

10 years of achievement of the  
United Nations on  
Global Navigation  
Satellite Systems






OFFICE FOR OUTER SPACE AFFAIRS  
UNITED NATIONS OFFICE AT VIENNA

Building a system of systems  
through the Action Team on  
Global Navigation Satellite Systems  
to the International Committee on  
Global Navigation Satellite Systems



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## Publication overview

This publication describes achievements of providers and users of positioning, navigation, and timing services, under the umbrella of the United Nations, in promoting Global Navigation Satellite Systems (GNSS) over the past 10 years.

In 2001, pursuant to the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE-III), the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) established the Action Team on GNSS under the leadership of the United States and Italy, and with the voluntary participation of 38 Member States and 15 organizations. The Action Team was one of 12 action teams established by COPUOS to implement priority recommendations of UNISPACE-III, as identified by Member States of the United Nations. The deliberations of the Action Team on GNSS led to the establishment of the International Committee on GNSS (ICG) under the umbrella of the United Nations. The resulting establishment of ICG recognizes that GNSS has become a truly international resource, and demonstrates the willingness of providers and users to ensure that GNSS services continue to be available in the future for the benefit of humankind. Furthermore ICG represents a milestone achievement in Member State cooperation in the use of outer space for peaceful purposes.

To support the work of ICG, the United Nations Office for Outer Space Affairs (UNOOSA) was designated as the Executive Secretariat of ICG. In that capacity UNOOSA, through its Programme on GNSS Applications, is organizing regional workshops, training courses and international meetings focusing on capacity-building in the use of GNSS-related technologies in various rapidly growing fields of science and industry, as well as deploying instruments for the International Space Weather Initiative (ISWI). UNOOSA is also leading the ICG's development of an in-depth GNSS education curriculum for inclusion in the training programmes at all United Nations-affiliated Regional Centres for Space Science and Technology Education, which also serve as ICG Information Centres. Annually all these activities bring together a large number of experts, including those from developing countries, to discuss and act on issues that are also of high relevance to ICG.

This publication is divided into three chapters and four annexes. Chapter I focuses on the work carried out in implementing the recommendation(s) of UNISPACE-III related to the use of global satellite-based positioning, navigation and timing systems. Chapter II focuses on the work of ICG and the Providers' Forum, and details their accomplishments. Chapter III provides information on activities carried out in the framework of the workplan of ICG. Annexes include the Terms of Reference of ICG and its Providers' Forum, the list of Member States of the United Nations and governmental and non-governmental organizations participating in ICG, as well as the list of documents and publications issued with regard to activities of ICG and UNOOSA's Programme on GNSS Applications.



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## 1999 Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE-III)

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In 1999, the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE-III) was convened at the threshold of the new millennium, which addressed significant opportunities for human development through advances in space science and technology. Facing unprecedented challenges to the goal of sustainable development, the States members that participated in UNISPACE-III decided to strengthen cooperation worldwide to help meet this challenges and to maximize opportunities for human development through the use of space science and technology and their applications.

UNISPACE-III adopted “The Space Millennium: Vienna Declaration on Space and Human Development<sup>1</sup>” that included key actions to use space applications for human security, development and welfare, advancing scientific knowledge of space and protecting the space environment, enhancing education and training opportunities and ensuring public awareness of the importance of space activities, and promoting international cooperation. Emerging from the framework of UNISPACE-III was the formation of action teams to deal with a number of selected recommendations that had been assigned highest priority by Member States.

In its resolution 54/68, the United Nations General Assembly endorsed “The Space Millennium: Vienna Declaration on Space and Human Development” adopted by UNISPACE-III. Specifically for enabling space technology providing positioning, navigation, and timing services, the Vienna Declaration called for action, inter alia, 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. In response to that call, in 2001, the Committee on the Peaceful Uses of Outer Space (COPUOS) established the Action Team on Global Navigation Satellite Systems (GNSS), under the chairmanship of the United States of America and Italy.

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<sup>1</sup> *Report of 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 (v), resolution 1.

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## 2001 Action Team on Global Navigation Satellite Systems

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The work of the Action Team on GNSS,<sup>2</sup> carried out between 2001 and 2004, included comprehensive reviews of existing and planned GNSS and augmentations, their utilization by system providers and user communities, as well as activities carried out by various entities to promote GNSS. The Action Team also examined the requirements of developing countries and gaps in meeting those requirements, as well as existing education and training opportunities in the field of GNSS.

To implement the recommendation of UNISPACE-III related to the use of GNSS and to support the work of the Action Team on GNSS, starting in 2001 UNOOSA organized four regional workshops<sup>3</sup> and three international meetings focusing on capacity-building in the use of GNSS in various areas of applications that support sustainable development. Such regional workshops were hosted by Malaysia (2001) for the benefit of countries in Asia and the Pacific, Austria (2001) for the benefit of countries in Europe, Chile (2002) for the benefit of countries in Latin America and the Caribbean, and Zambia (2002) for the benefit of countries in Africa. All international meetings (2002, 2003 and 2004) were held at the United Nations Office at Vienna, Austria.

Pursuant to the regional workshops and international meetings, the Action Team on GNSS, consisting of 38 member States and 15 inter-governmental and non-governmental organizations, recommended, inter alia, that an international committee on GNSS should be established to promote the use of GNSS infrastructure on a global basis and to facilitate exchange of information on existing and planned GNSS. COPUOS included this recommendation in the Plan of Action proposed in its report to the General Assembly<sup>4</sup> on the review of the implementation of the recommendations of UNISPACE-III. In 2004, in its resolution 59/2, the Assembly endorsed the Plan of Action. In the same resolution, the Assembly invited GNSS and augmentation system providers to consider establishing an international committee on GNSS in order to maximize the benefits of the use and applications of GNSS to support sustainable development.

At UNISPACE-III in 1999 and at the session of COPUOS in 2001, the issue of GNSS was one of the agenda items under consideration. In 2005, the issue was considered important enough to warrant the establishment of a separate body completely devoted to GNSS under the umbrella of the United Nations: the International Committee on Global Navigation Satellite Systems (ICG) for which UNOOSA acts as Executive Secretariat.

