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International Regulation of Global Navigation Satellite Systems

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INTERNATIONAL REGULATION OF GLOBAL NAVIGATION SATELLITE SYSTEMS

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I. INTRODUCTION

WE HAVE A PROBLEM. However, it is a good problem because the Global Navigation Satellite System (GNSS) is fertile, growing, and becoming ever more indispensable. But it is a problem because GNSS underlies our national securities, and we do not have an impregnable way to keep the process safe. Treaty law is the traditional strong law that assures that an international system will hold; but it seems unlikely that there can be ever a GNSS treaty. This article looks at how the GNSS works today, through a network of "soft" law. The article also explores future possibilities that might develop into something as secure as a treaty.

A. THE NEW GNSS WORLD

GNSS is one of the great technological developments of our times. People used to think of GNSS as a military system used mostly for aviation and for guided missiles.[1] That is no longer the case. While military authorities continue to maintain significant control of GNSS, only 16% of GNSS is used is by the military.[2] Civilian users now comprise 86% of GNSS use.[3] There is

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[1] *See GNSS in Military Affairs (And Vice Versa)*, INSIDE GNSS (May/June 2014), http://www.insidegnss.com/node/4018.

[2] *See* NDP Consulting Grp., *PNT Advisory Board Seeks Details on Economic Benefits of GPS*, INSIDE GNSS (Aug. 20, 2012), http://www.insidegnss.com/node/3170.html.

[3] *See id.* Military uses were the original and still significant policy reason for the existence of GNSS. *See GNSS in Military Affairs*, *supra* note 1. Compared with civilian uses, the military uses are small. *See* NDP Consulting Grp., *supra* note 2. Nev-

some national law.[4] There is little international law specifically regulating GNSS. The problem thus raised is how to develop an international legal structure that can accommodate the burgeoning GNSS. The soft law governance of the Internet may be a relevant analogy for GNSS.

This article will focus on recent developments in international regulation of GNSS. It will describe formal and informal efforts, in particular United Nations (UN) efforts, to coordinate the multiple GNSS services so that they do not interfere with each other. Interoperability is necessary so that the GNSS users can have access to any of the GNSS services at any time. This article will also discuss alternatives, including the Internet analogy and what can be applied from that experience.

B. THE GNSS SERVICES

1. The U.S. Global Positioning Service

The U.S. Global Positioning Service (GPS) is the most widely used GNSS in the world.[5] It is operated by the U.S. Department of Defense.[6] GPS is built into almost all GNSS receivers now in

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ertheless, GNSS is controlled by military authorities in the United States, Russia, and China. *See* Iain Ross Ballantyne Bolton, *Neo-Realism and the Galileo and GPS Negotiations, in* SECURING OUTER SPACE 191–92 (Natalie Bormann & Michael Sheehan eds. 2009). GNSS forms an essential part of military policy and military strategy; it is used to guide missiles accurately to targets. *See* CONGRESS OF THE U.S., CONGRESSIONAL BUDGET OFFICE, THE GLOBAL POSITIONING SYSTEM FOR MILITARY USERS: CURRENT MODERNIZATION PLANS AND ALTERNATIVES 1 (2011), *available at* http://www.cbo.gov/sites/default/files/10-28-GPS.pdf [hereinafter GLOBAL POSITIONING SYSTEM FOR MILITARY USERS]. GNSS is used by the military to guide soldiers on the ground, ships on the seas, and warplanes in the sky. *See id.* Military GNSS is more accurate than civilian GNSS; therefore, it is even more valuable. *See* Bolton, *supra* note 3, at 191. Its military importance is evidenced in national monetary support for national GNSS. *See Fiscal Year 2015 Program Funding*, GPS.GOV, http://www.gps.gov/policy/funding/2015/ (last updated Jan. 13, 2015). For example, the U.S. Congress continues to fund military GPS technology development and operation adequately, but this generosity does not extend to funding of civilian GPS. *See* Dee Ann Divis, *Congress Slashes Civil GPS Funding*, INSIDE GNSS (June 28, 2013), http://www.insidegnss.com/node/3615; *see also id.*

[4] *See* Paul B. Larsen, *Regulation of Global Navigation and Positioning Services in the United States, in* NAT'L REGULATION OF SPACE ACTIVITIES 459, 462 (Ram S. Jahku ed. 2010) [hereinafter Larsen, *Regulation of Global Navigation*].

[5] *What is GPS?*, EGNOS (Feb. 16, 2015), http://egnos-portal.gsa.europa.edu/diiscover-egnos/about-egnos/what-gps.

[6] *See* GPS.GOV, http://www.gps.gov (last updated Feb. 6, 2015); *see also* 10 U.S.C. § 2281 (2013).

operation.[7] Users are accustomed to the reliability and availability of GPS.[8] Its service continues to be updated and improved.[9] GPS provides both a standard positioning service open to all users and a precise positioning service open to U.S. military, government agencies, and allied governments.[10] U.S. policy assures continuous availability of global GPS service, interoperability and compatibility with international GNSS services, no civil user fees, and free access to GPS.[11] U.S. GPS operation is coordinated by a national committee chaired jointly by the Secretaries of Defense and Transportation.[12] International coordination and interoperability of GPS takes place in the United Nations International Committee on GNSS (ICG) and its related subgroups and in bilateral negotiations with the European Union (EU), Australia, Russia, China, India, and Japan.[13] The United States cooperates actively.[14]

GPS accuracy is improved in the United States by the Wide Area Augmentation Service (WAAS).[15] The EU's European Geostationary Navigation Overlay Service (EGNOS) augmentation service improves GPS accuracy in Europe.[16] The Japanese Multifunctional Transport Satellite-based Augmentation System (MTSAT or MSAS) augments GPS accuracy in the Asian and Pacific

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[7] *See* Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), July 19–30, 1999, *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, 55 U.N. Doc. ST/SPACE/24 (2004), *available at* http://www.unoosa.org/pdf/publications/st_space_24E.pdf [hereinafter UNISPACE III, *Report of the Action Team*]; *see also GPS Applications*, GPS.GOV, http://www.gps.gov/applications/ (last updated Nov. 25, 2014).

[8] *See* Carolyn Rice, *GPS: From Launch to Everyday Life*, BBC NEWS (Feb. 14, 2014), http://www.bbc.com/news/technology-26153506.

[9] *See* 10 U.S.C. § 2281(b)(1)–(4), (c).

[10] *See id.* § 2281(a), (b); TRIMBLE NAVIGATION LTD., GPS. THE FIRST NAVIGATION SATELLITE SYSTEM 15 (2007), *available at* http://www.saveourgps.org/pdf/GPS-The-First-Global-Satellite-Navigation-System-by-Trimble.pdf.

[11] EXEC. OFFICE OF THE PRESIDENT, NAT'L SPACE POLICY OF THE U.S. 5 (June 28, 2010), https://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf [hereinafter 2010 NAT'L SPACE POLICY].

[12] *See* 10 U.S.C. § 2281(c); DEP'T OF DEF. ET AL., DOT-VNTSC-OST-R-15-01, FED. RADIONAVIGATION PLAN (2014).

[13] *See International Cooperation*, GPS.GOV, http://www.gps.gov/policy/cooperation/ (last updated May 27, 2014).

[14] *See id.*

[15] *See Satellite Navigation—WAAS—How It Works*, FAA, http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/howitworks/ (last updated Feb. 4, 2015).

[16] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 42.

Ocean regions.[17] India's GPS-aided Geo-Augmented Navigation System (GAGAN) augments GPS accuracy in the Indian region.[18]

2. *Russia's GLONASS*

Russia's GLONASS was established in 1976 but declined during the economic difficulties of the 1990s.[19] Like GPS, it is now available all around the globe, and it is fully reconstituted and operational.[20] There are several kinds of GLONASS services.[21] The basic service is free and open to all users.[22] The restricted military signal is much more sophisticated.[23] GLONASS coordinates actively with other GNSS providers and users within the ICG and on a bilateral basis.[24] GLONASS created a global System of Differential Correction and Monitoring (SDCM) intended to establish integrity data and local correction data in order to increase accuracy.[25] GNSS users can now access both GPS and GLONASS globally.[26]

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[17] *See id.* at 42, 46; *see also International Cooperation*, *supra* note 13.

[18] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 42.

[19] *See* Paul B. Larsen, *Issues Relating to Civilian and Military Dual Uses of GNSS*, 17 SPACE POL'Y 111,112 (2001) [hereinafter Larsen, *Issues Relating to Civilian*]; *About GLONASS*, INSIDE GNSS, http://www.insidegnss.com/aboutglonass (last visited Mar. 21, 2015).

[20] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 63.

[21] *See* FRANCIS LYALL & PAUL B. LARSEN, SPACE LAW: A TREATISE 394 (2009).

[22] *Frequently Asked Questions*, FED. SPACE AGENCY INFORMATION-ANALYTICAL CENTRE, http://glonass-iac.ru/en/guide/potrfaq.php (last visited Aug. 18, 2015).

[23] *See Russian Global Positioning Satellites: GLONASS GPS*, SPACE TODAY ONLINE, http://www.spacetoday.org/Satellites/GLONASS.html (last visited Aug. 12, 2015).

[24] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 49; *see also International Cooperation*, *supra* note 13.

[25] *See* Glen Gibbons, *Russia Building Out GLONASS Monitoring Network, Augmentation System*, INSIDE GNSS (Aug. 19, 2009), http://www.insidegnss.com/node/1631. It is this system that has provoked relatively recent adverse U.S. legislative reaction. *See* Eric Schmitt & Michael Schmidt, *New Law All But Bars Russian GPS Sites in the U.S.*, N.Y. TIMES (Dec. 28, 2013), http://www.nytimes.com /2013/12/29/world/europe/new-law-all-but-bars-russian-gps-sites-in-us.html?_r=0. See further discussion of this issue in *infra* section IIII.

[26] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 67.

3. *The European Union's Galileo*

The EU's Galileo is not yet available for global service.[27] It is owned by the EU and delegated to the European Space Agency (ESA).[28] The GNSS augmentation system, EGNOS, is also financed by the EU.[29] The EU has established the European GNSS Agency (GSA) to promote the Galileo system, including marketing.[30] Galileo will offer four different services: (1) an open service that is free; (2) a publicly regulated service that is of high quality and encrypted; (3) a commercial service that is highly accurate; and (4) a search and rescue service.[31]

Galileo is expected to provide initial services in 2016.[32] Global completion with 24 satellites plus spares is currently planned for 2020.[33] Galileo will charge for the commercial higher-grade service.[34] The European EGNOS augmentation system is being integrated into Galileo.[35] Galileo is coordinated with other GNSS providers and users in the ICG and bilaterally with other providers in order to provide seamless global services.[36]

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[27] *See* European Space Agency, *Galileo and EGNOS*, ESA NAVIGATION, http://www.esa.int/our_activities/navigation/Galileo_and_EGNOS (last updated Aug. 22, 2014).

