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Committee on the Peaceful Uses of Outer Space

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

(Krasnoyarsk, Russian Federation, 18-22 May 2015)

I. Introduction

1. Following the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in 1999, in its resolution 54/68, the General Assembly endorsed the resolution adopted by the third United Nations Conference on the Peaceful Uses of Outer Space entitled "The Space Millennium: Vienna Declaration on Space and Human Development". The Vienna Declaration included, inter alia, key actions to improve the efficiency and security of transport, search and rescue, geodesy and other activities by promoting the enhancement and compatibility of, and universal access to, space-based navigation and positioning systems, including global navigation satellite systems (GNSS).

2. In that context, the International Committee on Global Navigation Satellite Systems (ICG) has been addressing the pursuit of freely available worldwide access to civil satellite navigation systems, while increasing their use to support sustainable development, particularly in developing nations.

3. Significant progress has been made through ICG, and the results of its work not only promote the capabilities of GNSS to support sustainable development, but also build capacity in the use of GNSS technologies and their applications for the benefit of all nations.

4. At its fifty-seventh session, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposiums and expert meetings relating to environmental monitoring, natural resource management, global health, GNSS, basic space science, basic space technology, space law, climate change, human space technology and the socioeconomic benefits of space activities, to be held in 2015 for the benefit of developing countries.[1]

[1] *Official Records of the General Assembly, Sixty-ninth Session, Supplement No. 20* (A/69/20).

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Subsequently, the General Assembly, in its resolution 69/85, endorsed the United Nations Programme on Space Applications for 2015.

5. Pursuant to General Assembly resolution 69/85 and as part of the United Nations Programme on Space Applications, a United Nations/Russian Federation workshop on the applications of global navigation satellite systems was organized by the Office for Outer Space Affairs in cooperation with the Russian Federal Space Agency (ROSCOSMOS) on behalf of the Government of the Russian Federation. The workshop was hosted by the joint stock company Academician M.F. Reshetnev Information Satellite Systems (JSC ISS) in Krasnoyarsk, Russian Federation, from 18 to 22 May 2015. It was supported by ICG. *Coordinates* magazine, an exclusive international monthly publication on positioning, navigation and beyond, was a media partner of the workshop.

6. Organized by the United Nations, previous regional workshops and international meetings on the applications of GNSS were 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) and the Office for Outer Space Affairs (A/AC.105/1019) in 2011, Latvia (A/AC.105/1022) in 2012, Croatia (A/AC.105/1055) in 2013 and the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, (A/AC.105/1087) in 2014. Those workshops addressed a wide array of GNSS applications for socioeconomic benefits and focused on initiating pilot projects and strengthening the networking of GNSS-related institutions in the regions.

7. The present report describes the background, objectives and programme of the workshop and provides 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 fifty-ninth session and its Scientific and Technical Subcommittee at its fifty-third session, both to be held in 2016.

A. Background and objectives

8. Global navigation satellite systems are the collection of satellite positioning systems that are now operating or planned. Two such systems that are currently in operation include the Global Positioning System (GPS) of the United States of America and the Global Navigation Satellite System (GLONASS) of the Russian Federation. Next-generation systems that are being developed include the European Satellite Navigation System (Galileo) and China's BeiDou Navigation Satellite System. Regional systems that provide additional signals from satellites operating over a given geographical area include the Indian Regional Navigation Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS), which are also compatible with one or more GNSS. Each of those navigation satellite systems will bring extra satellites and signals to deliver better accuracy, reliability and availability. As new systems emerge, signal compatibility and interoperability among the various systems and transparency in the provision of open civil services, will be key factors in ensuring that civil users receive maximum benefit from GNSS applications.

9. Satellite navigation and positioning data are now used in a wide range of areas, including mapping and surveying, monitoring of the environment, precision agriculture and management of natural resources, disaster warning and emergency response, aviation, maritime and land transportation, and research areas, such as climate change and ionospheric studies. GNSS applications offer a cost-effective way of pursuing sustainable economic growth while protecting the environment.

10. The objectives of the five-day United Nations/Russian Federation workshop were to: (a) strengthen regional information and data exchange networks on the use of GNSS technology, including various training programmes and capacity-building needs in GNSS and its applications; (b) develop a regional plan of action that would contribute to the wider use of multi-constellation GNSS and its applications, including the possibility of one or more national and/or regional pilot projects, in which interested institutions could incorporate the use of GNSS/GLONASS technology; and (c) define recommendations and findings to be forwarded as a contribution to the work of ICG.

