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Report on the United Nations/Republic of Moldova/United States of America Workshop on Applications of Global Navigation Satellite Systems

(Chisinau, 17-21 May 2010)

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I. Introduction

1. By its resolution 54/68, the General Assembly endorsed "The Space Millennium: Vienna Declaration on Space and Human Development",[1] which had been adopted by the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna from 19 to 30 July 1999. In the Vienna Declaration, the States participating in UNISPACE III called for action to be taken to improve the efficiency and security of transport, search and rescue, geodesy and other activities by promoting the enhancement of, universal access to and compatibility of space-based navigation and positioning systems. The Plan of Action contained in the note by the Secretary-General on review of the implementation of the recommendations of UNISPACE III (A/59/174, paras. 228-316) and endorsed by the General Assembly in its resolution 59/2 presented findings and proposed specific actions in those areas that are important for strengthening and further improving the well-being and the future of all nations. The actions identified in the Plan of Action include maximizing the benefits of the use and applications of global navigation satellite systems (GNSS) to support sustainable development, including by providing training opportunities in GNSS, in particular in developing countries.

2. Since 2001 and as part of the United Nations Programme on Space Applications, the Office for Outer Space Affairs of the Secretariat has organized regional workshops and international meetings to promote the use of GNSS (see A/AC.105/771, A/AC.105/776, A/AC.105/785, A/AC.105/795 and A/AC.105/846). At these workshops and meetings, participants have presented information on the status of existing and near-term GNSS technology and its applications. In an attempt to build a system of systems in the coming decade, the International Committee on Global Navigation Satellite Systems (ICG) was established in December 2005. ICG is a forum for discussing the use of GNSS for the benefit of people around the world.

3. In its resolution 61/111, the General Assembly noted with appreciation that ICG had been established on a voluntary basis as an informal body to promote cooperation, as appropriate, on matters of mutual interest related to civil satellite-based positioning, navigation, timing and value-added services, as well as the compatibility and interoperability of GNSS, while increasing their use to support sustainable development, particularly in developing countries.

4. To implement a programme on global navigation and positioning satellite systems, the Office for Outer Space Affairs is organizing regional workshops, training courses and international meetings focusing on capacity-building in the use of GNSS in a variety of applications on land, at sea and in the air. To support the work of ICG, the Office, acting as the ICG Executive Secretariat, is focusing on deploying instruments for the International Space Weather Initiative, developing a GNSS curriculum to be integrated into the educational programmes of the regional centres for space science and technology education, affiliated to the United Nations, and utilizing regional reference systems and frames.

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[1] *Report on the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1.

5. At its fifty-second session, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposiums and conferences scheduled to be held in 2010,[2] which the General Assembly subsequently noted with appreciation in its resolution 64/86.

6. Pursuant to General Assembly resolution 64/86 and as part of the United Nations Programme on Space Applications, the Office for Outer Space Affairs held the United Nations/Republic of Moldova/United States of America Workshop on Applications of Global Navigation Satellite Systems in Chisinau from 17 to 21 May 2010. The Agency for Land Relations and Cadastre hosted the Workshop on behalf of the Government of Moldova. The Workshop was co-sponsored by the United States of America, through ICG.

7. The present report provides information on the background and objectives of the Workshop and provides a summary of the presentations and observations made by the Workshop participants. The report is prepared pursuant to General Assembly resolution 64/86.

A. Background and objectives

8. The United States of America's Global Positioning System (GPS), the Russian Federation's Global Navigation Satellite System (GLONASS), Europe's Galileo satellite navigation system and China's Compass/BeiDou navigation system are designed to comprise a constellation of 24 or more satellites, ensuring that signals from at least four satellites are available at any location. In addition, there are the Global Positioning System and Geostationary (GEO) Augmented Navigation System (GAGAN) of India and the Quasi-Zenith Satellite System (QZSS) of Japan, which are regional navigation satellite systems. A satellite navigation receiver may derive a three-dimensional position and calibrate its clock offset by passive ranging from four satellites. In practice, there are usually more satellites in view, enabling the accuracy of the position to be refined and consistency checks to be performed.[3]

9. The four core systems and the two regional systems are augmented by additional information transmitted by space-based augmentation systems such as the United States Wide-area Augmentation System, the Russian System of Differential Correction and Monitoring and the European Geostationary Navigation Overlay Service. Each GNSS broadcasts a range of different signals on a number of frequencies that are used to advance applications that were pioneered using GPS and GLONASS.