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<sup>2</sup> *Report of the Action Team on Global Navigation Satellite Systems (GNSS): Follow-up to the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)* (United Nations Publication, sales No. E.05.I.3).

<sup>3</sup> See A/AC.105/771; A/AC.105/776; A/AC.105/795; A/AC.105/785; A/AC.105/846.

<sup>4</sup> See A/59/174.



The neutral, negotiation-friendly nature of the United Nations provides the context necessary to enable Member States such as the United States, the Russian Federation, States members of the European Union, China, India and Japan, which have highly-developed GNSS technologies, to come together, and to work out ways and means to use multiple GNSS systems and hence to build a system of space-based navigation and positioning systems.

GNSS consists of constellations satellites that provide continuously optimized location and time information, transmitting a variety of signals on multiple frequencies available at all locations on planet Earth. The GNSS are the Global Positioning System (GPS) of the United States, the Global Navigation Satellite System (GLONASS) of the Russian Federation, Galileo of the European Union, and the Compass/BeiDou of China. India and Japan have developed regional GNSS capability by launching a number of satellites into space that augment the capabilities that are already supplied by the global systems to provide additional regional coverage. As providers of GNSS services, the six global and regional system providers have grouped together in a Providers' Forum, in order to conduct discussions of mutual interest focused on improving coordinated service provision to benefit humankind.

When GPS, GLONASS, GALILEO, and COMPASS will be fully operational and interoperable, four times more satellites may be available for navigation, positioning, and timing, providing more types of signals broadcasted on more frequencies. However, to achieve a true system of GNSS systems, a host of questions concerning compatibility and interoperability need to be addressed by system providers. Additionally, GNSS user community inputs regarding interoperability and the provision of improved capabilities should be considered.



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## 2005 Establishment of the International Committee on Global Navigation Satellite Systems (ICG)

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In 2005, ICG was established in an international meeting at the United Nations Office at Vienna as an informal, voluntary forum where governments and interested non-government entities can discuss all matters regarding GNSS on a worldwide basis. ICG promotes international cooperation on issues of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services.

One of the goals of ICG is to promote the greater use of GNSS capabilities to support sustainable development and to promote new partnerships among committee members and institutions, particularly taking into account interests of developing countries. In 2006, in its resolution 61/111, the United Nations 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 on the compatibility and interoperability of GNSS, while increasing their use to support sustainable development, particularly in developing countries.

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## 2007 Establishment of the Providers' Forum

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In deliberations within ICG, global and regional system providers agreed that at a minimum, all GNSS signals and services must be compatible. To the maximum extent possible, open signals and services should also be interoperable, in order to maximize benefits to all GNSS users. To achieve compatibility and interoperability, the Providers' Forum has reached consensus on the general definitions of these two principles:

The basic principle of system compatibility is “do no harm”. This refers to the ability of space-based positioning, navigation, and timing services to be used separately or together without interfering with each individual service or signal.

The basic principle of interoperability is “better together than separate”. This refers to the ability of open global and regional satellite navigation and timing services to be used together to provide better capabilities at the user level than would be achieved by relying solely on one service or signal.

The Providers' Forum is not a policymaking body, but provides ways and means of promoting communication among system providers on key technical issues and operational concepts such as protection of the GNSS spectrum and orbital debris/orbit de-confliction.

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## 2007 Annual meetings of ICG and the Providers' Forum

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In 2007, in accordance with paragraph 10 of the United Nations General Assembly resolution 63/90, the Scientific and Technical Subcommittee of COPUOS started consideration of an agenda item on “Recent developments in GNSS”. The Subcommittee reviews issues related to ICG, the latest developments in the field of GNSS and new GNSS applications. Pursuant to paragraph 16 of the United Nations General Assembly resolution 62/217, the Subcommittee also hears presentations made by the respective chairperson of ICG on recent and future activities of ICG. The deliberations of the Subcommittee at its sessions on the agenda item GNSS are reflected in its reports, issued as United Nations General Assembly documents.<sup>5</sup> Such an established procedure allows direct interaction by ICG with COPUOS and its subsidiary bodies.

ICG is holding annual meetings to review and discuss developments on GNSS. The annual meetings also address GNSS science and innovative technology applications and future commercial applications. Representatives from industry, academia, governments and providers, and users of GNSS services share views on GNSS compatibility and interoperability. Annual meetings are utilized by ICG membership, consisting of Members, Associate Members, and Observers, to amend the Terms of Reference (see annex I) and to review and modify as necessary the ICG workplan.

In compliance with the workplan of ICG, as adopted in the first meeting of ICG in 2006, ICG organizes its work through four working groups focusing on: Compatibility and Interoperability; Enhancement of Performance of GNSS Services; Information Dissemination and Capacity-Building; and Reference Frame, Timing and Applications.

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## 2006 First meeting<sup>6</sup> of the International Committee on Global Navigation Satellite Systems

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Held in 2006 in Vienna. The meeting was hosted by UNOOSA. ICG was considered to be a high-level committee, which has the potential to have a broad overview on current and future developments in the navigation and positioning industry and being a vital component of the industry as satellite positioning becomes more and more a genuine multinational cooperative venture. In this respect, various United Nations committees play a vital role in regulating radio and telephone communications, postal services or airlines. In fact, they make international commerce possible. ICG provides a forum where providers of space and ground-based radio navigation systems can work together to address their differences. ICG

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<sup>5</sup> See A/AC.105/933, Report of the Scientific and Technical Subcommittee on its forty-sixth session, 9-20 February 2009, Vienna, Austria.

<sup>6</sup> See A/AC.105/879.

also addresses the pursuit of freely available worldwide access to civil satellite navigation systems and the compatibility and interoperability of these systems. Another significant issue before ICG is the integration of these services into national infrastructures, particularly in developing countries. Importantly, participants at the meeting agreed to cooperate to the maximum possible level to maintain radio frequency compatibility in spectrum use between the various GNSS systems. This is in accordance with the radio regulations of the International Telecommunication Union (ITU), which is a specialized agency of the United Nations. ITU is responsible for information and communication technologies and coordinates the shared global use of the radio spectrum. In this meeting, ICG also noted a proposal to establish a Providers' Forum to enhance compatibility and interoperability among current and future global and regional satellite-based systems.