B. Programme

11. At the opening of the workshop, introductory and welcoming statements were made by the Governor of the Krasnoyarsk Region, the Deputy Head of ROSCOSMOS, the General Director of JSC ISS, and representatives of the Ministry of Foreign Affairs of the Russian Federation and of the Office for Outer Space Affairs. The General Director of JSC ISS delivered the keynote presentation focusing on a brief history of satellite navigation in Russia, highlighting the role of JSC ISS, Russia's largest satellite manufacturer and the primary developer of the GLONASS programme.

12. The workshop included nine technical sessions on a variety of themes: (a) overview of GNSS in operation and development; (b) update on satellite-based augmentation systems; (c) implementation of GLONASS/GNSS technology; (d) GNSS infrastructure; (e) GNSS and space weather monitoring; (f) capacity-building, training and education in the field of GNSS; (g) GNSS applications and technology development; (h) GNSS applications: national programmes; and (i) case studies. Two discussion panels were convened to address developing partnerships and networks and capacity-building, training and education in the field of GNSS. In total, 51 presentations were made.

13. The programme was developed by the Office for Outer Space Affairs and JSC ISS in cooperation with ROSCOSMOS and ICG. An informative technical tour of JSC ISS (see www.iss-reshetnev.com/about/) was organized for participants in the workshop in the closed city of Zheleznogorsk, near Krasnoyarsk. The tour demonstrated GLONASS-M and GLONASS-K navigation satellites, which are a new generation of navigation satellites, as well as the latest developments in the field of space technology, walking participants through the main stages of construction of instruments and satellite systems.

C. Attendance

14. Representatives of national space agencies, academia, research institutions, international organizations and industry from developing and developed countries concerned with the development and the 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 in GNSS technology and its applications.

15. Funds provided by the United Nations and the Government of the Russian Federation were used to defray the costs of air travel and accommodation for 23 participants. A total of 80 specialists in satellite navigation systems were invited to attend the workshop.

16. The following 20 Member States were represented at the workshop: Argentina, Bangladesh, Bosnia and Herzegovina, Brazil, Bulgaria, China, Colombia, Finland, India, Italy, Lao People's Democratic Republic, Mexico, Mongolia, Morocco, Nigeria, Pakistan, Russian Federation, Tunisia, United States and Uzbekistan. Representatives of the European Space Research and Technology Centre of the European Space Agency and the Office for Outer Space Affairs were also present.

II. Observations and recommendations

17. 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).

18. The observations and recommendations of the participants in the workshop, which are based on reports submitted by the Chairs of the technical sessions and panel discussions, are summarized below.

A. Development of partnerships and networks

19. Participants in the workshop noted that the Russian Federation GLONASS constellation currently consisted of 28 satellites and that GLONASS civil services were free and unlimited globally. It was also noted that the system for differential corrections and monitoring had been developed as a satellite-based augmentation system to perform integrity monitoring of both GLONASS and GPS satellites and provide differential corrections and a posteriori analyses of the performance of the GLONASS system.

20. Participants noted that GPS of the United States, flying in an expanded 24+3 slot configuration, continued to provide a reliable and accurate space-based positioning, navigation and timing service to the international community. It was also noted that the improved accuracy of the wide area augmentation system enabled the United States Federal Aviation Administration to develop localizer performance with vertical guidance approach. It was noted that over 70,000 aircraft and their operators were benefiting from the increased safety and capacity provided by the United States implementation of a satellite-based augmentation system.

21. Participants further noted that the European satellite navigation system, Galileo, would consist of 30 satellites and that innovative receiver technologies had been developed as Galileo-based application programmes in a wide range of domains for all modes of transport, precision agriculture and personal mobility. It was also noted that benefits were already being reaped from the European Geostationary Navigation Overlay Service, the European satellite-based augmentation system, which was helping to improve the performance of GNSS.

22. They also noted a series of successful launches as part of China's BeiDou satellite navigation system and that the system had started providing initial positioning, navigation and timing services in the Asia-Pacific region. It was also noted that the BeiDou ground-based enhancement system would help to improve position accuracy and the reliability and integrity of the BeiDou services, in order to meet the demands of civil aviation and other users.

