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Committee on the Peaceful Uses of Outer Space

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

(Kathmandu, 12-16 December 2016)

I. Introduction

1. Since the beginning of the space age, international cooperation in the peaceful uses of outer space has evolved in such a way as to provide the impetus for a consideration of international mechanisms and infrastructures for space cooperation and coordination mechanisms at the international, regional, interregional and national levels.

2. The International Committee on Global Navigation Satellite Systems (ICG), established in 2005 under the umbrella of the United Nations, works to promote the introduction and utilization of global navigation satellite systems (GNSS) services and their future enhancements, including in developing countries, providing assistance, as necessary, for the integration of GNSS into existing infrastructure. ICG also assists 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 of the Secretariat, in its capacity as the executive secretariat of ICG and its Providers' Forum, promotes the use of GNSS through its programme on GNSS applications.

4. Numerous potential applications have already been identified, on the basis of the quality and reliability of GNSS signals, but the list is certain to grow, offering a cost-effective way of pursuing sustainable economic growth while protecting the environment.

5. As part of the United Nations Programme on Space Applications, a United Nations/Nepal workshop on the applications of GNSS was organized by the Office for Outer Space Affairs in cooperation with the Ministry of Land Reform and Management of Nepal. The Workshop was hosted by the Survey Department on behalf of the Government of Nepal and it was held in Kathmandu from 12 to 16 December 2016. It was co-sponsored by the United States of America and the European Union through ICG, and the Galileo Control Centre of the German Aerospace Centre (DLR).

6. Previous regional workshops and international meetings on the applications of GNSS organized by the United Nations had been hosted by the Governments of China

(A/AC.105/883) and Zambia (A/AC.105/876) in 2006, Colombia (A/AC.105/920) in 2008, Azerbaijan (A/AC.105/946) in 2009, the Republic of Moldova (A/AC.105/974) in 2010, the United Arab Emirates (A/AC.105/988) in 2011, Latvia (A/AC.105/1022) in 2012, Croatia (A/AC.105/1055) in 2013 and the Russian Federation (A/AC.105/1098) in 2015. In addition, a meeting on the applications of GNSS was hosted by the Office for Outer Space Affairs (A/AC.105/1019) in 2011 and a workshop on the use of GNSS for scientific applications was hosted the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, (A/AC.105/1087) in 2014. At all of those meetings and workshops, a wide array of GNSS applications for socioeconomic benefits was addressed and focus was placed on initiating pilot projects and strengthening the networking of GNSS-related institutions in the relevant regions.

7. The present report contains a description of the background, objectives and programme of the workshop held in Kathmandu from 12 to 16 December 2016 and also contains a summary of the observations and recommendations made by the participants. It has been prepared for submission to the Committee on the Peaceful Uses of Outer Space at its sixtieth session, to be held in 2017.

A. Background and objectives

8. Efforts to build capacity in space science and technology are considered a major focus of the Office for Outer Space Affairs and are of specific interest to ICG, with particular reference to GNSS and its applications. Such efforts are aimed at providing support to the regional centres for space science and technology education, affiliated to the United Nations, which also act as information centres for ICG. The regional centres are working towards the establishment of a network of institutions involved or interested in GNSS. They are also identifying new applications that could be developed in the regions on the basis of GNSS services. The centres coordinate their activities closely with ICG and its Providers' Forum through the ICG executive secretariat. Additional information is available at www.unoosa.org/oosa/en/SAP/centres/index.html.

9. Building resilient societies through better coordination and the forging of global partnerships is a key challenge of the twenty-first century and an integral part of meeting the commitments set out in the 2030 Agenda for Sustainable Development. Recognizing space weather as a global challenge and the need to address the vulnerability of society as a whole, one of the potential activities of ICG is to address the importance of space weather for GNSS systems and their users. Space weather is defined as "the conditions on the sun and in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems, and can endanger life and health". Space weather can interrupt communication and navigation systems, harm satellite electronics and expose aircraft passengers flying over the poles and at very high altitudes to increased levels of radiation. For GNSS users, space weather is the single largest contributor to the single frequency Global Positioning System (GPS) error budget, and a significant factor for differential GNSS users. As more and more nations of the world are becoming dependent on GNSS systems and signals, it is increasingly important to inform and educate users about the threat of space weather on GNSS systems and applications. Additional information is available on the website of the International Space Weather Initiative (www.iswi-secretariat.org).