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## 2007 Second meeting<sup>7</sup> of the International Committee on Global Navigation Satellite Systems

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Held in Bangalore, India, in 2007, to further review and discuss GNSS and their applications within the framework of the ICG workplan. A major development at this meeting was the establishment of a Providers' Forum as a mechanism to continue discussions on important issues addressed by ICG that require focused inputs from system providers. Members of the Providers' Forum that convened at the meeting included China, the European Union, India, Japan, the Russian Federation, and the United States.

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## 2008 Third meeting<sup>8</sup> of the International Committee on Global Navigation Satellite Systems

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Held in Pasadena, California, United States, in 2008 and reflected a more cautious approach by most members as they began collectively translating general principles into workplans that could lay the foundation for technically and operationally aligned systems without undercutting separate and frequently divergent goals for individual GNSS systems. Nonetheless, the meeting did mark new advances in ICG's development. For the first time, the Providers' Forum adopted a Terms of Reference (see annex II) and a workplan. The ICG plenary also agreed that the United Nations affiliated Regional Centres for Space Science and Technology Education would act as Information Centres for ICG in the future. ICG further agreed to establish a Task Force on Geodetic References and a Task Force on Time References to consider improvements based on closer alignments of those key parameters.

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<sup>7</sup>See A/AC.105/901.

<sup>8</sup>See A/AC.105/928.

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## 2009 Fourth meeting<sup>9</sup> of the International Committee on Global Navigation Satellite Systems

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Held in Saint Petersburg, Russian Federation, in 2009, where the Committee continued reviewing and discussing developments in GNSS and allowed ICG Members, Associate Members and Observers to consider matters of common interest. ICG and the Providers' Forum discussed the revision of their workplans, and the working group on Compatibility and Interoperability specifically aligned its workplan to address the specific interests of the Providers' Forum, and to allow deliberation and analysis of user perspectives for consideration by providers. ICG also decided to support a proposal for a multi-GNSS demonstration campaign/project in the Asia/Oceania region.

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## 2010 Fifth meeting<sup>10</sup> of the International Committee on Global Navigation Satellite Systems

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Held in Turin, Italy, in 2010 and addressed GNSS technology in the era of multi-system receivers and the impact of GNSS interoperability on timing and other user applications. ICG noted the substantive progress made in furthering the workplans of ICG and the Providers' Forum that had been approved at previous meetings of ICG. The Committee also noted the achievements of the Providers' Forum, as reflected in the publication entitled Current and Planned Global and Regional Navigation Satellite Systems and Satellite-based Augmentation Systems.<sup>11</sup> The working group on compatibility and interoperability addressed spectrum protection and interference detection and mitigation. The working group on enhancement of the performance of GNSS services discussed aspects of user position integrity and made several recommendations on how to proceed on the issue of integrity for users in the aviation and non-aviation sectors, taking into consideration the potential benefits arising from the development of multiple GNSS systems. The working group on information dissemination and capacity-building continued to develop a programme on GNSS applications and reiterated the importance of deploying worldwide instruments for ISWI developing a GNSS education curriculum and applying GNSS in support of sustainable development. An important new development in the working group on reference frames, timing and applications was the agreement reached by system providers to liaise with relevant international bodies to ensure that receiver output formats for future GNSS signals would be unambiguously defined.

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<sup>9</sup> See A/AC.105/948.

<sup>10</sup> See A/AC.105/982.

<sup>11</sup> See ST/SPACE/50.

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## 2011 Sixth meeting<sup>12</sup> of the International Committee on Global Navigation Satellite Systems

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Held in Tokyo, Japan, in 2011 to continue reviewing and discussing developments in GNSS and addressed GNSS space technology applications to agriculture, fishery, information technology construction (precision positioning), geographic information system (GIS), disaster mitigation, intelligent transportation system and location-based services. ICG noted that interference detection and mitigation, and open service provision and performance monitoring by multi-GNSS networks were the major areas of focus of the working group on compatibility and interoperability. The working group on enhancement of the performance on GNSS services discussed among other aspects the disaster information dissemination. Satellite navigation systems may provide essential contributions but the service concept still needs further elaboration. Due to the importance of this issue of spectrum protection a new work item was introduced in the workplan of the group. In addition, good progress was shown in various areas including indoor positioning, signal authentication, precise positioning, transportation, maritime and space applications. The working group on information dissemination and capacity-building addressed further aspects of its workplan, including training for capacity-building in developing countries; promoting the use of GNSS technologies as tools for scientific applications; ISWI; and regional workshops on applications of GNSS. A new item on education and training programmes on GNSS was added to the workplan. The working group on reference frames, timing and applications completed development of templates describing the geodetic and timing references for the navigation satellite systems currently represented in ICG. The working group recommended that interested system providers supply data from their respective monitor stations for inclusion in regular processing with the International GNSS Service (IGS) network of reference stations. Such inclusion is aimed at improving the alignment of the various GNSS reference frames with each other and with the International Terrestrial Reference Frame (ITRF). An important new development was the endorsement by the ICG of IGS Multi-GNSS Experiment, which follows on from the ICG's previous endorsement of the Multi-GNSS campaign in Asia and Oceania.

ICG accepted the invitation of China to host its Seventh Meeting in Beijing, from 4 to 9 November 2012. ICG noted the expression of interest by the United Arab Emirates to host the Eighth Meeting of ICG in December, 2013.

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<sup>12</sup>See A/AC. 105/1000.