23. Participants noted the progress made on the ICG workplan and the growing attention paid by the international community to multi-GNSS monitoring to improve performance and interoperability. It also noted that the ICG working groups focused on the following issues: compatibility and interoperability; enhancement of the performance of GNSS services; capacity-building and information dissemination; and reference frames, timing and applications.

24. They also noted that applications using GNSS covered a large array of sectors, including all forms of transportation (road, air, maritime and rail), energy production and distribution, advanced technologies (timing, scientific applications, Earth observation and network synchronization), life-saving (emergency and location-based services) and disaster management. Nevertheless, the applications were susceptible to disruption in the operation of GNSS receivers when malfunctions, failures or interference occurred. Radio frequency interference, detection and mitigation had, therefore, become topics of paramount importance owing to the increasing number of services and applications based on positions obtained by means of GNSS.

25. In order to take appropriate steps to protect GNSS users from interference and to improve the robustness of GNSS in countering interference, the need to raise the awareness of national spectrum managers and administrators regarding the threat of unwanted interference was identified as a possible area of focus.

26. In that context, participants in the workshop recommended that ICG conduct technical seminars and lectures focusing on GNSS spectrum protection and interference detection and mitigation. The following proposals were also made during the workshop for further consideration by ICG: (a) develop educational materials on sources of interference to GNSS, including an explanation of the difference between radionavigation satellite services and radiocommunication services and why radionavigation satellite services are more vulnerable to interference and (b) conduct a survey to identify national and international regulations on spectrum protection, their possible inconsistency and necessary improvement.

27. They also recommended that action should be taken through the International Telecommunication Union (ITU) and national frequency regulations to protect the GNSS frequency spectrum. The enforcement of regulations to protect the GNSS

frequency spectrum by national communications authorities would also be necessary.

28. Participants in the workshop noted with satisfaction that a new document on the NeQuick ionospheric model, a quick-run ionospheric electron density model, that used to compensate for the errors arising from interference when navigation signals broadcast by Galileo and other GNSS passed through the ionosphere, had been published. The document, entitled “European GNSS (Galileo) open service: ionospheric correction algorithm for Galileo single frequency users”, is available at www.gsc-europa.eu.

29. Participants noted that the Russian accident emergency response (ERA-GLONASS) system was built to have intelligent telematics-based vehicle safety systems in place to speed up emergency response times and that the system was harmonized with the European eCall system.

30. They also noted that the Russian satellite communications system Gonets was designed for the global exchange of different kinds of information with space vessels. The system would also be integrated with the ERA-GLONASS system. Those integrated terminals were to be used to access an array of additional services, such as navigation, information exchange, remote vehicle diagnostics, smart insurance etc.

31. Participants in the workshop took note of the cooperation mechanism of China with some countries in the Asia-Pacific region through the joint project “BeiDou Asia-Pacific tour” to promote systems applications in the areas of precision agriculture and disaster prevention and reduction.

32. Participants noted with satisfaction the adoption by the General Assembly of its resolution 69/266 on 26 February 2015, in which it specifically recognized the importance of international cooperation, “as no one country can do this alone, to realize the global geodetic reference frame and services to underpin Global Navigation Satellite Systems technology and provide the framework for all geospatial activity, as a key enabler of spatial data interoperability, disaster mitigation and sustainable development”.

33. Participants noted that for precise positioning in the Arctic with GNSS, such as GLONASS and GPS, there were a number of issues to be taken into account. The most important ones were satellite geometry, ionospheric effects and the distribution of correction data. The workshop expressed support for the ongoing projects with the purpose of testing measures for improved GNSS navigation in the Arctic, using all operational satellites and signals from current and future navigation systems.

34. They proposed that project groups focusing on specific topics of interest in different applications of GNSS (i.e. tropospheric investigation, ionospheric study, geodynamics etc.) be established, in order to enhance cooperation between countries at the regional and international levels and take part in calls for project proposals. Such project partnerships would ensure more strategic, in-depth and sustainable cooperation.