10. Development projects, applications, services and products requiring georeferencing require a uniform coordinate reference system. Most countries have some form of national reference frame or system. These reference frames or systems

are usually based on a local origin or datum point, which restrict their use to a particular country. It makes cross-border mapping, development and planning projects difficult, and the establishment of common and uniform continental reference coordinates frames and systems is therefore needed.

11. In line with the cross-cutting topics identified in document A/AC.105/L.297, the main objective of the workshop was on the importance of cooperation and the need to cooperate with regard to applying GNSS solutions through the exchange of information and the scaling up of capacities among countries in Asia and the Pacific.

12. In order to strengthen the ongoing processes in the lead-up to the fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50), which will be held in 2018, the specific objectives of the five-day United Nations/Nepal workshop were to: (a) introduce GNSS and its applications to transport and communications, aviation, surveying, mapping and Earth science, the management of natural resources, the environment and disasters, precision agriculture and high-precision mobile applications; (b) discuss space weather effects on GNSS and dual-frequency receivers; (c) promote greater exchange of actual experiences with specific applications; (d) encourage greater cooperation in developing partnerships and GNSS networks, in the framework of the regional reference frames; and (e) define recommendations and findings to be forwarded as a contribution to ICG and UNISPACE+50, in particular with regard to forging partnerships to strengthen and deliver capacity-building in the use and applications of space science and technology.

B. Programme

13. At the opening of the workshop, introductory and welcoming statements were made by the Minister of Land Reform and Management, the Vice-Chair of the National Planning Commission, the Director-General of the Survey Department of the Ministry of Land Reform and Management of Nepal and the representative of the Office for Outer Space Affairs.

14. The discussions at the workshop were also linked to the 2030 Agenda for Sustainable Development and to the targets set out under the Sustainable Development Goals. The discussions focused on the following aspects: (a) health (GNSS positioning enables individual patients, staff and equipment to be monitored and response teams to be directed more efficiently); (b) energy (GNSS reflectometry techniques can produce scatterometry models to assist in the optimum positioning of off-shore wind farms); and (c) ecosystems (GNSS reflectometry offers the potential for monitoring vegetation and biomass. It also has an important role in providing information for carbon modelling, greenhouse gas emission inventories and deforestation control).

15. The workshop included six technical sessions on of the following themes: (a) overview of GNSS; (b) GNSS applications and technology development; (c) environmental monitoring and management using GNSS; (d) GNSS reference frames and reference station networks; (e) technology and applications of real-time kinematic; and (f) case studies on GNSS implementation and uses.

16. A one-day seminar on the theme “Space weather and its effects on GNSS” was held during the workshop. The purpose of the seminar was to provide a background to the phenomenon of space weather and to illustrate its effects on GNSS. At the seminar, the challenging aspects of space weather phenomena, their impact on GNSS users, the variability of those impacts and the actions that might mitigate their effects were described.

17. A seminar on the theme “GNSS spectrum protection and interference detection and mitigation” was also organized during the workshop. The purpose of that seminar was to highlight the importance of GNSS spectrum protection at the national level and to explain how to reap the benefits of GNSS. Specifically, the seminar included an introduction to GNSS, spectrum management and protection and international and domestic efforts in interference detection and mitigation. Discussions between the ICG experts presenting the material and the workshop participants were also held.

18. Demonstrations were held on a free, open-source software (RTKLIB) that provided a low-cost GNSS receiver system for real-time kinematic. The system was based on a very low-cost GNSS receiver, namely Raspberry-Pi computer using RTKLIB.

19. The agenda of the workshop was developed by the Office for Outer Space Affairs and the Survey Department of the Ministry of Land Reform and Management in cooperation with ICG and the University of Tokyo, Japan.