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## 2008 International Committee on Global Navigation Satellite Systems Experts Meetings

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In 2008, a one-day ICG Experts Meeting on GNSS and Services was held in Montreal, Canada, as part of the regular programme of the Committee on Space Research's (COSPAR) Scientific Assembly, for the first time introducing scope and work of ICG to the international community. The meeting focused on identifying the needs of users and equipment manufacturers with respect to the compatibility and interoperability of global systems, regional systems, and space-based augmentations, providing or planning to provide GNSS services. The meeting served as an outreach to the international community by conveying information about the objectives of ICG, the Providers' Forum, the on-going efforts of ICG working groups, and the benefits of interaction between GNSS providers and users. The sessions of the meeting focused on (a) ICG workplan and working group overviews; (b) Overview on GNSS; (c) Compatibility and interoperability at the user equipment level; and (d) A panel of providers and users/producers on the importance of compatibility and interoperability among satellite systems.

The success of the Montreal meeting and its programme format led the ICG Executive Secretariat to recommend that the activities continue to be pursued by the four working groups of ICG by incorporating this into their workplans. Similar meetings were held in Munich and Vienna, specifically by Working Group A of ICG. As a follow-up to these meetings, ICG developed a questionnaire, made available to the international GNSS community, to contribute to the global debate on the interoperability of GNSS. Worldwide input was requested from industry, academic institutions and other representatives of the GNSS user community who had technical expertise in interoperability issues. Currently ICG defines interoperability as the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system. Results from the questionnaire effort contributed to the fourth ICG meeting hosted by the Russian Federation in 2009.

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## 2009 Multi-GNSS Demonstration Campaign/Project

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At the fourth ICG meeting in 2009, ICG and the Providers' Forum supported a proposal for a multi-GNSS Demonstration Project in the Asia/Oceania region. The objective of this project is to encourage and promote the introduction and utilization of satellite positioning, navigation and timing services in the Asia and Oceania region, assisted by the integration of GNSS services through national infrastructures. The Asia and Oceania region is unique due to the fact that the number of usable modernized navigation satellites is expected to increase much faster than in areas of the world. The multi-GNSS demonstration campaign/project



will encourage GNSS signal and service providers and users in the Asia and Oceania region to develop new applications, and to carry out joint experiments or demonstrations. In 2010, the Asia Pacific Economic Cooperation GNSS Implementation Team endorsed this project initiative.



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## Office for Outer Space Affairs Acting as the Executive Secretariat of ICG and Providers' Forum

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UNOOSA implements recommendations of the United Nations General Assembly and COPUOS (and its subsidiary bodies). UNOOSA is responsible for promoting international cooperation in the peaceful uses of outer space, and assisting developing countries in utilizing space science and technology for socio-economic benefits. UNOOSA is the Secretariat of COPUOS and serves as the Executive Secretariat of ICG and the Providers' Forum. As such, the Executive Secretariat is responsible for preparation activities for the annual meetings of ICG in cooperation with the host country of the meeting. Additionally, the Executive Secretariat handles coordination for the informal meetings of ICG and the Providers' Forum in conjunction with sessions of COPUOS and its subsidiary bodies, and the implementation of a Programme on GNSS Applications as mandated by ICG and the Providers' Forum. The Executive Secretariat maintains a comprehensive information portal<sup>13</sup> for ICG and users of GNSS services. The Executive Secretariat, in cooperation with the international GNSS community, contributes to international and regional conferences to introduce the work of ICG with all its elements.

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## Regional workshops on the applications of GNSS

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Regional workshops on applications of GNSS were held in Zambia and China (2006), Colombia (2008), Azerbaijan (2009), Republic of Moldova (2010) and the United Arab Emirates (2011). These workshops addressed a wide array of GNSS applications for socio-economic benefits. These workshops addressed, inter alia, GNSS space technology applications to remote sensing, precision agriculture, aviation, transport and communications, and e-learning. The workshop objectives were focused on initiating pilot projects, and strengthening the networking of GNSS related institutions in the regions. The workshops also addressed the areas of natural resource management and environmental monitoring by applying GNSS technologies to thematic mapping, forest management, and water resources management.

All aspects of the agriculture industry, from basic rural cadastre and surveying to advanced precision agriculture, benefit from the use of GNSS. Agro-climatic and ecologic-economical zonings, crop inventory, monitoring and forecasting are examples of agricultural activities where positioning and timing are of paramount importance. In the area of climate change, different factors and mechanisms drive land use and transformation. In

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<sup>13</sup>See [www.icgsecretariat.org](http://www.icgsecretariat.org)

many cases, climate, technology and economics appear to be determinants of land use. At the same time, land conversion is an adaptive feedback mechanism that farmers use to smooth the impact of climate variability, especially during extremely wet or dry periods.

Satellites are an indispensable resource for monitoring and observing the Earth and its weather systems. They gather data for global climate models, and efforts continue in developing refined models that can be used in regional and national settings. The use of GNSS has been significant in making detailed observations of key meteorological parameters, whose measurement stability, consistency and accuracy could make it possible to quantify long-term climate change trends.

In the area of transport, studies have shown that civil aviation will significantly benefit from the use of GNSS. These benefits include: improved navigation coverage in areas currently lacking conventional tracking aids, accurate and reliable information about aircraft positions and routes that enables safe and efficient management of air traffic, (particularly on airport approaches). Road transport applications can automatically revise a route to account for traffic congestion, changes in weather conditions or road works. Similarly, at sea, GNSS technologies can provide efficient route planning, collision avoidance and increased efficiency in search and rescue situations. For rail transport, GNSS offers enhanced cargo monitoring and assists track surveying. In addition, communication systems, electrical power grids, and financial networks all rely on precision timing for synchronization and operational efficiency. For example, wireless telephone and data networks use GPS time to keep all of their base stations in perfect synchronization. This allows mobile handsets to share limited radio spectrum more efficiently.

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## International Space Weather Initiative

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Globally there is growing interest in better understanding solar-terrestrial interactions, particularly patterns and trends in space weather. This is not only for scientific reasons, but also because the reliable operation of ground-based and space-based assets and infrastructures is increasingly dependent on their robustness against the detrimental effects of space weather. Consequently, in 2009, COPUOS proposed ISWI as a new agenda item to be dealt with in the COPUOS' Scientific and Technical Subcommittee under a three-year workplan from 2010 to 2012.