[28] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 64.

[29] *See id.* at 130.

[30] *See About GSA: The European GNSS Agency: Linking Space to User Needs*, EUROPEAN GLOBAL NAVIGATION SATELLITE SYS. AGENCY, http://www.gsa.europa.eu/gsa/about-gsa (last visited Feb. 18, 2015).

[31] GNSS Market Report: Issue 3, European Global Navigation Satellite Sys. Agency, at 10 (Oct. 2013), *available at* http://www.gsa.europa.eu/system/files/reports/GSA%20-Market%20Report%202013%20new_1.pdf.

[32] *See* European Space Agency, *What Is Galileo?*, GALILEO NAVIGATION, http://www.esa.int/our_activities/navigation/The_future_-_galileo/what_is_galileo (last updated Aug. 20, 2015) [hereinafter ESA, *What Is Galileo?*].

[33] *See* European Space Agency, *Next Steps*, GALILEO NAVIGATION, http://www.esa.int/our_activities/navigation/The_future_-_galileo/Next_steps (last updated June. 27, 2014) [hereinafter ESA, *Next Steps*].

[34] Press Release, European Comm'n, FAQ – Galileo, the EU's Satellite Navigation Programme from European Commission 2 (Aug. 20, 2014), *available at* http://europa.eu/rapid/press-release_MEMO-14-509_en.htm.

[35] *What is Egnos?*, EUROPEAN GLOBAL NAVIGATION SATELLITE SYS. AGENCY, http://www.gsa.europa.eu/egnos/what-egnos (last visited July 18, 2015).

[36] *See International Cooperation*, EUROPEAN GLOBAL NAVIGATION SATELLITE SYS. AGENCY, http://www.gsa.europa.eu/galileo/international-co-operation (last visited July 18, 2015); UN Office for Outer Space Affairs [UNOOSA], *International Committee on Global Navigation Satellite Systems*, UNOOSA.ORG, http://www.unoosa.org/oosa/en/SAP/gnss/icg.html (last visited July 18, 2015) [hereinafter UNOOSA, *ICG*]; UNOOSA, *ICG Members, Associate Members and Observers*, UNOOSA.ORG, http://www.unoosa.org/oosa/en/SAP/gnss/icg/members/index.html (last visited July 18, 2015) [hereinafter UNOOSA, *ICG Members*].

4. China's BeiDou

China's BeiDou is the Chinese GNSS.[37] It is not yet available globally, but it is currently operational in the region of China and adjoining countries.[38] It is expected to get a full complement of satellites and become globally available as early as 2017.[39] BeiDou has published information about how it will interphase with other GNSS services (interoperability), and GNSS receivers are now being built for link-up with the BeiDou system.[40] It is designed to be compatible with the International Civil Aviation Organization's (ICAO) international air navigation and the International Maritime Organization's (IMO) maritime navigation standards.[41] BeiDou's basic service will also be free of charge.[42] China and BeiDou actively participate in the ICG and in bilateral negotiations.[43]

5. Japan's Multi-Functional Transport Satellite-Based Augmentation System

Japan's Multi-Functional Transport Satellite-Based Augmentation System (MSAS) augments GPS service and will also aug-

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[37] *See* BeiDou Navigation Satellite Sys., *System Introduction: Survey*, BEIDOU .GOV.CN, http://www.beidou.gov.cn/2012/12/14/201212142e8f29c30e0d464c9b34d6828706f81a.html (last visited July 18, 2015) [hereinafter BeiDou, *Survey*].

[38] *See* BeiDou Navigation Satellite Sys., *System Introduction: Development Plan*, BEIDOU.GOV.CN, http://www.beidou.gov.cn/2012/12/14/2012121481ba700d7ca84dfc9ab2ab9ff33d2772.html (last visited July 18, 2015) [hereinafter BeiDou, *Development Plan*].

[39] *See id.*; Glen Gibbons, *China Plans to Complete BeiDou Ahead of Schedule*, INSIDE GNSS (May 21, 2014), http://www.insidegnss.com/node/4040.

[40] *See* CHINA SATELLITE NAVIGATION OFFICE, REPORT ON THE DEVELOPMENT OF BEIDOU NAVIGATION SATELLITE SYSTEM (VERSION 2.0), 9, 12–14 (May 2012), *available at* http://www.beidou.gov.cn/attach/2012/10/27/201210274790650a6f2c466683c88c13f57e9eff.pdf.

[41] *See* BeiDou Navigation Satellite Sys., *The BeiDou System to be Incorporated into ICAO Standard Framework Advances Steadily*, BEIDOU.GOV.CN (Nov. 28, 2012), http://www.beidou.gov.cn/2012/12/26/20121226f38884ed79bd41689d373fe3ea85a24a.html; BeiDou Navigation Satellite Sys., *Chinese BeiDou Navigation Satellite System Officially Into Global Radio Navigation System*, BEIDOU.GOV.CN, http://www.beidou.gov.cn/2014/12/01/2014120161d5b9e6272547ddb9d141b4129491f4.html (last visited July 18, 2015). See a more detailed discussion *infra* sections III(J) and III(K). *See also* Gibbons, *China Plans to Complete BeiDou*, *supra* note 39.

[42] *See* BeiDou Navigation Satellite Sys., *System Introduction: Construction Principles*, BEIDOU.GOV.CN, http://www.beidou.gov.cn/2012/12/14/2012121453762790daeb4fd1aef4d4d5c94b4c35.html (last visited July 18, 2015) [hereinafter BeiDou, *Construction Principles*].

[43] *See id.*; CHINA SATELLITE NAVIGATION OFFICE, *supra* note 40, at 12–14.

ment the services of other GNSS providers.[44] Augmentation service is available in Japan and in the ocean areas.[45] The basic interoperable service is free.[46] The MSAS is monitored both by the governmental MSAS network and by the International GNSS Service (IGS).[47]

6. *India's GPS-Aided Geo-Augmented Navigation System*

India's GPS-Aided Geo-Augmented Navigation System (GAGAN) will operate in the Indian region.[48] Its service will be seamless and will be interoperable.[49]

II. NATIONAL POLICY MOVEMENTS TOWARDS INTERNATIONAL REGULATION OF GNSS

GPS, GLONASS, and BeiDou are controlled by their national governments.[50] Galileo is governed by the EU, but it is largely delegated to the European Space Agency.[51] Development and acceptance of multiple GNSS systems highlight the need for international coordination of this new technology and for greater understanding of the needs of the global GNSS users by the largely national military (with the exception of Galileo) providers of GNSS. The policy changes in the direction of international coordination are evidenced by increasing organized activity in the United Nations through the Committee on Peaceful Uses of Outer Space (COPUOS), the ICG, its subcommittees, and its related groups.[52] Besides coordination within the United Nations, there are bilateral negotiations and coordination arrangements among the respective countries of the GNSS

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[44] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 46.

[45] *See* Atsushi Shimamura, *MSAS (MTSAT Satellite-Based Augmentation System) Project*, 1 AIR & SPACE EUR. 63, 64 fig. 4 (1992).

[46] *See* FAA, GLOBAL SBAS STATUS BRIEFING 4 (2014), *available at* http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/library/briefings/media/SBAS_Global_Status_June%202014.pdf.

[47] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 46; UNOOSA, *ICG Members*, *supra* note 36.

[48] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 46.

[49] *See id.*

[50] *See About IAC*, FED. SPACE AGENCY INFORMATION-ANALYTICAL CENTRE, http://glonass-iac.ru/en/AboutIAC/ (last visited Aug. 12, 2015); BeiDou, *Survey*, *supra* note 37; GPS.GOV, *supra* note 6.

[51] *See* TRIMBLE NAVIGATION LTD., *supra* note 10, at 64.

[52] *See* UNOOSA, *ICG*, *supra* note 36.

providers.[53] All the GNSS providers and users are moving towards international coordination.[54]

A. THE UNITED STATES

U.S. law and policy now favor international standards for GNSS.[55] This is a shift towards international cooperation marked by the 2010 U.S. National Policy Statement[56] to "[e]ngage with foreign GNSS providers to encourage compatibility and interoperability, promote transparency in civil service provision, and enable market access for U.S. industry."[57] The U.S. 2010 Policy Statement seeks to avoid provocative unilateral activities in outer space.[58] The U.S. government is directed to enter into new areas of international cooperation on GNSS issues.[59] As a consequence of this shift toward international coordination, the United States is increasingly active in coordinating activities in the United Nations fora, including not only in the ICG but also in the International Telecommunication Union (ITU), ICAO, and IMO.[60]

B. RUSSIA

The current policy of Russia is to cooperate actively in the International Committee on GNSS.[61] Russia also cooperates with the European Space Agency on GLONASS and with the U.S. GPS administration with the goal of establishing compatibility and interoperability of the three GNSS services[62] and ob-

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53 *See, e.g., International Cooperation, supra* note 13.

54 *See id.*; *see also infra* Section V.

55 *See* 51 U.S.C. § 50112(2) (2012); 2010 NAT'L SPACE POLICY, *supra* note 11, at 2; *see also* Larsen, *Regulation of Global Navigation, supra* note 4, at 462.

56 *See* 2010 NAT'L SPACE POLICY, *supra* note 11, at 5.

57 *Id.*

58 *See id.* at 6–7.

59 *See id.*

60 *See International Cooperation, supra* note 13.

61 *See About IAC, supra* note 50.

62 *See* U.N. Office for Outer Space Affairs, *Current and Planned Global and Regional Navigation Satellite Systems and Satellite-based Augmentation Systems of the International Committee on Global Navigation Satellite Systems Providers' Forum*, 63,U.N. Doc. ST/Space/50 (2010), *available at* http://www.unoosa.org/pdf/publications/icg_ebook.pdf [hereinafter U.N. Doc ST/Space/50.] It is notable that Russian GLONASS plans to use the voluntary International GNSS service system. *See* Dee Ann Divis, *Russians Consider IGS as Congress Moves to Limit GLONASS, Foreign Monitoring Stations on U.S. Soil: Russian Space Agency May Turn to International GNSS Service Network for Help*, INSIDE GNSS (Dec. 16, 2013), http://www.insidegnss.com/node/3830. *See also* discussion *infra* Section III(F).

taining assistance in establishing necessary monitoring and reference facilities around the globe for greater accuracy of the GLONASS system.[63]

C. China

China's policy is to coordinate actively with other countries and their providers in the ICG.[64] China also participates actively in coordination of radiofrequency through which users access the BeiDou satellites.[65] In China's view:

> With the participation of States Members of the United Nations, intergovernmental bodies and non-governmental organizations, the ICG has already become an important platform for communication and cooperation in the field of global satellite navigation. Presently, the main satellite navigation service providers (countries and organizations) attach importance to the communication and cooperation that happens through the ICG. As a country with an independent navigation satellite system, China wishes to exchange information and cooperate with all the other navigation satellite systems via the ICG.[66]

D. European Union and ESA

ESA and Galileo strongly support coordination with the other GNSS services through participation in the ICG: Achieving compatibility for both radiofrequency and national security is essential.[67] Galileo and EGNOS have established coordination with GPS and WAAS[68]

III. INTERNATIONAL REGULATION OF GNSS

International regulation of GNSS is based on the international space law treaties, including the Outer Space Treaty, the ITU legal instruments, the UN Charter, and a number of related treaties, such as the International Civil Aviation Convention (Chicago Convention), the International Maritime Convention, as well as the implementing organizational structures created by these treaties, such as the UN, the ITU, ICAO, IMO, World Meteorological Organization (WMO), and other international or-

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[63] *See* Divis, *Russians Consider IGS*, *supra* note 62.