10. In accordance with the recommendation of UNISPACE III on the use of global navigation and positioning systems and in support of the programme on GNSS applications, regional workshops on such applications were held in Zambia (A/AC.105/876) and China (A/AC.105/883) in 2006, in Colombia (A/AC.105/920) in 2008 and in Azerbaijan (A/AC.105/946) in 2009. These workshops addressed,

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[2] *Official Records of the General Assembly, Sixty-fourth Session, Supplement No. 20* (A/64/20), para. 82.

[3] *Current and Planned Global and Regional Navigation Satellite Systems and Satellite-based Augmentation Systems* (ST/SPACE/50).

inter alia, space technology applications such as remote sensing, precision agriculture, aviation, transport and communications, and e-learning.

11. Aiming to develop a uniform georeferencing system in Central and Eastern Europe, participants in the United Nations/Republic of Moldova/United States of America Workshop on Applications of Global Navigation Satellite Systems, held in Chisinau from 17 to 21 May 2010, discussed how GNSS-enabling technology could strengthen a network of national reference stations and promote the interoperability of navigation, positioning and timing systems in adjacent regions.

12. The objective of the Workshop was to increase the awareness of national and regional users of the growth of GNSS applications. The applications presented at the Workshop included navigation, surveying and mapping; scientific applications to combine GNSS with other sensors and systems; remote sensing; and space weather monitoring. The workshop was structured so as to provide participants with detailed examples of various GNSS applications and tools that could help to identify the specific needs of individual plans and projects on GNSS at the regional and international levels, taking into consideration the local institutional settings, including specific training and capacity-building needs. The specific objective was to address ways and means that would contribute to the wider use of GNSS technology and its applications, including the possibility of one or more national or regional pilot projects, or both, in which interested institutions could incorporate the use of GNSS technologies.

B. Programme

13. At the opening of the Workshop statements were made by the Director-General of the Agency for Land Relations and Cadastre, the President of the Academy of Sciences of the Republic of Moldova and the Mayor of Chisinau, as well as by representatives of the Office for Outer Space Affairs and the United States.

14. The Workshop consisted of a keynote presentation, seven plenary sessions and four discussion sessions, including working group sessions. The keynote presentation, entitled “The International Committee on Global Navigation Satellite Systems: a system of systems” was made by a representative of the Office for Outer Space Affairs. Presentations were given at five of the plenary sessions, on the following: GNSS in operation and development; GNSS reference station systems and services; GNSS applications; international and regional experiences with using and implementing GNSS technologies; and education and training on GNSS. Two other plenary sessions focused on the use of GNSS in scientific research, including the use of GPS signals for remote sensing of the environment and space weather studies. In total, 34 presentations were made during the plenary sessions.

15. At the four discussion sessions participants held deliberations on structured topics such as capacity-building and institutional strengthening, geodetic reference station networks (like the European Position Determination System (EUPOS) and the International Association of Geodesy Reference Frame Sub-Commission for Europe (EUREF)) and specific GNSS applications for the development of partnerships in the region and the initiation of pilot project proposals.

16. The Workshop was conducted in English and Russian, with the use of simultaneous interpretation.

C. Attendance

17. A total of 80 participants from the following 18 countries attended the Workshop: Armenia, Azerbaijan, Belarus, Croatia, Czech Republic, Georgia, Germany, Latvia, Lebanon, Norway, Republic of Moldova, Romania, Russian Federation, Saudi Arabia, Turkey, Ukraine, United States and Uzbekistan. The Office for Outer Space Affairs was also represented.

18. Funds provided by the United Nations, the Government of the Republic of Moldova and the Government of the United States through ICG were used to defray the costs of air travel and accommodation for 19 participants from developing countries and three representatives of the Office for Outer Space Affairs.

II. Summary of presentations

19. The sessions provided participants with the opportunity to learn how GNSS could be used in aviation, maritime and land transportation, mapping and surveying, environmental monitoring, precision agriculture and natural resources management, disaster warning and emergency response. Throughout the Workshop, national and regional success stories were demonstrated and potential applications were explained. The sessions stimulated discussion on how Central and Eastern European countries could find cost-effective means of achieving their sustainable development goals by strengthening satellite navigation technology and its applications.