ISWI contributes to the observation of space weather phenomena through the deployment of ground-based worldwide instrument arrays (GPS receivers, magnetometers, solar telescopes, very-low frequency (VLF) monitors, solar particle detectors) and the sharing of recorded data among researchers around the world. It is implemented by UNOOSA in the framework of its United Nations Basic Space Science Initiative (UNBSSI) and its series of annual workshops for UNBSSI. A first series of workshops dedicated to basic space science was held from 1991 to 2004 for Asia and

the Pacific, Latin America and the Caribbean, Africa, Western Asia, and Europe. From 2005 to 2009, the UNBSSI workshops were dedicated to the International Heliophysical Year 2007 that contributed to the deployment of instrument arrays. Currently, more than 1,000 instruments are operational in 97 countries as part of these instrument arrays.

Ionospheric modeling using GPS data is the focus of extensive efforts within the GPS provider and user communities. The range error caused by ionospheric delay in GPS signals is currently the largest component that affects the accuracy of positioning and navigation determination using single frequency GPS measurements. Ionospheric modeling is an effective approach for correcting the ionospheric range error and improving the GPS positioning accuracy. The abundance of GPS measurements from worldwide distributed GPS reference networks, which provide 24-hour uninterrupted operational services to record dual-frequency GPS measurements, provides an ideal data source for ionospheric modeling research. In the past decade, a large number of GPS reference networks have been deployed worldwide and the GPS network facilities provide ionospheric model researchers an excellent data source, allowing researchers to test, analyse and validate their ionospheric models with extensive GPS data sets. Many efforts of ionospheric model studies have been undertaken in developing innovative mathematical approaches, to produce better modeling performance and to generate near real-time ionospheric updates.

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## Reference frames and systems

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Development projects, applications, services or products requiring georeferencing, require a uniform coordinate reference system. Most countries have some form of national reference frame or system. These reference frames/systems are usually based on local origin or datum point, which restrict their use to a particular country. This makes cross-border mapping, development and planning projects difficult. This therefore calls for the establishment of a common and uniform continental reference coordinates frames/systems.

All regions (Africa, Latin America and the Caribbean, Western Asia, Europe, and Asia and the Pacific) are embracing the use and applications of GNSS technologies, particularly GPS, in geo-information applications, services, and products. GPS uses the World Geodetic System 1984 (WGS84) coordinates system. The WGS84 system is a modern, global and uniform coordinate system conveniently fitting the shape of planet Earth. The International Terrestrial Reference System (ITRS) is the global terrestrial reference system officially adopted by the International Association of Geodesy (IAG). The WGS84 reference system of GPS, which is widely used, is now identical to ITRS at the centimeter level. With the increased use and application of GNSS and the requirements to relate GPS solutions with already existing mapping products based on local and national coordinates reference systems, there is an urgent need

to establish and determine transformation data to and from such systems to GNSS reference systems. This will be achieved by full realization of the regional reference frames known as African Geodetic Frame (AFREF) for Africa, Geocentric Reference System for the Americas (SIRGAS) for Latin America and the Caribbean, Reference Frame Sub-Commission (EUREF) and the European Position Determination Systems (EUPOS) for Europe, and Asia-Pacific Reference Frame (APREF) for Asia and the Pacific. The Executive Secretariat of ICG is utilizing the aforementioned regional reference frames as the next to top level cooperation partners in the implementation of ICG projects at the regional level. This corresponds to the United Nations Economic and Social Commissions for Africa (ECA), Latin America and the Caribbean (ECLAC), Europe (ECE), Asia and the Pacific (ESCAP), and Western Asia (ESCWA). Accordingly, the ICG Executive Secretariat initiated cooperation between the ICG and the regional reference frames in 2008. Cooperation between the ICG and regional reference frames has vast potential for geodesy, mapping, surveying, geo-information, natural hazards mitigation, Earth sciences, etc. As one element of the Programme on GNSS Applications, this cooperation, also facilitated through the United Nations-affiliated Regional Centres for Space Science and Technology Education, may provide a major springboard for the transfer and enhancement of skills and knowledge in surveying, geodesy and GNSS with its applications.

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### Regional Centres for Space Science and Technology Education, Affiliated to the United Nations, and Information Centres of ICG

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Efforts to build capacity in space science and technology are considered a major focus of UNOOSA and are of specific interest to ICG with particular reference to GNSS. The regional centres for Africa are located in Morocco and Nigeria; for Asia and the Pacific in India; and for Latin America and the Caribbean in Brazil and Mexico.

Within the framework of the Working Group C of ICG, negotiations with the regional centres are on-going in order to utilize them as “hubs” for training and information dissemination on global applications of GNSS and their benefits for humanity. ICG Information Centres aim to foster a more structured approach to information exchange in order to fulfil the reciprocal expectations of a network between ICG and regional centres. By using the existing infrastructure of the regional centres, ICG (more specifically GNSS service providers) may save significant effort and financial resources by taking advantage of the operational regional centres for information dissemination. The regional centres can then expand their range of training programmes and services and thus open new opportunities to connect to other GNSS providers (or future providers).

The ICG Executive Secretariat and GNSS providers see two areas where they can assist the process of the development and progress towards

the further development of ICG Information Centres: the technical level, which will include various GNSS technologies, and the cooperative level with possible collaboration with industry leaders and linkages with current and planned system and augmentation system providers. Linkages would be facilitated through collaboration with the Providers' Forum (seminars/trainings and supportive material), as well as communication and outreach to the wider community through the ICG information portal, mailing lists, brochures and newsletter.

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### GNSS education curriculum

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The work of ICG, particularly in establishing the interoperability among global systems, will allow a GNSS user to utilize one instrument to receive signals from multiple satellite systems. This will provide additional data, particularly in urban and mountainous regions, and greater accuracy in timing and position measurements. To benefit from these achievements, GNSS users need to stay abreast of the latest developments in GNSS-related areas, and build the capacity to use the GNSS signal.