[64] *See* BeiDou, *Construction Principles*, *supra* note 42.

[65] *See* China Satellite Navigation Office, *supra* note 40, at 9, 12–13.

[66] *See* U.N. Doc ST/Space/50, *supra* note 62, at 40.

[67] *See id.* at 34.

[68] *See id.* at 32.

ganizations.[69] Importantly, GNSS is increasingly being regulated by informal "soft" law guidelines.[70]

A. GNSS Provider Access to Outer Space and User Access to the GNSS Services[71]

States are provided free access to outer space in Article I of the Outer Space Treaty.[72] It states that use of outer space "shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law."[73] Furthermore, the use of outer space "shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."[74]

From the GNSS users' point of view, it is a huge benefit that the ordinary GNSS services are freely available. Virtually all the

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[69] *See* Int'l Telecomm. Union [ITU], Collection of the Basic Texts of the International Telecommunication Union Adopted by the Plenipotentiary Conference 3–134 (2011 ed.), *available at* http://www.itu.int/pub/S-CONF-PLEN-2011; *About Us: WMO in Brief*, World Meteorological Org., https://www.wmo.int/pages/about/index_en.html (last visited July 18, 2015); ITU, *Legal Framework*, About ITU, http://www.itu.int/net/about/legal.aspx (last updated Mar. 14, 2015) [hereinafter ITU, *Legal Framework*]; *see generally* U.N. Charter, arts. 1, 2, 7, para. 2; Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 5, 1979, 1363 U.N.T.S. 3 [hereinafter Moon Treaty]; Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty]; Convention on Registration of Objects Launched Into Outer Space, Nov. 12, 1974,1023 U.N.T.S. 15 [hereinafter Objects Launched into Outer Space]; Convention on the International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 961 U.N.T.S. 187 [hereinafter Liability Convention]; Agreement on Rescue of Astronauts, the Return of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space, Apr. 22, 1968, 672 U.N.T.S. 119 [hereinafter Rescue & Return Agreement]; Convention on the Intergovernmental Maritime Consultative Organization, Mar. 6, 1948, 289 U.N.T.S. 48 [hereinafter IMO Convention]; Convention on International Civil Aviation, Dec. 7, 1944, 15 U.N.T.S. 295 [hereinafter Chicago Convention].

[70] Irmgard Marboe, Soft Law in Outer Space 5 (2012) (describing outer space soft law to include principles, guidelines, resolutions, standards, and codes of conduct that channel the behavior of States but are not obligatory such as treaties and national laws). *See "Soft Law" in Outer Space*, Nat'l Point of Contact for Space Law Austria, http://www.spacelaw.at/index.php?option=com_content&view=article&id=69:soft-law-in-outer-space&catid=41:npoc-austria-activities&Itemid=63 (last visited Aug. 20, 2015).

[71] *See* Lyall & Larsen, *supra* note 21, at 404.

[72] Outer Space Treaty, *supra* note 69, art I.

[73] *Id.*

[74] *Id.*

users are able to access GPS, and they will gradually acquire technical ability to become interoperable. Consequently, an airplane flying from Singapore to New York may use multiple GNSS systems to navigate across Asia, across Europe, and to the United States without the need to identify which GNSS system is being deployed. GNSS systems will operate in accordance with a uniform ICAO navigation standard.[75] The various systems will be seamless, and they will be interoperable.[76]

The Outer Space Treaty, Article I, does not specifically provide that all States shall have access to GNSS services.[77] However, in 1998, the ICAO Assembly adopted by resolution a Charter expressing that States "shall have access, on a non-discriminatory basis under uniform conditions, to the use of GNSS services."[78] Almost all the States are parties to the Chicago Convention and are members of ICAO.[79] Nevertheless, an ICAO Assembly resolution does not have the legal authority of a treaty right.[80] Furthermore, the ICAO resolution only pertains to aviation.[81] Thus, disruption of GNSS service is possible, for example, if a later UN Security Council Resolution, by virtue of the UN Charter Chapter 7, adopts a resolution to disrupt GNSS service for a State that breaches the peace, or if a State decides to shut down its GNSS for national security reasons.[82]

B. International Regulation of Military Uses of GNSS[83]

GNSS is inherently dual (civilian and military) use.[84] Most GNSS services (GPS, GLONASS and BeiDou) are provided by,

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[75] *See* ICAO, *Global Air Navigation Plan*, at 35, ICAO Doc. 9750-AN/963 (4th ed. 2013), *available at* http://www.icao.int/publications/Documents/9750_cons_en.pdf [hereinafter ICAO Doc. 9750-AN/963].

[76] *See id.* at 35, 37.

[77] *See* Lyall & Larsen, *supra* note 21, at 404.

[78] ICAO, *Charter on the Rights and Obligations of States Relating to GNSS Services*, Assemb. Res. A32-19 (1998), *compiled in Assembly Resolutions in Force*, at V-3. ICAO Doc. 9848 (Oct. 8, 2004) [hereinafter ICAO Assemb. Res. A32-19].

[79] *See* Chicago Convention, *supra* note 69.

[80] *See, e.g.*, *ICAO Assembly Agreed on a Roadmap to a Global MBM in 2020*, Verifavia (July 10, 2013), http://www.verifavia.com/greenhouse-gas-verification/vn-icao-assembly-agreed-on-a-roadmap-to-a-global-mbm-in-2020-133.php.

[81] *See* Chicago Convention, *supra* note 69.

[82] *See* U.N. Charter, *supra* note 69, arts. 39–41.

[83] Regarding military GNSS, *see infra* Section IV(B), VII.

[84] *See* Larsen, *Issues Relating to Civilian*, *supra* note 19, at 111.

and under the immediate control of, military authorities.[85] They are used for multiple military purposes.[86] Therefore, they are subject to the Outer Space Treaty Article IV, providing that "States Parties to the Treaty undertake not to place in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner."[87] GNSS satellites carry small amounts of nuclear material because the satellites contain a very accurate atomic clock; however, that alone does not make the clock an atomic bomb because it is not explosive.[88] GNSS satellites may have other military capabilities.[89] For example, GPS satellites are known to be able to detect nuclear explosions.[90] GNSS guidance is used for so-called smart missiles and bombs, which may be classified as weapons of mass destruction.[91]

The Outer Space Treaty, Article III, could also be triggered by military GNSS uses.[92] The Treaty provides that "States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations . . . ."[93] The UN Charter, Article 2, provision regarding non-intervention applies as well as the same provision on settlement of disputes.[94] Military uses of GNSS are subject to the peacekeeping activities of the United Nations.[95] Use of GNSS for activities that may disturb the peace may trigger action

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[85] *See* GPS.GOV, *supra* note 6; *Russian Global Positioning Satellites: GLONASS GPS*, *supra* note 23; *Satellite Wars: China Unveils 'Cheaper' Answer to GPS*, RT NEWS (Dec. 27, 2012), http://rt.com/news/satellite-beidou-china-gps-944/.

[86] *See, e.g.*, GLOBAL POSITIONING SYSTEM FOR MILITARY USERS, *supra* note 3, at 1–3.

[87] Outer Space Treaty, *supra* note 69, art. IV; *see also* discussion of International Code of Conduct for Outer Space Activities, *infra* Section III(N).

[88] *See How the Galileo Atomic Clocks Work*, EUROPEAN SPACE AGENCY (July 24, 2012), http://www.esa.int/our_activities/navigation/How_the_Galileo_atomic_clocks_work.

[89] *See* LYALL & LARSEN, *supra* note 21, at 392–93.

[90] *See* Howard Hirano, *Nonproliferatoin Programs and Arms Control Technology*, SANDIA LAB NEWS, http://www.sandia.gov/LabNews/LN03-07-03/LA2003/la03/arms_story.htm (last updated Mar. 14, 2003).

[91] *See* LYALL & LARSEN, *supra* note 21, at 392–93, 403. It does not seem to be argued, however, that they are part of weapons of mass destruction and thus prohibited by the Outer Space Treaty, Article IV.

[92] *See* Outer Space Treaty, *supra* note 69, arts. III–IV.

[93] *Id.* art. III.

[94] *See* U.N. Charter, *supra* note 69, art. 2, paras. 3–4.

[95] *See* UNISPACE III, *Report of the Action Team*, *supra* note 7, at 7, 43 n.4.

of the UN Security Council under UN Charter, Chapter VII.[96] Furthermore, States using GNSS for self-defense may invoke the UN Charter, Article 51.[97]

C. Oversight of GNSS Activities for Compliance with Space Law

Enforcement of GNSS compliance with the space law treaties rests largely with individual member States.[98] Under the Outer Space Treaty, Article VI, the GNSS provider State (the "appropriate" State) assumes international responsibility for its GNSS activities in outer space[99] The States must assure that national activities comply with the Outer Space Treaty.[100] When the State itself is the provider of GNSS (USA, Russia, or China), then the Party State must assure its own compliance.[101] If a GNSS satellite is transferred to a non-governmental entity, then the appropriate Party State must assure compliance through the licensing process.[102] A State will not only issue a license but also must continuously supervise compliance with the Outer Space Treaty under Article VI.[103]

In addition to individual party State oversight, States that violate the Outer Space Treaty may also be charged by other States for violation of the Treaty.[104] According to the Vienna Convention on the Law of Treaties, Article 60, a material breach of a multilateral treaty by one of the parties permits other parties to suspend or to terminate their treaty obligations .[105] Parties may also submit the dispute to the International Court of Justice.[106]

D. UN Registration

Pursuant to the UN Registration Convention, Article II, GNSS satellites, as space objects, shall be registered in an appropriate

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96 *See* U.N. Charter, *supra* note 69, arts. 39–51.

97 *See id.* art. 51.

98 *See* Outer Space Treaty, *supra* note 69, arts. VI–IX.

99 *See id.* art. III.

100 *See id.* art. VI.

101 *See id.*

102 *See id.*

103 *See id.*

104 *See id.* art. IX.

