologies might improve many aspects of the methods typically used in surveying and remote sensing;

(e) GNSS errors needed to be quantified in order to enhance the confidence of stakeholders in different applications, which could be accomplished through long-term data analysis and modelling;

(f) Continuous training and capacity-building in the use of GNSS technology would support the exploration of new areas of application, and collaborative research.

27. The discussion sessions provided guidance on how institutions could work together through regional partnerships to share and transfer knowledge and develop joint activities and project proposals. Participants were divided by area of expertise and interest into two working groups, one on capacity-building and institutional strengthening and the other on specific GNSS applications. During the sessions, each working group discussed activities that would contribute to increasing the use of GNSS technology in the region. Participants also discussed the establishment of a regional network that would promote partnerships. Summaries of the discussions were presented at the closing session, at which a final round-table discussion was held and the conclusions reached and recommendations made during the sessions were adopted.

28. The working group on capacity-building and institutional strengthening emphasized the need to strengthen national capacities to use GNSS technology, specifically through targeted training courses and workshops that were tailored to the regional context and that took advantage of existing regional structures. The need for continuing education and training in GNSS science and applications, raising the awareness of decision makers, and the development and consolidation of national and regional expertise were identified as possible areas of focus. Cooperation with industry was also emphasized.

29. Furthermore, it was noted that continuous efforts should be made to raise awareness among local decision makers, service providers and product manufacturers of the potential of GNSS technology, and institutions within each country should assume responsibility for periodically carrying out activities focusing on the use of GNSS technology and its applications and on how such technology could contribute to sustainable development.

30. The working group on specific GNSS applications recognized that all relevant actions should be coordinated at the national, regional and international levels. The working group focused on ways and means of strengthening the use of GNSS technologies in the region and discussed ongoing and planned initiatives and actions that should be carried out collaboratively for the establishment of a regional network for the exchange of information on GNSS applications among national and regional institutions.

31. Discussions were held on the key challenges and the issues presented and resulted in initiatives and actions to advance capacity development in South-East Asian countries. The outcomes of the discussions included the following:

(a) Outreach activities should be continued through the Office for Outer Space Affairs and the ICG programme on GNSS applications, especially in countries where the benefits of GNSS applications have not yet resulted in the systematic application of GNSS for the advancement of their societies, particularly in the areas of traffic congestion management, early warning systems for natural hazards, disaster risk reduction, marine and shipping activities and agriculture;

(b) A request was made for a technical advisory mission to assess one Member State’s capacity to take full advantage of GNSS science, technology and education in instrumentation, data processing and analysis;

(c) Efforts should be made to encourage interactions between the research community and developers of GNSS applications to share, for example, case studies and technical solutions in order to avoid duplication of effort;

(d) Efforts should be made to increase recognition of the fact that GNSS signals are very vulnerable to intentional and unintentional interference, owing to their relatively weak signal power;

(e) Efforts should be made to ensure that there is a solid understanding of the processes and organizations involved in the regulation of the GNSS spectrum in the respective countries;

(f) It was noted that training needed to be tailored to the available equipment and infrastructure in a particular country or region. It was also noted that it should be appropriately scaled and directed to the identified problems and capability levels in a given country. Particular attention should be paid to the following topics:

(i) Technology demonstrations of MADOCA-PPP;

(ii) Low-cost GNSS receiver systems;

(iii) GNSS applications based on Android for mobile phones;

(iv) Underwater navigation systems, underwater surveying, buoy positioning, locating navigation hazards, dredging and mapping;

(v) Space-based augmentation system services;

(g) When seeking training resources, it is important to identify the current state of capabilities and to articulate needs for accomplishing goals;

(h) The view was expressed that the quality infrastructure should be implemented in terms of standards, metrology and accreditation. The main focus should be on the organizations that operated continuously operating GNSS reference stations for precise positioning services and their data centres to ensure the reliability of measurements;

(i) Follow-up training for the purposes of sustainably maintaining core competencies and of continuous learning was also emphasized.

32. Participants recognized that the website of the Office for Outer Space Affair was vital for disseminating information and recommended that the Office further develop the website, in particular the ICG information portal.

33. Participants expressed their appreciation to the United Nations, the Government of the Philippines and the co-organizers for both the excellent organization and the substance of the workshop.