20. Further information on the Workshop programme, background materials and presentations are available from the website of the Office for Outer Space Affairs (www.unoosa.org).

21. During the keynote address, the role of ICG as a forum for providers, industry and users to build the basis for compatible and interoperable operations for the benefit of end-users was highlighted. It was noted that the United Nations had assisted in establishing ICG information centres for training and disseminating information on global GNSS applications and the socio-economic benefits they can bring to humanity. The regional centres for space science and technology education, affiliated to the United Nations, are currently acting as ICG information centres.

22. The first presentation provided an overview of GPS and GLONASS constellations, their accuracy, universal availability and future developments, as well as of the ongoing interactions among service providers. Speakers also emphasized multilateral discussions in the framework of ICG in an effort to encourage interoperable and compatible GNSS across the globe.

23. With the increased use and applications of GNSS and requirements to relate GNSS solutions with the already existing mapping products based on local and national coordinate reference systems, the presentations on GNSS reference station systems and services demonstrated that there was an urgent need to establish and determine the transformation parameters from national coordinate reference systems

to GNSS reference systems. The EUPOS initiative, which is based on a network of differential GNSS (DGNSS) reference station systems, was outlined, along with some examples of DGNSS correction data for real-time positioning and navigation, as well as GNSS observation data for post-processing position determination. It was noted that those data could be used in the large variety of applications requiring accuracy of up to one centimetre in real time and one sub-centimetre in post-processing. Technical guidelines and standards developed by the EUPOS working group on site quality, integrity and interference monitoring were also discussed.

24. An overview of two GNSS services currently being developed by EUREF was given during one of the sessions. The first service, which aims to provide GNSS satellite clock and orbit corrections in real time, would allow better performance and improved accuracy for user applications, e.g. deriving other real-time products carrying ionosphere and troposphere information might support the space weather and meteorological community. The second service would provide re-processed results for the complete period since the EUREF permanent network was established in 1996; these long-term results would be of interest for climate-related research. The use of Radio Technical Commission for Maritime Services (RTCM) observation correction data in GNSS positioning services was demonstrated. It was emphasized that it was necessary to define transformation algorithms and data structures that would allow GNSS services to transmit respective RTCM transformation messages to GNSS service users, coupled with the software and communication architecture for the use of RTCM transformation messages in a GNSS service, which could be realized as a server-client concept.

25. The following session included six presentations on main features of the national GNSS reference systems, which were developed on the basis of the EUPOS standards. Some technical details were presented to show the data flow in the respective systems and the kinds of equipment that were used. In particular, participants were provided with an overview of the establishment of a network of continuously operating permanent geodetic reference stations on Moldovan territory and information on the development of geodetic transformation databases for real-time service. The development of the Romanian Position Determination System, which consists of geodetic and real-time kinematic services, was presented. It was noted that these services were realized for geodetic network modernization and precise positioning at the “centimetre-millimetre” level and at the real-time “centimetre-decimetre” level positioning. A test fragment of the Ukrainian GNSS-based positioning-timing navigation system was demonstrated. The participants were also shown examples of requirements that must be met to work with the maps supporting geodetic systems of coordinates in Uzbekistan and the realization of the project for a network of reference stations in Armenia. Overall, the presentation demonstrated the importance of building national reference station systems with a common standard in order for the systems to perform well and to enable data to be exchanged across borders.

26. Seven presentations over two sessions covered international and regional initiatives on GNSS implementation, with examples of the use of GNSS in various areas. One presentation was made on the use of GNSS augmentation for aviation to achieve a more precise signal in a particular region. Participants learned that the addition of compatible augmentation systems around the world and dual frequency GNSS could result in the equivalent satellite-based augmentation system service

being expanded to reach global coverage. The significance of the GPS measurements in the development of orthophoto maps and precise digital surface models was demonstrated. The need for a higher position accuracy compared to that provided by single digital orthophotos was emphasized for updating forest maps, whereas the integrated GPS/terrestrial laser system provided sufficiently accurate information and performed adequately in urban areas. A research programme for precision agriculture, ranging from vehicle guidance systems to product quality and environment management in Belarus was introduced, as were the activities of the geodetic observatory in Pecný, Czech Republic, which continuously provides time series of Earth's gravity, seismic, environmental (ground water level, soil moisture) and meteorological observations, and supports the national GNSS network in the Czech Republic.