105 Vienna Convention on the Law of Treaties, May 23, 1969, 1155 U.N.T.S. 331, 346 [hereinafter Vienna Convention].

106 *See* U.N. Charter, *supra* note 69, art 93, para. 1 ("All Members of the United Nations are *ipso facto* parties to the Statute of the International Court of Justice.").

state registry by the launching State.[107] Open access to the state registry is not required, but the registry maintained by the United Nations is readily accessible to anyone by electronic means.[108] Article IV of the Convention details the information to be recorded.[109] The Article also provides for updating that information as GNSS satellites are relocated.[110]

The UN Registration Convention, Article II, raises the issue of which is the launching State when Galileo satellites are launched by Russia or a U.S. launch company.[111] Only launching States may register space objects such as GNSS satellites.[112] States that are classified as launching states may enter into agreements about which State shall be the launching State entitled to register.[113]

E. JURISDICTION

Article VIII of the Outer Space Treaty[114] underscores the importance of space object registration. Each GNSS provider launches approximately thirty satellites in mid-Earth orbits.[115] It is important to establish which States may exercise jurisdiction. It is the state of registry that can exercise jurisdiction and control over GNSS satellites registered in that State.[116] The satellites are, or will be, interoperable and users do not necessarily know which satellites they are using.[117] In that context, it is important to identify and keep track of those satellites belonging to each particular provider.[118] Registration is the means to accomplish that task.[119]

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[107] *See* Registration Convention, *supra* note 69, art. II.

[108] *See id.* art. III.

[109] *See id.* art. IV, para. 1(a)–(d).

[110] *See id.* art. IV, para. 1(e).

[111] *See id.* art. II, para. 2.

[112] *See id.* art. II, para. 1.

[113] *See id.* art. II, para. 2.

[114] *See* Outer Space Treaty, *supra* note 69, art. VIII; *see also* LYALL & LARSEN, *supra* note 21, at 67–69.

[115] *See Step 1: Satellite*, NOVATEL, http://www.novatel.com/an-introduction-to-gnss/Chapter-2-basic-gnss-concepts/step-1-satellites/ (last visited Aug. 20, 2015).

[116] *See* Outer Space Treaty, *supra* note 69, art. VIII.

[117] *See* ICAO Doc. 9750-AN/963, *supra* note 75, at 35, 37.

[118] *See* LYALL & LARSEN, *supra* note 21, at 84, 86.

[119] *See* LYALL & LARSEN, *supra* note 21, at 83–84, 86; *see also* Outer Space Treaty, *supra* note 69, art. VIII.

F. Search and Rescue[120]

GNSS is not only important for facilitating search and rescue of lost people, but also of lost satellites.[121] GNSS satellites are subject to the Search and Rescue Convention;[122] if a GNSS satellite is lost and found, it must be returned to the launching State.[123] The launching State may be required to compensate the damaged State if the satellite causes or threatens to cause hazardous damage.[124]

G. International Regulation of GNSS International Telecommunication[125]

ITU regulation of GNSS is an example of UN regulation.[126] GNSS operates entirely by transmission of positioning, navigation and timing information by radio frequencies that are regulated by ITU.[127] GNSS requires radio signals free of radio interference in order to function reliably.[128]

1. Coordination of GNSS Frequencies on the Radiofrequency Spectrum

The GNSS radio signals are weak and are easily subject to radio interference from other radiofrequency uses in their close proximity.[129] Article 44 of the ITU Constitution states that users shall restrict their use of radio frequencies to an absolute minimum because they are "limited natural resources."[130] Secondly,

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120 *See generally* Rescue & Return Agreement, *supra* note 69.

121 *See id.*; *see, e.g.*, *Emergency Beacons*, NOAA Search & Rescue Satellite Aided Tracking, http://www.sarsat.noaa.gov/emerbcns.html (last visited Aug. 20, 2015).

122 *See* Rescue & Return Agreement, *supra* note 69, art. 5.

123 *See id.*

124 *See id.*

125 *See* ITU, *Constitution of the International Telecommunication Union*, CS/Art.44 (1998), *compiled in* Collection of the Basic Texts of the International Telecommunication Union Adopted by the Plenipotentiary Conference 42 (2011 ed.), *available at* http://www.itu.int/pub/S-CONF-PLEN-2011 [hereinafter ITU, *Constitution*]. Radio frequencies and orbital slots are registered with ITU. *See* Lyall & Larsen, *supra* note 21, at 230–33, 237–38.

126 *See About ITU: Overview*, ITU, http://www.itu.int/en/about/Pages/overview.aspx (last visited Aug. 20, 2015).

127 *See* Lyall & Larsen, *supra* note 21, at 520.

128 *See id.* at 229, 520.

129 *See* Larsen, *Issue Relating to Civilian*, *supra* note 19, at 117. They are also easily disrupted by intentional and unintentional radio interferences. *See id.*; *see also* Lyall & Larsen, *supra* note 21, at 229, 406.

130 ITU, *Constitution*, *supra* note 125, at 42.

their use is subject to regulation in accordance with the ITU Radio Regulations.[131]

GNSS radio frequencies are regulated and allocated by ITU to States under a system by which States propose ITU user allocation.[132] A proposed allocation will be recorded by ITU if the proposing state can prove that the radio frequencies are clear and are not subject to radio interference.[133] Once registered to a user by ITU, that assignment will be protected by ITU.[134] However, the operator does not own an allocated orbital slot or a radio frequency.[135]

An example of necessary coordination to clear radio frequencies of interferences is the agreement between the United States and the EU concerning GPS's and Galileo's use of radio frequencies.[136] The EU is authorized to act on behalf of all the EU Member States regarding radio frequencies for Galileo and EGNOS.[137] However, there remains a potential problem of EU conflict with China over radiofrequency allocation to Galileo and BeiDou.[138]

A current issue is the increasing scarcity of spectrum, in particular in the areas of the spectrum used by GNSS.[139] The GNSS signals can easily be disturbed by high-powered signals of other users (for example, broadband).[140] Other broadband users, due to scarcity of bandwidth, wish to utilize parts of the spectrum now reserved for GNSS uses.[141] An example is the recent controversy created by a company called Lightsquared and its efforts to

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131 *See id.*; *see also* LYALL & LARSEN, *supra* note 21, at 229.

132 *See* LYALL & LARSEN, *supra* note 21, at 230–33, 406–07.

133 *See id.* at 406–07.

134 *Id.*

135 *See id.* at 230–34.

136 *See* Press Release, Under Secretary for Public Diplomacy and Public Affairs, Bureau of Public Affairs, Office of Press Relations, United States and European Union Announce Collaboration on the Use of Global Navigation Satellite Systems (July 30, 2010), *available at* http://www.state.gov/r/pa/prs/ps/2010/07/145465.htm.

137 *See id.*

138 *See* Susanna Dienar, *José-Ángel Ávila-Rodríguez: Dreaming of Satellites*, INSIDE GNSS (Mar./Apr. 2014), http://www.insidegnss.com/node/1915.

139 *See* Jules McNeff, *RF Spectrum Protection: What Does It Mean for GNSS?*, INSIDE GNSS (Nov./Dec. 2013), http://www.insidegnss.com/node/3791.

140 *See id.*

141 *See* Press Release, FCC, Statement from FCC Spokesperson Tammy Sun on Letter from NTIA Addressing Harmful Interference Testing Conclusions Pertaining to Lightsquared and Global Positioning Systems (Feb. 14, 2012), *available at* http://www.fcc.gov/document/spokesperson-statement-ntia-letter-lightsquared-and-gps.

get the Federal Communication Commission's permission for spectrum, the use of which would create interference with spectrum reserved for GNSS.[142] The controversy raises not only issues relating to interference with GNSS spectrum, but also how efficiently GNSS uses the spectrum allocated for its use.[143] Related are current efforts in ITU Joint Task Group 4-5-6-7 to increase the spectrum allocation for mobile broadband services.[144] GNSS interest groups fear that such allocations may be made at the expense of GNSS spectrum.[145]

Furthermore, GNSS is used to monitor potential disasters.[146] All the GNSS providers are now adding a special radio frequency solely for location and rescue of people in dire circumstances, for example, when they are lost at sea or in a desert.[147] A standardized radio frequency is used by all the GNSS systems.[148] The victims need only activate a special transmitter (SAR beacon) in order to be found.[149] They will then be assisted quickly by the nearest rescue facility.[150]

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[142] *See id.* LightSquared tried to build a network using radio frequencies close to those used by GPS. *See LightSquared and GPS*, GPS.GOV, http://www.gps.gov/spectrum/lightsquared/ (last updated Oct. 17, 2014). The U.S. National Telecommunication and Information Administration, joined by the GPS Industry Council, objected. *See* Press Release, Tammy Sun, *supra* note 141. Tests indicated possible interference with GPS signals. *See id.* The Federal Communication Commission then indicated that it planned to withdraw the license issued to LightSquared. *See LightSquared and GPS*, *supra* note 142.

[143] *See* McNeff, *supra* note 139.

[144] *See* Int'l Comm. on Global Navigation Satellite Sys. [ICG], Note by Secretariat on its 8th Meeting, Nov. 9–Nov. 14, 2013, 9 U.N. Doc. A/AC.105/1059 (Nov. 29, 2013) [hereinafter U.N. Doc. A/AC.105/1059].

[145] *See id.* at 3, 9.

[146] *See Emergency Mechanisms*, UN-SPIDER KNOWLEDGE PORTAL, http://www.unspider.org/space-application/emergency-mechanisms (last visited Aug. 20, 2015).

[147] *See Emergency Beacons*, *supra* note 126.

[148] *See About Sarsat: International System*, NOAA SEARCH & RESCUE SATELLITE AIDED TRACKING, http://www.sarsat.noaa.gov/cospas_sarsat.html (last visited Aug. 20, 2015). The United States, Canada, Russia and France formed the SARSAT system in 1979. *See Cospas-Sarsat*, NASA SEARCH & RESCUE MISSION OFFICE, http://searchandrescue.gsfc.nasa.gov/dass/cospas_sarsat.html (last visited Aug. 20, 2015). Forty-one countries are now members of the COSPAS-SARSAR organization. *See Participants*, COSPAS-SARSAT.INT, https://www.cospas-sarsat.int/en/about-us/participants (last visited Aug. 20, 2015). The capability is part of the payload of GNSS satellites. *See About Sarsat: International System*, *supra* note 148.

[149] *See About Sarsat: International System*, *supra* note 148.

[150] *See id.*

2. *GNSS Signal Interference*

The signal strength of GNSS is extremely low and can easily be disrupted either by intentional jamming by individuals, by use of personal privacy devices, or by military jamming for the purpose of a military advantage.[151] Jamming may also occur accidentally by radio interference from other signals that are too close to the GNSS signals or possibly by intense solar flares.[152] GNSS signal interference may also be created by spoofing signals that are the consequence of intentional or unintentional mimicking.[153] Radio interference is contrary to national policy and law.[154] Interference with radio frequencies is also contrary to ITU policy and international law.[155] It is also in the self-interest of GNSS users and providers who need clear channels to conduct business. Technology is being developed to impede jamming.[156] New GNSS satellites have eight times the jamming resistance than GNSS satellites previously launched.[157] GNSS jamming and spoofing continue to be an unsolved problem for integration of drones.[158] Use of GNSS to control unmanned

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[151] *See* Paul Craven et al., *Studying the Effects of Interference on GNSS Signals, in* PROCEEDINGS OF THE 2013 INT'L TECHNICAL MEETING OF THE INST. OF NAVIGATION 893 (ION 2013), *available at* http://www.ion.org/publications/abstract.cfm?articleID=10878; *Monster Solar Flare Jams Radio Signals,* DISCOVERY NEWS (Feb. 17, 2011), http://news.discovery.com/space/solar-flare-radio-communications-disruption-110217.htm.