C. Attendance

20. Representatives of national space agencies, academia, research institutions, international organizations and industry of developing and developed countries working in the field of the development and use of GNSS for practical applications and scientific exploration were invited to participate in the workshop. Participants were selected on the basis of their scientific or engineering background, the quality of the abstracts of their proposed presentations and their experience in programmes and projects involving GNSS technology and its applications.

21. Funds provided by the United Nations, the Government of Nepal and co-sponsors were used to defray the costs of air travel and accommodation for 25 participants. A total of 154 specialists in GNSS were invited to attend the workshop.

22. The following 31 Member States were represented at the workshop: Australia, Bahrain, Bangladesh, Brazil, China, Croatia, Egypt, Estonia, Fiji, France, Germany, India, Indonesia, Japan, Lao People’s Democratic Republic, Latvia, Malaysia, Mongolia, Morocco, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Russian Federation, Saudi Arabia, Thailand, Turkey, Ukraine, United States and Uzbekistan. The European Union was also represented. A representative of the Office for Outer Space Affairs also participated.

II. Observations and recommendations

23. The workshop addressed the use of GNSS for various applications that could provide sustainable social and economic benefits, in particular for developing countries. Current and planned projects using GNSS technology for both practical applications and scientific explorations were presented. Cooperative efforts and international partnerships for capacity-building, training and research were discussed.

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

25. Recognizing that GNSS technology had enormous potential to contribute to the management and protection of the environment, disaster risk reduction, agriculture and food security, emergency response, improving efficiency in surveying and mapping and enhancing the safety and effectiveness of transportation by land, sea and

air, the participants put forward a number of observations and recommendations, which are summarized below.

A. Global navigation satellite system applications and technology development

26. Participants recognized that GNSS had very important applications in surveying and mapping and in precise positioning. It was noted that GNSS technology played a prominent role in all infrastructure developments. Participants also recognized the importance of the use of GNSS technology to improve emergency response to natural disasters and reduce the associated risk to and impact on human life. That was an extremely important application for GNSS, requiring robust information technology and multi-agency cooperation and interoperability that included both governmental and non-governmental organizations. Overall, the presentations featured works that leveraged existing mobile phone and Internet technologies coupled with GNSS to provide improved services for disaster management, primarily through reducing location uncertainties and information timelines.

27. GNSS reference frames, reference station networks and determination of vertical datums were major topics of discussion, in which knowledge-sharing played an essential role. It was noted that continuously operating reference stations played an important role in critical national priorities such as identifying seismic hazards, disaster recovery and mitigation and infrastructure development, particularly in developing countries. In order to take full advantage of emerging GNSS technology, the development of modernized national horizontal reference systems, including deformation models and vertical datums based on accurate local geoid models, was essential. International cooperation in terms of sharing knowledge, resources and information in the development of networks of continuously operating reference stations and geodetic reference systems was therefore emphasized.

28. Key recommendations included the following: (a) continuing the development and integration of information, geographical information system (GIS), mobile phone, GNSS and remote sensing technologies to achieve improved disaster management tools accessible to the public; and (b) engaging public and private agencies and organizations in influencing public policy to ensure maximum benefit for the population being served. Those activities might include the following: (a) obtaining endorsement for those efforts; (b) enabling access to databases and data sources in support of those efforts; and (c) developing a framework to formally manage the cross-agency cooperative and collaborative efforts needed to adopt and exploit the new capabilities.

B. Space weather and its effects on global navigation satellite systems

29. In general, near the peak of a solar cycle, a significant increase in space weather events such as solar radio bursts, solar flares and coronal mass ejections can be seen. It was noted that those events could affect the performance of ground- and space-based technological systems, with results ranging from minor digital upsets to severe power grid disruptions that could cause loss of service for millions. For GNSS users, space weather events could ultimately degrade ranging measurements, which would affect the performance and ability of the many GNSS-based applications used in daily life.

30. In that connection, ionospheric research is an essential component of the development and implementation of GNSS augmentation systems, as understanding of

the challenges posed by the ionosphere could provide important insights into the development of GNSS. On the other hand, existing data from GNSS stations serve as a valuable source of data for evaluating aspects of the response of the mid- and low-latitude ionosphere to magnetic storms and space weather effects.