Within the framework of the workplan of ICG, UNOOSA organized international training courses on satellite navigation and location-based services at the United Nations affiliated regional centres located in India (2008), Mexico and Morocco (2009), and Nigeria (2010). These courses were part of the work of UNOOSA to develop a GNSS education curriculum for teaching GNSS applications as part of the proven standard model education curricula of the regional centres, developed through UNOOSA and comprising the following core disciplines of space science and technology: remote sensing and geographic information systems, satellite communications, satellite meteorology and global climate, and space and atmospheric sciences.

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### Long-term fellowship programme for in-depth training

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In 2004, the United Nations and the Government of Italy through the Politecnico di Torino and the Istituto Superiore Mario Boella and with the collaboration of the Istituto Elettrotecnico Nazionale Galileo Ferraris, initiated an offer of 12-month fellowship programme for postgraduate study on GNSS and related applications for specialists from developing countries. The Master in Navigation and Related Applications (MNA) programme provides an extensive background knowledge in navigation/localization systems as well as a detailed analysis on NAV/COM integration and environmental monitoring applications. The MNA programme curriculum had been structured to meet effectively work market demands for high-level technicians endowed with a broad vision of the navigation/localization state-of-the-art.

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## Concluding remarks

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Since UNISPACE-III in 1999, Member States have expressed a great interest in GNSS as an enabling space technology, which subsequently led to the establishment of ICG. Significant progress continues to be made through ICG, and the results of this work not only promote the capabilities of GNSS to support sustainable development, but also promote new partnerships among members of ICG and institutions of the broader user community, particularly in developing countries. As a member of ICG and serving as the ICG Executive Secretariat, UNOOSA will continue to further its contributions to these achievements in the future.



# Annex I.

## Terms of Reference of the International Committee on Global Navigation Satellite Systems

### A. Background

1. Global navigation satellite systems (GNSS) have evolved from an early period of limited programmes to a point where a number of systems and their augmentations are operating or planned. In the future, a number of international and national programmes will operate simultaneously and support a broad range of interdisciplinary and international activities. Discussions taking place at national, regional and international levels have underscored the value of GNSS for a variety of applications. The emergence of new GNSS and regional augmentations has focused attention on the need for the coordination of programme plans among current and future operators in order to enhance the utility of GNSS services.
2. The representatives of GNSS core system providers, GNSS augmentation providers and the international organizations primarily associated with the use of GNSS and representatives of international projects in developing countries,

*Aware of the overlap of GNSS mission objectives and of the interdisciplinary applications of GNSS services,*

*Recognizing the advantages of ongoing communication and cooperation among operators and users of GNSS and their augmentations,*

*Recognizing the need to protect the investment of the current user base of GNSS services through the continuation of existing services,*

*Aware that the complexity and cost of user equipment should be reduced whenever possible,*

*Convinced that GNSS providers should pursue greater compatibility and interoperability among all current and future systems in terms of spectrum, signal structures, time and geodetic reference standards to the maximum extent possible,*

*Desiring to promote the international growth and potential benefits of GNSS,*

*Noting that General Assembly resolution 59/2 (paragraph 11) invites GNSS and augmentation providers to consider establishing an international committee on GNSS in order to maximize the benefits of the use and applications of GNSS to support sustainable development,*

*Have agreed to establish on the basis of these non-binding terms of reference, the ICG for the purpose of promoting the use and application of GNSS on a global basis.*

## B. Objectives

3. The objectives of the ICG are to:

- (a) Benefit users of GNSS services through consultations among members of the ICG;
- (b) Encourage coordination among providers of GNSS core systems and augmentations in order to ensure greater compatibility and interoperability;
- (c) Encourage and promote the introduction and utilization of satellite positioning, navigation and timing services, particularly in the developing countries through assistance with the integration of GNSS services into their infrastructures;
- (d) Assist both the members of the ICG and the international user community by, *inter alia*, serving as the focal point for international information exchange related to GNSS activities, respecting the roles and functions of GNSS service providers and intergovernmental bodies such as the International Telecommunication Union (ITU), the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO);
- (e) Better address future user needs in the GNSS development plans and applications; and
- (f) Report periodically on its activities to the Committee on the Peaceful Uses of Outer Space.

These objectives will be accomplished by an indicative workplan of the ICG.

## C. Participants (Members, Associate Members and Observers)

4. The International Committee will be open to States Members of the United Nations, international organizations or international entities that are responsible for GNSS and their augmentations operating under governmental authority or involved in implementing or promoting GNSS services and applications. There will be three categories of participants in the Committee: Members, Associate Members and Observers.

### *Members*

Current and future core system providers, including China (Compass/BeiDou Navigation Satellite System (CNSS)), the European Union (European Satellite Navigation System (Galileo)), the Russian Federation (Global Navigation Satellite System (GLONASS)) and the United States of America (Global Positioning System (GPS));

States Members of the United Nations with an active programme in implementing or promoting a wide range of GNSS services and applications (Italy, Malaysia, United Arab Emirates);

Current and future space-based regional or augmentation system providers including, for example, the European Space Agency (European Geostationary Navigation Overlay Service (EGNOS)), India (GPS and Geostationary (GEO) Augmented Navigation System (GAGAN) and Indian Regional Navigation System (INRSS)), Japan (Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS) and Quasi-Zenith Satellite Space Based Augmentation System (QZSS)), Nigeria (Nigerian Communication Satellite Space Based Augmentation System (NigComsat-1 SBAS)), the Russian Federation (Wide-area System of Differential Corrections and Monitoring (SDCM) and the United States (Wide-area Augmentation System (WAAS));

### *Associate Members*

International and regional organizations and associations dealing with GNSS services and applications, including the Office for Outer Space Affairs of the United Nations Secretariat, the Civil GPS Service Interface Committee (CGSIC), the International Association of Geodesy (IAG), the International Association of Geodesy Reference Frame Sub-Commission for Europe (EUREF), the International Cartographic Association (ICA), the International GNSS Service (IGS, formerly International GPS Service), the International Society for Photogrammetry and Remote Sensing (ISPRS), the International Earth Rotation and Reference Systems Service (IERS), the Fédération internationale des géomètres (FIG), the European Position Determination System (EUPOS) and the Fédération Aéronautique Internationale (FAI);

### *Observers*

The Committee on Space Research (COSPAR), the Bureau international des poids et mesures (BIPM), the International Association of Institutes of Navigation (IAIN), the Union radio-scientifique internationale (URSI), the International Telecommunication Union (ITU) and the Interagency Operations Advisory Group (IOAG).