[152] *See* Craven et al., *supra* note 151, at 893.

[153] *See id.*; *GPS Spectrum and Interference Issues,* GPS.GOV, http://www.gps.gov/spectrum (last updated Feb. 9, 2015).

[154] *See GPS Spectrum and Interference Issues, supra* note 153.

[155] *See id.*; Paul B. Larsen, *GNSS Interference Testing: Legal Issues, in* PROCEEDINGS OF THE THIRTY-NINTH COLLOQUIUM ON THE LAW OF OUTER SPACE, INTERNATIONAL INSTITUTE OF SPACE LAW OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION, OCT. 7–OCT. 11, 1996, 202, 204–05 (1997). In 2014, the FCC levied a $35 million fine against CTG Technology for selling a signal-jamming device in the United States because radio interference endangers the public by blocking communication with emergency personnel. *See* Quinten Plummer, *FCC Fines Chinese Company Record $35 Million for Marketing, Selling Illegal Jamming Devices in U.S.,* TECH TIMES (June 23, 2014), http://www.techtimes.com/articles/8973/20140623/fcc-fines-chinese-signal-jammer-seller-record-35-million-for-marketing-and-selling-illegal-devices.htm. *See also* Press Release, Tammy Sun, *supra* note 146.

[156] *See* Mike Gruss, *Companies See Market for Systems to Counter GPS Jamming Devices,* SPACE NEWS (Oct. 10, 2013), http://spacenews.com/37706companies-see-market-for-systems-to-counter-gps-jamming-devices/.

[157] *See id.*

[158] *See* Logan Scott, *Spoofs, Proofs & Jamming: Towards a Sound National Policy for Civil Location and Time Assurance,* INSIDE GNSS (Sept./Oct. 2012), http://www.insidegnss.com/node/3183.

drones and their integration into air traffic presents a particularly difficult problem.[159]

3. *Coordination of GNSS Orbital Slots*

ITU also regulates allocation of orbital slots.[160] Thus, the GNSS providers not only need to launch approximately thirty satellites each, but all the satellites are concentrated in the crowded mid-earth orbit.[161] Therefore, ITU coordination for the purpose of traffic separation is important.

H. SOLE USE

A basic GNSS policy and strategy issue related to possible interference is that of sole use.[162] The question is whether GNSS is sufficiently dependable so that the users can rely totally on sole use of GNSS. Because of the possibility of intentional and unintentional interference with GNSS signals, GNSS is not fully 100% reliable.[163] For most countries, including the United States, current GNSS safety is sufficiently reliable to permit deletion of Loran-C, the former navigation system for aviation and ships.[164] Loran-C was scheduled by the United States to be dismantled in 2010.[165] Plans to replace Loran-C with a new, similar, but enhanced, navigation system called eLoran were placed on

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159 *See* Dee Ann Divis, *Funding at Risk as Work on UAV Standards Fall Behind*, INSIDE GNSS (Nov. 28, 2014), http://www.insidegnss.com/node/4321. The U.S. government is finding that integration into air traffic of unmanned air vehicles is much more complex than originally thought. *See generally* GOV'T ACCOUNTABILITY OFFICE, GAO-12-981, UNMANNED AIRCRAFT SYSTEMS: MEASURING PROGRESS AND ADDRESSING POTENTIAL PRIVACY CONCERNS WOULD FACILITATE INTEGRATION INTO THE NATIONAL AIRSPACE SYSTEM (2012); *see also* Inside GNSS News, *Enhanced Differential Loran Maritime Trials in the Netherlands Declared Successful*, INSIDE GNSS (Jan. 6, 2014), http://www.insidegnss.com/node3838 [hereinafter Inside GNSS News, *Enhanced*].

160 *See* ITU, *Constitution*, *supra* note 130, at 42. In particular, note Article 44 of the ITU Constitution. *See id.*

161 *See What is Galileo?*, EUROPEAN SPACE AGENCY, http://www.esa.int/Our_Activities/Navigation/The_Future_-_Galileo/What_is_Galileo (last updated June 27, 2014).

162 *See* Larsen, *Issues Relating to Civilian*, *supra* note 19, at 117–18; *see also* FED. RADIONAVIGATION PLAN, *supra* note 12, 1.7.5.2.

163 *See id.*

164 *See* U.S. Dep't Homeland Sec., *Loran-C Termination Status: Loran-C General Information*, NAVIGATION CTR., http://www.navcen.uscg.gov/?pageName=loranMain (last updated June 8, 2012).

165 *See id.*

hold.[166] However, recent action by the U.S. Congress favors keeping the Loran system and upgrading it to eLoran.[167] South Korea is susceptible to interference from North Korea.[168] Thus, South Korea and countries in similar situations plan to retain and develop alternative means of navigation such as eLoran.[169] The Netherlands has announced development and testing of an Enhanced Differential Loran (eDLoran).[170] Other countries are also developing alternatives to GNSS.[171]

I. INTERNATIONAL REGULATION OF GNSS LIABILITY

Liability for defective service is an incentive for maintaining a high standard of reliability for GNSS. Liability of the GNSS providers for defective control and navigation would compensate users for damages experienced from defective service.[172] ICAO Assembly Resolution 32-19 cautioned GNSS providers to insure the reliability of their GNSS services, "including effective arrangements to minimize the operational impact of system malfunctions or failure, and to achieve expeditious service recovery."[173] But ICAO has not managed to reach agreement on an international treaty that would make providers liable for faulty GNSS. The provider countries, such as the United States, have opposed such regulation with the argument that the service is reliable and that it is in the inherent self-interest of prov-

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[166] *See* Dee Ann Divis, *House Committee Moves to Block Loran-C Teardowns: To Preserve for Possible Use in GPS Backup System*, INSIDE GNSS (Feb. 14, 2014), http://www.insidegnss.com/node/3913.

[167] *See id.* eLoran is extremely difficult to jam. *Id.* Jamming would require a huge antenna, which could easily be detected. *See id.* eLoran could use most of the existing Loran-C installations. *See id.*; *see also* Glen Gibbons, *GAO Report on GPS Disruptions Faults DHS, DOT Efforts Failed to Fulfill Mandates of 2004 Presidential Directive for GPS Back Up System and Interference Detection and Mitigation*, INSIDE GNSS (Nov. 6, 2013), http://www.insidegnss.com/node/3766.

[168] *See* Inside GNSS News, *North Korea's Jamming Prompts South Korea to Endorse Nationwide eLoran System*, INSIDE GNSS (Apr. 24, 2013), http://www.insidegnss.com/node/3532 [hereinafter Inside GNSS News, *North Korea's Jamming*].

[169] *See id.*

[170] *See* Inside GNSS News, *Enhanced*, *supra* note 159.

[171] *See* Inside GNSS News, *North Korea's Jamming*, *supra* note168. The U.K. has installed eLoran in Southern England along the English Channel to insure safe navigation in the event that GNSS fails. *See UK Presses Ahead with eLoran DGPS Modernization*, INSIDE GNSS (Nov. 19, 2008), http://www.insidegnss.com/node/926.

[172] *See* ICAO, *Development and Elaboration of an Appropriate Long-Term Legal Framework to Govern the Implementation of GNSS*, Assemb. Res. A32-20 (1998), *compiled in Assembly Resolutions in Force*, at V-4. ICAO Doc. 9848 (Oct. 8, 2004).

[173] ICAO Assemb. Res. A32-19, *supra* note 78, at V-3.

iders to provide service of high standard.[174] Furthermore, the service is delivered free of charge, and consequently, there is no quality guaranty attached to the service.[175] The United States promises that the Global Positioning Service will continue to "be free of direct user charges."[176] GLONASS, Galileo, and BeiDou will also continue to provide free, open service.[177] A different claim situation would exist if the GNSS providers charged for their services because that might come with an implied guaranty of its quality of service.[178] The European GNSS service, Galileo, intends to charge for its special high quality service and, consequently, intends to permit itself to be held liable for defects in that service.[179] At the urging of some European States, UNIDROIT has engaged in preparatory work on a treaty that would allow users to present claims for defective GNSS service (Third-Party Liability for Global Navigation Satellite (GNSS) Services).[180] UNIDROIT's third party liability project would seem applicable only to Galileo and would thus lack universal applicability to all GNSS providers.[181]

A separate liability issue is whether the GNSS provider countries are liable for defective service under the Convention on International Liability for Damage Caused by Space Objects (the Liability Convention).[182] Under the Liability Convention, liabil-

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[174] *See* Ranjana Kaul & Ram S. Jakhu, *Regulation of Space Activities in India, in* NATIONAL REGULATION OF SPACE ACTIVITIES 153, 188 (Ram S. Jahku ed. 2010).

[175] *See id.*

[176] *See* Exchange of Letters Between FAA Administrator and ICAO Council President, dated September 19, 2007; *see also* 2010 NAT'L SPACE POLICY, *supra* note 11, at 5.

[177] *See* Peter B. de Selding, *China Official Beidou Gear Will Receive GPS, GLONASS, Galileo Signals*, SPACE NEWS (Feb. 6, 2015), http://www.spacenews.com/china-official-beidou-gear-will-receive-u-s-russian-and-european-gnss-signals/.

[178] Art. 5.1.2, UNIDROIT Principles of International Commercial Contracts 2010, *available at* http://www.unidroit.org/english/principles/contracts/principles2010/integralversionprinciples2010-e.pdf.

[179] *See* de Selding, *China Official Beidou Gear*, *supra* note 177.

[180] *See Third-Party Liability for Global Navigation Satellite System (GNSS) Services: The Proposed Unidroit Project*, UNIDROIT, http://www.unidroit.org/work-in-progress-studies/studies/civil-liability/96-about-unidroit/workprogramme/530-third-party-liability-for-global-navigation-satellite-system-gnss-services-the-proposed-unidroit-project (last updated Nov. 20, 2013).