31. Participants recognized that the space weather seminar was very useful and requested more programmes on the topic. The importance of space weather to civil aviation and the future of space flight was highlighted. In that context, participants recommended that: (a) space weather discussion forums should be developed to educate the public as well as policymakers about space weather phenomena; and (b) other workshops should provide opportunities for students and professionals to be involved in space weather data analysis and prediction.

C. Global navigation satellite system spectrum protection and interference detection

32. Representatives from ICG conducted a seminar. The seminar stemmed from a recommendation by ICG in 2015 to reach out to developing nations about the importance of spectrum protection and interference detection and mitigation.

33. Feedback at the end of the seminar confirmed that the seminar had achieved its objective of informing participants about GNSS spectrum protection and the importance of good national spectrum management. The participants and ICG experts agreed to consider holding additional seminars in the future, with further discussions to take place within the ICG Working Group on Systems, Signals and Services.

D. Capacity-building training and education in the field of global navigation satellite systems

34. Participants recognized the need for the continuous building of national and regional expertise, through the provision of scholarships, long-term and short-term training and education at the regional centres for space science and technology education, affiliated to the United Nations, and other academic centres of excellence. In addition, participants stressed the need to make existing educational opportunities available to a wider university community.

35. Participants recognized the need for additional workshops building upon the results of the current workshop, including workshops focusing on training decision makers (covering the integrated application of combined remote sensing, GIS and decision support systems).

36. Participants recommended that a regional geodetic capacity-building workshop with a focus on GNSS data processing and the use of open geodetic software should be conducted in cooperation with the International Federation of Surveyors and the International Association of Geodesy, and that the reference frames should be made more visible and understandable to society.

37. It was noted that those workshops could be arranged to coincide with other related conferences and meetings, including International Federation of Surveyors working weeks.

38. In order to enable knowledge-sharing, participants recommended that institutions implemented exchange programmes, providing opportunities for experts to visit and work with partner institutions. In particular, participants recommended that national, regional and international institutions should make every effort to provide support to Nepalese institutions through exchange programmes and technical support.

III. Concluding remarks

39. Participants learned about improvements in existing infrastructure, either by launching new satellites, in case of Galileo, the Beidou Navigation Satellite System, the Quasi-Zenith Satellite System and the Indian Regional Navigation Satellite Systems, or by modernization of existing signals, as with GPS and the Global Navigation Satellite System (GLONASS).

40. Participants noted the release of new interference control documents for all GNSS, along with activities for international collaboration on compatibility and interoperability among GNSS operators.

41. Participants recognized that the seminar on GNSS spectrum protection and interference detection and mitigation had been successful in fulfilling its intended purpose of educating the workshop participants on the importance of GNSS spectrum protection and challenging them to engage with their national spectrum management agencies to ensure continued access to the benefits provided by GNSS.

42. Participants also recognized that operators of continuously operating reference stations should be encouraged to facilitate the Earth's deformation studies. The importance of modernizing national geodetic reference systems was emphasized.

43. The participants found that the low-cost GNSS receiver system for real-time kinematic using RTKLIB was very useful for education and training and even for surveying and mapping, where required accuracy was within a sub-meter level. The participants requested improvements to the system to make it compatible with different types of base-station receiver makers. It was noted that the system would be developed on an android platform in the future.

44. Participants noted that the Public Health Concern Trust Nepal had expressed an interest in using GNSS technology and that a project on integrating GNSS technology into the rural healthcare model of Nepal would be conducted, with training and technical support provided by the Galileo Control Centre.

45. The recommendations and observations put forward by the participants in the workshop provided guidance on how institutions could work together through regional partnerships. The Office for Outer Space Affairs should provide support for the consolidation of the partnerships formed at the workshop. Those partnerships would result in the sharing and transfer of knowledge and the development of joint activities and project proposals.

46. Additionally, it was recommended that the Office should continue its work on capacity-building through the regional centres for space science and technology education, affiliated with the United Nations, and centres of excellence, and work further towards ensuring that end users would benefit from the GNSS multi-constellation.

47. The participants in the workshop expressed their appreciation to the United Nations, the Government of Nepal and the co-sponsors for the excellent organization of the workshop.