5. The ICG will make decisions by consensus of the Members. Associate Members and Observers will provide advice, monitor the work of the ICG participate in working groups established in accordance with paragraph 8 below, participate in activities identified in the workplan of the ICG and report back to their own organizations. Members and Associate Members may host meetings of the ICG and chair and participate in working groups and host or provide support to the executive secretariat that supports the ICG. The admission of new Members, Associate Members and Observers will be with the consensus of the Members of the ICG.

## **D. Procedures of work, structure and organization**

6. The structure of the ICG consists of a chairperson, a plenary session of the Committee, an executive secretariat and working groups. The chair will rotate on an annual basis among the Members and Associate Members.

7. The ICG will convene at least once every year in plenary session. Meetings of the ICG will be organized by the designated host. Each Member, Associate Member and Observer should designate its principal and its point of contact. Any change to the principals and/or points of contact should be communicated to the chairperson of the ICG through the executive secretariat. Interim planning meetings may be required and can be organized as needed by the executive secretariat.
8. The ICG may establish, as mutually agreed and on an ad hoc basis, working groups to investigate specific areas of interest, cooperation and coordination and to report at subsequent plenary sessions. The chairpersons of such groups shall report at each plenary session on accomplishments and future plans. Continuation of each working group requires confirmation at each plenary session by the Members.
9. All recommendations of the ICG or its working groups will be decided on the basis of consensus of its Members, do not create legal obligations, and will be acted upon at the discretion of each Member; Associate Member and Observer. Recommendations should not be disseminated outside the ICG or its participants until careful deliberations have been conducted in plenary, and full consensus is reached.
10. The ICG may revise these terms of reference on the basis of proposals made by Members or Associate Members and adopted by consensus of the Members.
11. The ICG may revise the workplan on the basis of proposals made by Members, Associate Members and Observers and adopted by consensus of the Members.
12. Members, Associate Members and Observers will fund their own participation in the activities of the ICG, including the working groups. Requirements for financial support to the executive secretariat (in-kind or direct funding) will be determined by the Members and Associate Members of the ICG

# Annex II.

## Terms of Reference of Providers' Forum

### A. Background

International Committee on Global Navigation Satellite Systems (ICG) was established on a voluntary basis as an informal body to promote cooperation, 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 global navigation satellite systems, while increasing their use to support sustainable development, particularly in developing countries.

In response to a recommended action in the ICG workplan, providers of global and regional navigation satellite systems and satellite-based augmentation systems proposed establishing a Providers' Forum to enhance compatibility and interoperability among current and future systems. The first Providers' Forum meeting, co-chaired by the United States of America and India, was held on September 2007, immediately preceding the second meeting of the ICG. China, India, Japan, the Russian Federation and the United States, as well as the European Union, were present at the meeting.

### B. Objectives

3. The objectives of the Providers' Forum are to:
  - (a) Promote compatibility and interoperability among current and future global and regional space-based systems by exchanging detailed information about planned or operating systems and the policies and procedures that govern their service provision, consistent with the template for information sharing among providers that was circulated prior to the first meeting;
  - (b) Act as a mechanism to continue discussions on important issues addressed by the ICG that require focused inputs from system providers.
4. Providers' Forum is not a policymaking body, but provides a means to promote discussion among system providers based on agreed guidelines for provision of open services, including transparency, cooperation, performance monitoring and spectrum protection; and agreed principles for ensuring compatibility and interoperability among systems.

### C. Membership

5. The Providers' Forum will be open to States Members of the United Nations that are or will be global navigation satellite systems (GNSS) providers.

Current members and their respective systems are as follows:

- (a) *China*: Compass/BeiDou Navigation Satellite System (CNSS);
  - (b) *India*: Global Positioning System and Geostationary (GEO) Augmented Navigation System (GAGAN) and Indian Regional Navigation Satellite System (IRNSS);
  - (c) *Japan*: Quasi-Zenith Satellite System (QZSS) and Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS);
  - (d) *Russian Federation*: Global Navigation Satellite System (GLONASS) and Wide-area System of Differential Corrections and Monitoring (SDCM);
  - (e) *United States*: Global Positioning System (GPS) and Wide-area Augmentation System (WAAS);
  - (f) *European Union*: European Satellite Navigation System (Galileo) and European Geostationary Navigation Overlay Service (EGNOS).
6. Additional Member States who become GNSS service providers will be invited to join the Providers' Forum upon consensus of the current members.

#### D. Procedures of work, structure and organization

7. During each meeting, the members will select, on the basis of consensus, a chair for the next meeting. The Office for Outer Space Affairs of the United Nations Secretariat, consistent with its role as the Executive Secretariat of ICG, will also fulfill these responsibilities for the Providers' Forum, in support of the chair:
8. The Providers' Forum will convene once every year in conjunction with the ICG annual meeting and more often if needed. Actions and recommendations developed by working groups of ICG that could impact the compatibility and interoperability, system development and operations, and/or service provision policies and procedures of providers of GNSS will be of particular interest to the Providers' Forum. Therefore, the results of Providers' Forum deliberations and consensus decisions on these and other issues will be reported to ICG as appropriate and when possible, at the next scheduled plenary session of ICG immediately following a Providers' Forum meeting.
9. The meetings of the Providers' Forum will be organized by the chair and designated host, with support from the Executive Secretariat. Each member should designate its principal and additional points of contact.
10. Any recommendations resulting from Providers' Forum meetings will be decided on the basis of consensus of its members.
11. Members will fund their own participation in the activities of the Providers' Forum. Financial support (in-kind or direct funding) to the Executive Secretariat that is above and beyond the annual budget of the Office for Outer Space Affairs or existing funds provided for ICG secretariat services will be provided by members on a voluntary basis.
12. The Providers' Forum may revise these terms of reference on the basis of proposals made by members and adopted by consensus.