[181] *See id.*

[182] *See generally* Liability Convention, *supra* note 69; *see* Paul B. Larsen, *Liability Limitation Under National Law and the Liability Convention, in* PROCEEDINGS OF THE INTERNATIONAL INSTITUTE OF SPACE LAW 2010 416, 419 (Corinne M. Jorgenson ed., 2011).

ity is absolute for damages caused on Earth and in the air; it requires proof of fault to yield compensation for damages caused in outer space.[183] The plain meaning of the Liability Convention may appear to provide compensation for damages caused by faulty GNSS services; however, the interpretation of the Liability Convention by many States, including the United States, is that the Liability Convention applies only to direct damages.[184] Their position is that defective GNSS service is not covered by the Liability Convention because it would be an indirect damage.[185] Their reasoning is that the signals from the satellite to the users are activated by the users themselves.[186] The providers do not actively send signals to the users.[187] The United States Government contends that "nothing about the implementation of satellite navigation, communication, and surveillance—including advent of additional participants in provision of air traffic control services—raises legal or factual issues that cannot be handled by current claims mechanisms."[188]

BeiDou operates differently than other GNSS services. It is an active system in which the users request for positioning, and navigation information is directed to a ground control station, which in turn provides the information.[189] An argument could be made that an active system qualifies as direct control rather than as indirect control and thus triggers application of the Liability Convention.[190] The argument would be that erroneous information guiding the user into a collision is similar to a situation in which air traffic control guides an airplane to land on the wrong runway to its destruction.

The military nature of GPS, GLONASS, and BeiDou is an important policy reason for these three GNSS providers to oppose international liability.[191] Their policy objections to liability for GNSS service by the military authorities remain strong.[192] Euro-

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183 *See* Liability Convention, *supra* note 69, art. III.

184 *See* Larsen, *Issues Relating to Civilian*, *supra* note 19, at 115.

185 *See id.*

186 *See id.*

187 *See id.* at 117.

188 Larsen, *Regulation of Global Navigation*, *supra* note 4, at 463.

189 *See* CHINA SATELLITE NAVIGATION OFFICE, *supra* note 40, at 3–4.

190 *See* LYALL & LARSEN, *supra* note 21, at 107 n.103. Such damage might constitute direct damage under the Liability Convention. *See id.* at 107.

191 *See* GPS.GOV, *supra* note 6; *Russian Global Positioning Satellites: GLONASS GPS*, *supra* note 23; *Satellite Wars: China Unveils 'Cheaper' Answer to GPS*, *supra* note 85.

192 Governments might argue that the service is a Governmental service, which is provided for Governmental purposes.

pean Galileo, being of civilian nature, has more flexibility.[193] But it will only accept liability for its high quality service.[194] Under these circumstances, it would be difficult to establish liability for GNSS at the ordinary (common) level of service because all the services plan to be interoperable.[195] The users would not necessarily know which GNSS service they are using and thus would not know which provider to sue.

J. International Civil Aviation Organization

Use of GNSS is fundamental to ICAO's Global Air Navigation Plan.[196] ICAO is established by the Convention on International Civil Aviation (Chicago Convention).[197] The Chicago Convention, Article 28, requires ICAO to regulate air navigation.[198] Article 37 establishes ICAO standards and recommended practices.[199] The Chicago Convention Annex 10 is the ICAO document establishing GNSS air navigation standards.[200] Furthermore, ICAO adopted Assembly Resolution A32-19 in 1998, to the effect that States shall seek "to secure the highest practicable degree of uniformity in the provision and operation of GNSS services."[201] Aviation has adopted GNSS navigation and is gradually moving from Earth-based air traffic control facilities to satellite-based navigation via GNSS.[202]

ICAO has therefore worked extensively on coordination of the GNSS services of the various national providers.[203] ICAO has

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193 ESA, *What Is Galileo*, *supra* note 32.

194 Euro. Space Agency, Galileo: The European Programme for Global Navigation Services 22–23 (Andrew Wilson eds., 2d ed. 2005), *available at* http://www.esa.int/esapub/br/br186/br186e.pdf.

195 *See* ICAO Doc. 9750-AN/963, *supra* note 75, at 35, 37.

196 *See id.* at 12.

197 *See* Chicago Convention, *supra* note 69, arts. 28, 37.

198 *See id.* art. 28.

199 *See id.* art. 37.

200 *See* ICAO, *Annex 10 to the Convention on International Civil Aviation Aeronautical Telecommunications: Volume II Communication Procedures Including Those with PANS Status*, 1-1 (6th ed. 2001), *available at* http://www.icao.int/Meetings/anconf12/Document%20Archive/AN10_V2_cons%5B1%5D.pdf [hereinafter ICAO, Annex 10].

201 ICAO Assemb. Res. A32-19, *supra* note 78, at V-3.

202 *See* GNSS Market Report: Issue 3, *supra* note 31, at 28. "GNSS is essential for the introduction of Performance-Based Navigation (PNB) in line with ICAO standards that place requirements on the quality and accuracy of aircraft navigation along predefined routes, on an instrument approach procedure or in designated airspace. It envisages a transition from traditional ground-based navigation towards space-based navigation." *Id.*

203 *See* ICAO Doc. 9750-AN/963, *supra* note 75, at 104–06.

been able to get GNSS providers' agreement to create a seamless interoperable web so that pilots do not need to be concerned about shifting from one GNSS system to another.[204]

K. International Maritime Organization[205]

IMO's purpose is similar to the purpose of ICAO for aviation, that is, to establish international maritime standards for safe navigation.[206] By virtue of the IMO Convention, Articles 15, 21, and 28, IMO has established uniform safety navigation standards for shipping.[207] IMO has established safety standards requiring GNSS maritime capability for security and port operations as well as inland water navigation.[208] The greatest nautical uses of GNSS are for general navigation, for navigation in inland waterways, and for search and rescue.[209] More than 50,000 vessels are subject to the IMO GNSS standards.[210]

L. Regulation of GNSS Tracking: Privacy Issues

GNSS ability to locate and track people almost anywhere on Earth improves safety, but it also raises basic legal privacy concerns.[211] GNSS tracking devices can be inserted into, or otherwise attached to, people and their cars and other instrumentalities.[212] Most commonly, a GNSS chip is already built into cell phones by the manufacturer and thus carried eve-

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[204] *See* 2010 Nat'l Space Policy, *supra* note 11, at 5. The United States will "[e]ngage with foreign GNSS to encourage compatibility and interoperability, promote transparency . . . , and enable [GNSS providers] market access for U.S. industry." *Id.* The United States may use "[f]oreign positioning, navigation, and timing (PNT) services . . . to augment and strengthen the resiliency of GPS." *Id.*

[205] *See generally* IMO Convention, *supra* note 69; *see also* exchange of letters regarding continued free GNSS between IMO Secretary General and the Commandant, U.S. Coast Guard, dated 16 July 2001.

[206] *See* IMO Convention, *supra* note 69, art. 1, para. (a).

[207] *See id.* arts. 15, 21, 28.

[208] *See* GNSS Market Report: Issue 3, *supra* note 31, at 46.

[209] *See id.*

[210] *See id.*

[211] *See* United States v. Jones, 132 S. Ct. 945, 949 (2012). In *Jones*, the U.S. Supreme Court held that warrantless installation of GPS and subsequent surveillance by the police was a search, and thus a violation of the 4th Amendment; consequently, the evidence was excluded. *See id.* at 948–49, 954.

[212] *See* Michelle Cottle, *The Adultery Arms Race*, The Atl. (Oct. 14, 2014), http://www.theatlantic.com/magazine/archive/2014/11/the-adultery-arms-race/380794/.

rywhere the owner of the cell phone goes.[213] GNSS can locate people lost at sea, lost people with Alzheimer's disease, and lost children.[214] It also tracks lost pets and other creatures that carry GNSS receivers.[215] Privacy rights policy issues are triggered when GNSS is used to track people against their will.[216]

Ongoing negotiations between the United States and the European Union illustrate that privacy considerations differ significantly from one country to another.[217] For example, the rules for storage of data obtained by GNSS differ between the United States and the EU.[218] Another potential problem is whether the GNSS provider used for tracking is located within the jurisdiction of a State, for example, or whether the GNSS provider is GPS, Galileo, or GLONASS.[219] Jurisdiction may be difficult to obtain if the GNSS provider is a foreign provider that is outside of the jurisdiction of a country and its courts.[220] A governmental

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213 *See* Frank Van Diggelen et al., *GNSS Inside Mobile Phones: GPS, GLONASS, QZSS, and SBAS in a Single Chip*, INSIDE GNSS (Mar./Apr. 2011), http://www.insidegnss.com/node/2507.

214 *See* Alissa Sauer, *10 Lifesaving Location Devices for Dementia Patients*, ALZHEIMERS.NET (Aug. 8, 2014), http://www.alzheimers.net/8-8-14-location-devices-dementia; *Wearable GPS Tracking for Children, to Ease Parents' Minds*, CBS NEWS (July 9, 2014), http://www.cbsnews.com/news/wearable-gps-tracking-for-children-to-ease-parents-minds/ [hereinafter *Wearable GPS*].

215 *See Trax Personal Tracker Integrates U-blox GNSS and Cellular Technologies*, PR NEWSWIRE (Mar. 27, 2014), http://www.prnewswire.com/news-releases/trax-personal-tracker-integrates-u-blox-gnss-and-cellular-technologies-252615511.html.

216 *See, e.g.*, *Jones*, 132 S. Ct. at 947–49.

217 *See, e.g.*, Press Release, European Comm'n, European Commission Seeks High Privacy Standards in EU-US Data Protection Agreement, IP/10/609 (May 26, 2010), *available at* http://europa.eu/rapid/press-release_IP-10-609_en.htm. Article 8 of the Convention for the Protection of Human Rights and Fundamental Freedoms protects individuals from undue invasion of their privacy, including unlawful searches. *See* Convention for the Protection of Human Rights and Fundamental Freedoms, Nov. 4, 1950, 213 U.N.T.S. 221, 230. Storage of information is held to be restricted. *See* Rotaru v. Romania, 2000-V Eur. Ct. H.R. 109, 128–29 (2000).

218 *See Data Retention*, EUROPEAN COMM'N, http://ec.europa.eu/dgs/home-affairs/what-we-do/policies/police-cooperation/data-retention/index_en.htm (last updated June 4, 2014); *GPS Location Privacy*, GPS.GOV, http://www.gps.gov/policy/privacy/ (last updated Oct. 9, 2014).

219 *See* Outer Space Treaty, *supra* note 69, art. VIII. Article VIII of the Outer Space Treaty limits jurisdiction and control of a State to GNSS satellites that are registered by that State. *See id.*

220 *See id.*; *see also* Paul Larsen, *The Space Protocol to the CAPE Town Convention and the Space Law Treaties*, *in* PROCEEDINGS OF THE INTERNATIONAL INSTITUTE OF SPACE LAW 2012 203–05 (Corinne M. Jorgenson ed., 2013) (discussing jurisdiction under Article VIII of the Outer Space Treaty).

provider is likely to claim immunity.[221] The EU is concerned about GNSS privacy issue and is currently surveying professional uses in Europe.[222]

In the U.S. Supreme Court case of *United States v. Antoine Jones*, the police hid a GNSS tracking device in Mr. Jones's car and tracked all his movements for an entire month without his consent.[223] Mr. Jones argued that his rights under the Fourth Amendment to the U.S. Constitution—to be free from unreasonable search and seizure—had been violated and that use of GNSS was contrary to his reasonable expectations of privacy.[224] The police had failed to obtain a search warrant from a court.[225] The U.S. Supreme Court held that Mr. Jones's privacy had been violated and that the evidence of his movements could not be used against him in a criminal trial.[226] Police extensively track people through the GNSS chips imbedded in their cell phones.[227] Studies of recidivism (convicted criminals resuming criminal activities) indicate that former convicts are much less likely to return to crime if released on parole with a GNSS monitor.[228] Private individuals, other than police, also use GNSS devices to track their children, their spouses, and their employees whose activities they wish to monitor.[229]

Privacy policy and strategy issues relating to privacy may occur suddenly because the technology is developing so quickly. States need to identify and develop possible privacy policy even before problems occur in order to meet technology challenges.