27. Five presentations on GNSS education and training highlighted the available capacity-building opportunities supported by national and international institutions. In particular, the role of GNSS and geomatics within the training centre curricula of the University of Agronomical Sciences and Veterinary Medicine in Bucharest was introduced. Participants were also given an overview of the Russian Federation's training centres equipped with distance learning facilities for specialists in GNSS and in-depth courses on GNSS technology and its applications offered by Moscow State University. The Office for Outer Space Affairs contributed with a presentation on the regional centres for space science and technology education, affiliated to the United Nations, which would serve as ICG information centres to strengthen networks in the regions for the transfer and enhancement of skills and knowledge, and research on and development of GNSS applications. The regional centres are located in Morocco and Nigeria for Africa, in Brazil and Mexico for Latin America and the Caribbean, and in India for Asia and the Pacific.

28. Three presentations were made on the probable impacts of space weather on GNSS technology. Participants were informed about research on local patterns of geomagnetic and ionospheric conditions, and the sources of a GNSS error pattern that was carried out in Croatia. GPS data were used to measure total electron content variations during the earthquake that occurred in Uzbekistan in 2008. The work of the Office for Outer Space Affairs on monitoring solar-terrestrial interaction at the United Nations Office at Vienna was presented. In addition, an overview of currently operational instrument arrays was given, during which it was emphasized that the instrument arrays would be used in the International Space Weather Initiative from 2010 to 2012.

29. Five presentations were made during the final session. A description was given of how GNSS signals and augmentation sensors and systems could be used in remote sensing applications. In general, case studies carried out in Armenia, Azerbaijan, Lebanon and Turkey demonstrated that information on location is useful in a number of remote sensing applications, for example in disaster management, earth monitoring, environmental protection and natural resources management.

III. Conclusions and recommendations

30. Three discussion sessions were organized as part of the Workshop. During the first two of those sessions, participants had an opportunity to discuss issues and

concerns relating to the use and application of GNSS and to define a framework for a mechanism of regional cooperation. During the third session, participants were divided into three working groups according to their area of expertise and interest to discuss the following themes: capacity-building and institutional strengthening; geodetic reference networks; and specific GNSS applications. During the discussion sessions, the participants, in their working groups, defined activities that would contribute to increasing the use of GNSS technology in the region. Participants also discussed the format for a regional network that would enable the creation of partnerships. The results of the deliberations were summarized and presented at the closing session, when a final round-table discussion was held and the conclusions and recommendations were put forward.

31. The working group on capacity-building and institutional strengthening held discussions on GNSS education and training, as well as on the appropriate format for a regional network that would enable the creation of partnerships in the use of GNSS technology. The development of an educational curriculum on GNSS that could be used by the regional centres for space science and technology education, affiliated to the United Nations, was discussed. It was noted that such a curriculum would supplement the existing standard model educational curricula of the regional centres, developed through the United Nations Programme on Space Applications and comprising the following core disciplines: remote sensing and geographic information systems, satellite communications, satellite meteorology and global climate, and space and atmospheric science. Attention was also drawn to a curriculum on space law that was under development.

32. It was suggested that the development of GNSS modules should focus on assessing the short-term training courses on satellite navigation and location-based services, which were held at the training centres in India in 2008 (A/AC.105/922), in Mexico and Morocco in 2009 (A/AC.105/950) and in Nigeria in 2010 and their areas of interest. A subsequent step would be to incorporate available teaching materials, software and data. It was noted that the deployment of low-cost space weather monitors could complement data analysis and applications. Cooperation with industries should also be taken into consideration. It was agreed that the scope and extent of the optional tools and services could be explored in cooperation with the Office for Outer Space Affairs before a formal proposal was prepared.

33. The working group noted that many universities had a long tradition in both GNSS technology and its applications and in the development of materials designed to teach basic principles and concepts of communications and navigation. Such expertise and information should be made available to the regional centres for space science and technology education, affiliated to the United Nations. The importance of web-based distance learning programmes was also highlighted as being vital for a variety of user levels.