## Annex III.

### List of States Members of the United Nations and governmental and non-governmental organizations participating in the International Committee on Global Navigation Satellite Systems

China  
India  
Italy  
Japan  
Malaysia  
Nigeria  
Russian Federation  
United Arab Emirates  
United States of America  
European Union  
Civil Global Positioning System Service Interface Committee (CGSIC)  
Committee on Space Research (COSPAR)  
European Space Agency (ESA)  
Fédération Aéronautique Internationale (FAI)  
Interagency Operations Advisory Group (IOAG)  
International Association of Geodesy (IAG)  
International Association of Geodesy Reference Frame Sub-Commission for Europe (EUREF)  
International Association of Institutes of Navigation (IAIN)  
International Bureau of Weights and Measures (BIPM)  
International Cartographic Association (ICA)  
International Earth Rotation and Reference Systems Service (IERS)  
International Federation of Surveyors (FIG)  
International Global Navigation Satellite System Service (IGS)  
International Society for Photogrammetry and Remote Sensing (ISPRS)  
International Steering Committee of the European Position Determination System (EUPOS)  
International Telecommunication Union (ITU)  
International Union of Radio Science (URSI)  
United Nations Office for Outer Space Affairs (UNOOSA)





## Annex IV.

### List of documents and publications

1. Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19–30 July 1999, United Nations Document A/CONF.184/6, United Nations, New York, 1999
2. First United Nations/United States of America Workshop on the Use of Global Navigation Satellite Systems, Kuala Lumpur, Malaysia, 20–24 August 2001, United Nations Document A/AC.105/771, 2001
3. Second United Nations/United States of America Workshop on the Use of Global Navigation Satellites Systems, Vienna, Austria, 26-30 November 2001, United Nations Document, A/AC.105/776, 2001
4. Third United Nations/United States of America Workshop on the Use of Global Navigation Satellite Systems, Santiago, Chile, 1–5 April 2002, United Nations Document A/AC.105/795, 2002
5. Fourth United Nations/United States of America Workshop on the Use of Global Navigation Satellite Systems, Lusaka, Zambia, 15–19 July 2002, United Nations Document A/AC.105/785, 2002
6. Report on the United Nations/United States of America International Meeting on the Use and Applications of Global Navigation Satellite Systems, Vienna, 13–17 December 2004, United Nations Document A/AC.105/846, 2005
7. Report of the Action Team on Global Navigation Satellite Systems (GNSS), follow-up to the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE-III), United Nations Document, ST/SPACE/24, New York, 2004
8. International committee on global navigation satellite systems, Space Policy 23 (2007), 245–247, United Nations Document, A/AC.105/879, 2006
9. United Nations/Zambia/European Space Agency Regional Workshop on the Application of Global Navigation Satellite Systems Technologies for Sub-Saharan Africa, Lusaka, Zambia, 26-30 June 2006, United Nations Document, A/AC.105/883, 2006
10. United Nations/China/European Space Agency Training Course on the Use and Applications of Global Navigation Satellite Systems, Beijing, China, 4-8 December 2006, United Nations Document, A/AC.105/876, 2006

11. United Nations/Colombia/United States of America Workshop on the Applications of Global Navigation Satellite Systems, Medellin, Colombia, 23-27 June 2008, United Nations Document, A/AC.105/920, 2008
12. International Committee on Global Navigation Satellite Systems (ICG) Providers' Forum: First meeting, Space Policy 24 (2008), 53–55, United Nations Document, A/AC.105/901, 2007
13. The International Committee on Global Navigation Satellite Systems: Building a System of Systems for a Global World, High Frontier, 2008, 22–24
14. United Nations/Azerbaijan/United States of America/European Space Agency Workshop on the Applications of Global Navigation Satellite Systems, Baku, Azerbaijan, 11-15 May 2009, United Nations Document, A/AC.105/946, 2009
15. Third Meeting of the International Committee on Global Navigation Satellite Systems (ICG): Joint statement, Space Policy 25 (2009), 141–143, United Nations Document, A/AC.105/928, 2008
16. Regional Centres for Space Science and Technology Education and ICG Information Centres affiliated to the United Nations, Advances in Space Research 43 (2009), 1863–1865
17. United Nations/Moldova/United States of America Workshop on the Applications of Global Navigation Satellite Systems, Chisinau, Moldova, 17-21 May 2010, United Nations Document, A/AC.105/974, 2010
18. Fourth Meeting of the ICG: Joint Statement, Space Policy 26 (2010), 73, United Nations Document, A/AC.105/948, 2009
19. The International Committee on Global Navigation Satellite Systems: A system of systems, ICES Yearbook and directory of members 2010, 49-56
20. Progress in basic space science education and research: The UNBSSI, Space Policy 26 (2010), 61–63
21. Current and Planned Global and Regional Navigation Satellite Systems and Satellite-based Augmentation Systems, United Nations Document, ST/SPACE/ 50, New York, 2010
22. Fifth Meeting of the International Committee on Global Navigation Satellite Systems, Turin, Italy, 18–22 October 2010, United Nations Document, A/AC.105/982, 2010
23. United Nations/United Arab Emirates/United States of America Workshop on the Applications of Global Navigation Satellite Systems, Dubai, United Arab Emirates, 16-20 January 2011, United Nations Document, A/AC.105/988, 2011
24. United Nations/National Aeronautics and Space Administration/Japan Aerospace Exploration Agency Workshop on the International Space Weather Initiative, Cairo, Egypt, 6-10 November 2010, United Nations Document, A/AC.105/994
25. Sixth Meeting of the International Committee on Global Navigation Satellite Systems, Tokyo, Japan, 5-9 September 2011, United Nations Document, A/AC.105/1000, 2011



■ The United Nations Office for Outer Space Affairs (OOSA) is responsible for promoting international cooperation in the peaceful uses of outer space and assisting developing countries in using space science and technology.



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