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221 *See* Anthony J. Colangelo, *Jurisdiction, Immunity, Legality, and Jus Cogens*, 14 CHI. J. INT'L L. 53, 57 (2013).

222 Report of Working Group A, International Committee on Global Navigation Satellite Systems, 8th Meeting, Nov. 9–14, 2013, at 2 Doc. ICG/WGA/2013 (2013).

223 *See* United States v. Jones, 132 S. Ct. 945, 948 (2012).

224 *See id.*

225 *See id.* at 948 n.1.

226 *See id.* at 949, 954.

227 *See GPS Location Privacy, supra* note 218.

228 *See GPS-Aided Monitoring of Parolees: No Privacy Issues, Just Large Addressable Market*, INSIDE GNSS (May 20, 2012), http://www.insidegnss.com/node/3056.

229 *See* Cottle, *supra* note 212; *Wearable GPS, supra* note 214; Rob Woutat, *Spy vs. Spy, Now Available to All*, KITSAP SUN (Nov. 14, 2014), http://www.kitsapsun.com/opinion/rob-woutat-spy-vs-spy-now-available-to-all_61748198.

M. IADC Outer Space Debris Guidelines Applicable to GNSS

The crowded mid-Earth orbits raise the issue of orderly removal of non-functional GNSS satellites from orbits to avoid interference and possible collisions. The provider States have agreed to dispose of non-functioning GNSS satellites in accordance with the Interagency Debris Committee (IADC) guidelines formulated within COPUOS and issued by the UN General Assembly Resolution.[230]

N. International Code of Conduct for Outer Space Activities[231]

Transparency and confidence building in outer space activities are the major principles of the proposed International Code of Conduct for Outer Space Activities (the Code of Conduct).[232] The dual use nature of GNSS and the open exchange of information about the GNSS activities of the GNSS provider States within the UN, described in the next section, cause GNSS to fit well into the objectives of the Code of Conduct.[233] The case-in-point described below in Section IV and the refusal of the United States to assist in monitoring GLONASS within U.S. territory is caused by lack of information about the capability of GLONASS monitors in the United States.[234] The openness of IGS monitoring described below shows the importance of transparency.

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[230] *See* International Cooperation in the Peaceful Uses of Outer Space, G.A. Res. 62/217, paras. 26–27, U.N. Doc. A/RES/62/712 (Feb. 1, 2008). Originally prepared by the Inter-Agency Space Debris Coordination Committee and approved by COPUOS. *See* Report of the Comm. on the Peaceful Uses of Outer Space [COPUOS], 62d Sess., Sept. 18–Dec. 21, 2007, paras. 117, 118, annex paras. 2, 4, U.N. Doc. A/62/20; GAOR, 62d Sess., Supp. No. 20 (2007).

[231] *See Draft International Code of Conduct for Outer Space Activities*, 1, 3 (Sept. 16, 2013), *available at* http://eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_16_sept_2013_en.pdf [hereinafter *Draft Code of Conduct*]; *see also* Paul Larsen, *Code of Conduct for Military Activities in Outer Space*, *in* Proceedings of the Fiftieth Colloquium on the Law of Outer Space: 24–28 September 2007, Hyderabad, India 330 (2008).

[232] *See Draft Code of Conduct*, *supra* note 231, at 2–3.

[233] *See* U.N. Doc. A/AC.105/1059, *supra* note 144, at 5–6; *Draft Code of Conduct*, *supra* note 231, at 2–3.

[234] *See* Divis, *Russians Consider IGS*, *supra* note 62.

IV. GNSS REGULATION WITHIN THE SCOPE OF THE UN INTERNATIONAL COMMITTEE ON GNSS

A. NEED FOR UNIVERSAL COORDINATION OF GLOBAL NAVIGATION SATELLITE SYSTEMS

GNSS is inherently international.[235] The satellites exist in non-sovereign outer space. GNSS provides service not only in the country of the provider State but also around the globe.[236] It is fragile because it depends on communication by use of radiofrequency allocated by the ITU.[237] Interference with the radio signals is very easy.[238] Nevertheless, we depend on GNSS for safe navigation of airplanes, ships, and a host of safety-related activities.[239]

GNSS service is becoming increasingly complex, not only because of the technology, but also because there will soon be four global GNSS providers (GPS, GLONASS, BeiDou, and Galileo).[240] Each of them has twenty-four to thirty satellites in mid-Earth orbit.[241] They tend to provide the same kind of service. The GNSS users do not really care which GNSS service they use.;they just need a reliable service. Being inherently international, GNSS services need to be regulated internationally. This section describes present GNSS coordination activities in the UN and in UN-related fora. In contrast to hard law, such as the

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[235] *See* Outer Space Treaty, *supra* note 69, art. VI. Under Article VI of the Outer Space Treaty the GNSS provider State ("[t]he State Part[y] to the Treaty") assumes "international responsibility for [its GNSS] activities in outer space . . . ." *Id.* The State must "assur[e] that national activities" comply with the Outer Space Treaty. *Id.* When the State itself is the provider of GNSS (USA, Russia, or China) then the Party State must assure its own compliance. *See id.* However, if a GNSS satellite were transferred to a non-governmental entity then the appropriate Party State would assure compliance through the licensing process. *See id.* A State will not only issue a license, but must continuously supervise compliance with the Outer Space Treaty under Article VI. *See id.* Enforcement of compliance with the space law treaties rests with the member States. *See id.*

[236] *See, e.g.*, TRIMBLE NAVIGATION LTD., *supra* note 10, at 42–46.

[237] *See* LYALL & LARSEN *supra* note 21, at 230–33, 406–07.

[238] *See* Craven et al., *supra* note 151, at 893.

[239] *See, e.g.*, *GPS Applications*, *supra* note 7.

[240] *See* ESA, *What Is Galileo*, *supra* note 32; GPS.GOV, *supra* note 6; *Russian Global Positioning Satellites: GLONASS GPS*, *supra* note 23; *Satellite Wars: China Unveils 'Cheaper' Answer to GPS*, *supra* note 85.

[241] *See* de Selding, *China Official Beidou Gear*, *supra* note 177; ESA, *Next Steps*, *supra* note 33; *Glonass Constellation Status, 22.03.2015*, FED. SPACE AGENCY INFORMATION-ANALYTICAL CENTRE, http://glonass-iac.ru/en/GLONASS/ (last visited Mar. 21, 2015); *Space Segment*, GPS.GOV, http://www.gps.gov/systems/gps/space/ (last updated Mar. 17, 2015).

Outer Space Treaty, or national law, the present activities in the UN and UN-related fora tend to be soft law in the form of developing guidance and practices based on consensus of the experts who are involved in the operation and use of GNSS.[242]

B. CASE-IN-POINT

Global GNSS operations require the systems to be checked and monitored not only nationally but also globally.[243] That presents a problem for the national GNSS providers because they need the cooperation of other nations for international monitoring.[244] GPS requires monitors in the Eastern Hemisphere, and GLONASS requires monitors in the western atmosphere.[245] The need for monitors on the Earth's surface is particularly necessary for GNSS augmentations such as the WAAS, the European EGNOS, and the Russian SDCM.[246] Russia approached the United States about placing SCDM monitors within U.S. territory.[247] The Russian SDCM would serve the dual purpose of augmentation as well as monitoring and collecting performance data.[248]

Both SDCM[249] and GDGPS[250] report monitoring data to the International GNSS Service (IGS), a voluntary organization linked to the ICG.[251] Russia similarly approached thirty other States around the globe for permission to place SDCM monitors

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[242] *See* Gregory C. Shaffer & Mark A. Pollack, *Hard vs. Soft Law: Alternatives, Complements, and Antagonists in International Governance*, 94 MINN. L. REV. 706, 714–15 (2010); *see also* MARBOE, *supra* note 70.

[243] *See* Glen Gibbons, *GNSS Monitoring Stations Slide into U.S.-Russia Rift*, INSIDE GNSS (June 17, 2014), http://www.insidegnss.com/node/4067.

[244] *See* Outer Space Treaty, *supra* note 69, arts. III–IV.

[245] *See* Gibbons, *GNSS Monitoring Stations*, *supra* note 243; Schmitt & Schmidt, *supra* note 25.

[246] *See* Gibbons, *GNSS Monitoring Stations*, *supra* note 243; *see also* Victor Ashurkov et al., *GLONASS for Precise Navigation in Space*, INSIDE GNSS (Sept./Oct. 2015), http://www.insidegnss.com/node/4627.

[247] *See id.*

[248] *See id.*

[249] *Id.* The SDCM monitors can monitor accuracy of both GLONASS and GPS satellites just like the Global Differential GPS System (GDGPS) monitor can monitor GLONASS. *See id.*

[250] *See id.* "GDGPS is a network of more than 100" GPS monitoring stations within the United States and in foreign countries. *See* Dee Ann Divis, *FAA May Tap Three Reference Networks to Monitor Civil GPS Signals*, INSIDE GNSS (Mar.18, 2014), http://www.insidegnss.com/node/3929. Most of the stations are operated by NASA. *Id.*

[251] *See* Gibbons, *GNSS Monitoring Stations*, *supra* note 243.

in their countries.[252] Russia has not yet disclosed the exact scope of its monitoring.[253]

In the context of Russia's current conflict with Ukraine, the U.S. Congress became concerned that Russian SDCM monitors located in the United States could be used to spy on the U.S. defense equipment.[254] Therefore, Congress adopted a provision in the 2014 Defense Authorization Act requiring the President to obtain certificates from the U.S. Defense Department and from the CIA before giving permission for construction of SDCM Russian sites within the United States. The law is currently in effect.[255] In retaliation, Russia now requires any U.S. GPS monitoring stations in Russia to be closed.[256] The over-all adverse effect on accuracy and consistency of global GNSS is evident.