34. To begin work on developing a curriculum for a basic course on GNSS, it was recommended that a group of educators and experts on GNSS be established. In that regard, the Office for Outer Space Affairs was requested to collect information on relevant GNSS curricula taught in selected universities, to be used as background material. It was recommended that the group work by electronic means and by meeting around ICG activities during the course of 2010 with a view to concluding the first draft of an educational curriculum at the meeting of the ICG working group

on information dissemination and capacity-building to be held in conjunction with the fifth meeting of ICG in Turin, Italy, from 18 to 22 October 2010.

35. The working group on geodetic reference networks held discussions on ways and means of following up geodetic framework projects, based on continuous observation and analysis of GNSS data that could support many geospatial applications across the region.

36. Recognizing the present status of GNSS and the prospects for continued development of a wide variety of applications critical to science, commerce and infrastructure, the working group recommended that more workshops like the one they were attending in Chisinau continue to be held, in order to bring together core systems and geodetic infrastructure providers, end-users, academics and representatives of industry.

37. The working group agreed that GNSS training courses and workshops should be organized for countries in the region that were not currently operating permanent reference stations. In that respect, tutorials should be made available for better understanding concepts related to terrestrial reference systems and frames. Collaboration between States in the region and the reference station networks, such as EUPOS and EUREF, was encouraged. It was also noted that cooperation between ICG and regional reference systems, facilitated through the regional centres for space science and technology education, affiliated to the United Nations, could provide a major springboard for the transfer and enhancement of skills in and knowledge of surveying, geodesy and GNSS applications, taking into account the unique conditions present in each region and the need for tailored approaches.

38. The working group emphasized that links needed to be developed between EUPOS and EUREF and other ongoing projects and initiatives, such as the Africa Geodetic Reference Frame (AFREF), the Geocentric Reference System for the Americas (SIRGAS) and the Asia Pacific Reference Frame (APREF), and suggested that ICG could act as a facilitating body to strengthen cooperation among the regional geodetic reference frames. Participants welcomed the offer by the International EUPOS Steering Committee to take on a coordinating role and to organize a follow-up symposium on GNSS, space-based and ground-based augmentation systems and applications in Brussels in November 2010. It was also noted that the Office for Outer Space Affairs, as the Executive Secretariat of ICG, would cooperate with regional reference frames in the implementation of ICG projects at the regional level.

39. The working group on specific GNSS applications recognized that all actions should be coordinated at the national, regional and international levels. The working group identified five priority applications: disaster management (i.e. management of earthquakes, floods, oil spills), agriculture, transportation (by air, sea and land), map updates and the modelling of climate change.

40. 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 global information exchange network on GNSS applications among national and regional institutions.

41. With regard to the management of natural resources and natural disasters, and the protection of the environment, the participants agreed that the proposed regional network should aim to promote and disseminate information on the use of GNSS technology and facilitate management and decision-making. With regard to transportation, the overall objective should be to raise the awareness of decision makers and end-users about the benefits that GNSS could provide to all transportation modes.

42. The working group considered possible pilot projects and recommended that institutions that were part of the proposed regional network should recognize the work being done, especially the work that had already won local commitment. Those institutions should communicate primarily by e-mail, provide information to all interested institutions on activities carried out and foster partnerships among the different initiatives.

43. The working group agreed that the Office for Outer Space Affairs in cooperation with ICG or ICG by itself should be invited to assist in soliciting seed funding and expertise for potential projects related to disaster management and environmental protection. Participants agreed to propose projects that could be completed in a short period of time (one or two years) and involved cooperation between two or more countries, and to identify contact points for each country.

44. Participants recognized that the website of the Office for Outer Space Affairs was vital for disseminating information and recommended that the Office further develop its site, in particular the ICG information portal (www.icgsecretariat.org).

45. Participants also recognized the need for additional workshops and training courses that would build upon the results of the current Workshop.

46. Participants expressed their appreciation to the Agency for Land Relations and Cadastre of the Republic of Moldova for the hospitality, substance and organization of the workshop.

47. Participants also expressed their appreciation for the significant support provided by the United Nations, as well as by the Government of the Republic of Moldova and the Government of the United States.