35. To support the development of GNSS applications, participants in the workshop recommended compiling and maintaining a catalogue of case studies and best practices, for example the space weather study and monitoring programme of the National Institute for Space Research in Brazil. Data obtained

through the programme is available on the website of the Institute at www.inpe.br/climaespacial/. This ionospheric product provides a measurement of the ionospheric total electron content over South America. It is designed to estimate the signal delay for single and dual frequency GNSS applications.

36. Participants noted that the need to standardize GNSS reference documents should be addressed by ICG in the future.

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

37. Participants in the workshop observed with satisfaction that the regional centres for space science and technology education affiliated to the United Nations, which had been established in Brazil, China, India, Jordan, Mexico, Morocco and Nigeria, had been carrying out education, research and application programmes in the GNSS field since 2009 (see www.unoosa.org/oosa/en/ourwork/psa/regional-centres/index.html).

38. They also noted that the activities and opportunities provided in the centres should result in the development and growth of capacities that would enable each country in the different regions to enhance its knowledge, understanding and practical experience of those aspects of GNSS science and technology that had the potential for the greatest impact on its economic and social development, including the preservation of its environment.

39. Participants also noted that the regional centres were requesting on-site training courses, to be conducted by GNSS providers, in order to develop top-level skills to execute their missions as information centres for ICG and its Providers' Forum, and hence to work towards the establishment of a network of associated centres in the regions and increase awareness among the main actors around GNSS, such as decision makers, research institutions, industry, service and data providers and end users.

40. Participants noted with satisfaction that the GLONASS training course would be organized during the nine-month postgraduate course on remote sensing and geographic information systems and satellite meteorology and climate change in 2016 at the African Regional Centre for Space Science and Technology Education in the French Language in Morocco (see www.crastelf.org.ma/).

41. They further noted the experience of the Abdus Salam International Centre for Theoretical Physics in Italy in delivering education and training in the field of satellite navigation science and technology, including the training project European Geostationary Navigation Overlay Service-GNSS in Africa aimed at assisting the aviation sector in Africa (see www.ictp.it).

42. Participants also noted the interdisciplinary, multilevel training programmes of the Moscow State University of Geodesy and Cartography (see www.miigaik.ru/eng/training.htm), including its research activities.

43. Participants in the workshop recommended that, with the active support of the ICG Providers' Forum and scientific organizations, the United Nations should lead an international effort to establish an international centre for GNSS science,

technology and education in an existing national educational and research institution. That centre might grow into a network of centres around the world, focusing on GNSS science and technology, and all dedicated to the advancement of GNSS research, applications and education. The centre would provide capacity-building and technical guidance to nations that wished to engage in GNSS science, technology and education, including training on GNSS instrumentation and data processing and analysis. Participants noted that JSC ISS of the Russian Federation had offered to host such a centre.

44. The objective of the centre would be to provide trainees with advanced skills and knowledge in the field of GNSS and its related applications, in order to prepare them to enter the highly dynamic GNSS and GNSS-dependent industry. In addition, the students would receive training in satellite telecommunications, as those fields are strongly complementary.

45. The centre would cooperate with the regional centres affiliated to the United Nations for space science and technology education, the international centre for space weather science and education, located in Japan, and other centres of excellence in space science, technology and education.

46. The centre would report annually to ICG Working Group C on capacity-building and information dissemination, led by the Office for Outer Space Affairs. The centre would also act as the information centre for ICG.

47. Participants in the workshop recommended that outreach activities should be continued through the Office for Outer Space Affairs and the ICG working groups, especially in countries where the benefits of GNSS applications had not yet resulted in the application of GNSS for the advancement of their societies, in particular in the areas of agriculture, transportation, geophysical dynamics and disaster management.

48. Participants noted that, despite a substantial capacity-building infrastructure, several applications still had significant gaps that needed to be bridged between potential end users and the GNSS capabilities that had been developed for their use.

III. Concluding remarks

49. The workshop provided a unique opportunity to channel support for the further use of GNSS technology in various domains, such as aviation, maritime transportation, communications, timing, science and agriculture. 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 consolidation of the partnerships that were formed at the workshop. Those partnerships will result in the sharing and transfer of knowledge and the development of joint activities and project proposals. Additionally, 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 will benefit in many ways from accurate and reliable positioning services.

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

51. The participants in the workshop expressed their appreciation to the United Nations and the Government of the Russian Federation for the substance and the excellent organization of the workshop.