These reciprocal curtailments of GNSS monitoring undermine the accuracy of GPS and GLONASS. Fortunately a fallback monitoring service is available; however, it is not controlled by the provider States and is thus less satisfactory to them.[257] A voluntary IGS service, linked to the UN International Committee on GNSS, continues to operate around the globe monitoring both GLONASS and GPS accuracy performance.[258] Thus, the drastic effect of the U.S. decision is ameliorated by the IGS according to its voluntary service and guidelines.[259] Russia is now likely to use the IGS fallback monitoring capability.[260]

The following discussion will focus on the very active and successful international GNSS coordination monitoring activity taking place within and related to UN GNSS activities. It will also show how its soft law guidelines and standards substitute for hard law rules and can even be used to circumvent those hard law rules.

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[252] *See id.*

[253] *See id.*

[254] *See id.*

[255] *See* Schmitt & Schmidt, *supra* note 25.

[256] *See* Gibbons, *GNSS Monitoring Stations*, *supra* note 243.

[257] *See* Divis, *Russians Consider IGS*, *supra* note 62.

[258] *See* Gibbons, *GNSS Monitoring Stations*, *supra* note 243.

[259] *See* Divis, *Russians Consider IGS*, *supra* note 62.

[260] *See* Gibbons, *GNSS Monitoring Stations*, *supra* note 243; *see also* Divis, *Russians Consider IGS*, *supra* note 62 ("[o]n April 1, 2013, the IGS launched its Real-Time Service (RTS) for GLONASS as a beta service with full operational capability expected by the end of this year. The RTS will provide free access to and free use of real-time GLONASS orbital ephemerides and clock products").

C. The UN International Committee on GNSS

The 1999 UNISPACE III Resolution 54/68 recommended international coordination of GNSS.[261] Consequently, the UN COPUOS was instrumental in organizing the special ICG to promote international GNSS coordination and to be an international forum for discussion of GNSS issues.[262] In 2004, UN General Assembly Resolution 59/2 expressed agreement on establishment of such a committee.[263] In 2005, the ICG was established as an informal forum for the purposes of promoting international GNSS cooperation, coordination, and interoperability on a voluntary basis, as follows: "The goal of the 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 the interests of developing nations."[264]

Afterwards, the UN-based GNSS activities grew rapidly. In 2005, the ICG agreed to be administered within the UN Office of Outer Space Affairs (UNOOSA).[265] Consequently, UNOOSA administers the annual meetings of the ICG and of the related GNSS Providers' Forum.[266] In its administrative role, UNOOSA

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261 *See* Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, G.A. Res. 54/68, paras. 26–27, U.N. Doc. A/RES/54/68 (Feb. 11, 2000); Paul B. Larsen, *Expanding Global Navigation Services, in* Proceedings of the Workshop on Space Law in the Twenty-first Century, at 155, U.N. Doc. ST/SPACE/2 (2000); *see also* Terms of Reference of the International Committee on Global Navigation Satellite Systems, International Committee on Global Navigation Satellite Systems, 8th Meeting, Nov. 9–14, 2013, at 1, Doc. ICG/TOR/2013 (2013).

262 *See* UNOOSA, *ICG*, *supra* note 36.

263 *See id.*

264 U.N. Doc. A/AC.105/1059, *supra* note 144, at 1. Furthermore,

> [a]mong the core missions of ICG are to encourage coordination among providers of global navigation satellite systems (GNSS), regional systems and augmentations in *order to ensure greater compatibility, interoperability and transparency, and to promote the introduction of utilization* of those services and their future enhancements, including in the developing countries, through assistance, if necessary, with the integration into their infrastructures. ICG also serves to assist GNSS users with their development plans and applications by encouraging coordination and serving as a focal point for international information exchange.

Id. at 12 (emphasis added).

265 *See* UNOOSA, *ICG*, *supra* note 36.

266 *See Providers' Forum*, UNOOSA.org, http://www.unoosa.org/oosa/SAP/gnss/icg/providersforum.html (last visited Mar. 20, 2015); *ICG Meetings*, UNOOSA.org, http://www.unoosa.org/oosa/en/SAP/gnss/icg/meetings.html (last visited Mar. 21, 2015).

also is a point of information about ICG activities.[267] It informs other international conferences about ICG activities.[268] UNOOSA also provides GNSS education.[269] In 2014, it issued its Education Curriculum on Space Law, which includes a special module on GNSS.[270] The curriculum is taught at the UN regional centers.[271]

Each year the ICG reports to the COPUOS Scientific and Technical Subcommittee on progress made by the ICG towards interoperability and compatibility.[272] The scope of these meetings includes all the different GNSS activities from transportation to agriculture.[273] For example, the International Space Weather Initiative is one active area of interest.[274]

The informal ICG and its related international bodies are active sources of soft law regulation of GNSS.[275] The member States and GNSS organizations tend to be represented in UN GNSS fora by technical experts rather than by lawyers.[276] The technical experts are motivated toward practical problem solving for GNSS development.

At its 2007 meeting in Bangalore, India, the ICG divided its work program among four working groups: Compatibility and

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[267] *See Activities Supported by the International Committee on Global Navigation Satellite Systems (ICG): Promoting the Use of GNSS Technologies*, UNOOSA.ORG, http://www.unoosa.org/oosa/en/SAP/gnss/icg/activities.html (last visited Mar. 21, 2015) [hereinafter *Activities*].

[268] *See Providers' Forum*, *supra* note 266; *see also* UNOOSA, 10 YEARS OF ACHIEVEMENT OF THE UNITED NATIONS ON GLOBAL NAVIGATION SATELLITE SYSTEMS 5–11 (2011), *available at* http://www.unoosa.org/pdf/icg/2011/11-85461_ICG-ST-55_eBook.pdf [hereinafter UNOOSA, 10 YEARS].

[269] *See* UNOOSA, 10 YEARS, *supra* note 268, at 17.

[270] *See* UNOOSA, EDUCATION CURRICULUM ON SPACE LAW at 56, Doc. ST/SPACE/59 (2014), *available at* http://www.unoosa.org/pdf/publications/st_space_064E.pdf [hereinafter Doc. ST/SPACE/59]; *UNOOSA Releases Education Curriculum on Space Law*, SECURE WORLD FOUND., http://swfound.org/news/all-news/2014/04/unoosa-releases-education-curriculum-on-space-law/ (last updated Apr. 23, 2014).

[271] *See Education Curriculum on Space Law*, UNOOSA.ORG, http://www.unoosa.org/oosa/en/SpaceLaw/curriculum/index.html (last visited Feb. 24, 2015).

[272] *See Activities*, *supra* note 267; *see generally, e.g.*, ICG Secretariat, *Activities Carried Out in 2012 in the Framework of the Workplan of the International Committee on Global Navigation Satellite Systems*, U.N. Doc. A/AC.105/1034 (Dec. 14, 2012) [hereinafter U.N. Doc. A/AC.105/1034].

[273] *See* U.N. Doc. A/AC.105/1034, *supra* note 272, at 1.

[274] *See id.* at 5; *see also International Space Weather Initiative*, UNOOSA.ORG, http://www.unoosa.org/oosa/en/SAP/gnss/icg/iswi.html (last visited Mar. 21, 2015).

[275] *See* Shaffer & Pollack, *supra* note 242, at 714–15; *"Soft Law" in Outer Space*, *supra* note 70.

[276] *See, e.g.*, UNISPACE III, *Report of the Action Team*, *supra* note 7, at iii, 1–4.

Interoperability; Enhancement of Performance of GNSS Services; Information Dissemination and Capacity Building, including GNSS education and training; and Reference Frames, Timing and Applications.[277] The following sections discuss the ongoing work of the working groups.[278]

1. Working Group on Compatibility and Interoperability

GNSS interoperability is an important issue because of the increasing availability of diverse GNSS providers. GPS is the most widely used GNSS system;[279] GLONASS is second.[280] Both have been in existence for a long time.[281] GNSS users have become dependent on the availability of GPS, and their receivers are GPS-capable. Galileo and BeiDou are gradually coming on line.[282] The existing augmentations systems, WAAS, EGNOS, GAGAN, and MSAS, are all GPS capable.[283] Increasingly receivers are interoperable, that is, they can access several of the GNSS systems.[284]

An important justification for multiple GNSS systems is that if one GNSS system is incapacitated then use of alternative systems is readily available. The added safety of multiple GNSS systems motivates countries to support international coordination.

The ICG Interoperability Working Group reported to the 2013 ICG regarding protection of the spectrum against radio signal interference, open service performance, and monitoring the open services.[285] Recommendations were also made to improve interoperability.[286] This working group most recently discussed coordination of satellite based augmentation systems at its meeting in New Delhi, India, from February 5–7, 2014.[287] As

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277 *See* UNOOSA, 10 YEARS, *supra* note 268, at 6, 7.

278 *See id.* at 6.

279 *See What is GPS?*, *supra* note 5.

280 *See* Alan Cameron, *In GNSS Race, Could Galileo Be Surging into Second?*, GPS WORLD (Mar. 4, 2015), http://gpsworld.com/in-gnss-race-could-galileo-be-surging-into-second/.

281 *See* LYALL & LARSEN, *supra* note 21, at 391; *About GLONASS*, *supra* note 19.

282 *See* U.N. Doc. A/AC.105/1059, *supra* note 144, at 1.

283 *See* FAA, *supra* note 46, at 13, 16.

284 *See* Oliver Montenbruck et al., *IGS-MGEX: Preparing the Ground for Multi-Constellation GNSS Service*, INSIDE GNSS (Jan./Feb. 2014), http://www.insidegnss.com/node/3849.

285 *See* U.N. Doc. A/AC.105/1059, *supra* note 144, at 8–9.

286 *See id.* at 7.

287 *See* ICAO, *Report of Fourth Meeting of Ionospheric Studies Task Force (ISTF/4)*, at i-2, 9 (Feb. 10, 2014), *available at* http://www.icao.int/APAC/Meetings/2014%20ISTF4/Final%20Report%20of%20ISTF-4.pdf.

described previously, the GPS is augmented in the United States by the WAAS, in Europe by EGNOS, in Japan by the MSAS, and in India by GAGAN.[288] The other three GNSS systems (GLONAS, Galileo, and BeiDou) are on line and require augmentation.[289] The working group aims to establish standardized augmentation that will serve all four GNSS systems.[290] The plan is to propose interoperable, standardized augmentation systems to the ICAO's Radio Technical Commission for Aeronautics for approval.[291] The goal is to establish interoperable augmentation for aviation by 2020.[292] Ideally, all the GNSS receivers should be able to receive signals from all the providers; however, some GNSS equipment operators may be reluctant to build receivers with access to all four GNSS systems due to the extra cost. They may plan for only two options.[293] Because it is the latecomer, Galileo is concerned that it may be left out.[294] Therefore, the EU is considering mandating that Galileo be made one of the two available GNSS options within the EU.[295] However, such a regulation may require international consultations because that may be contrary to ICG recommendation for augmentation serving all the GNSS systems.[296]

2. *Working Group on the Enhancement of Performance of GNSS Services*[297]

The work of this group is closely related to that of the interoperability working group.[298] The Working Group on the En-

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[288] *See* FAA, *supra* note 46, at 13, 16.

[289] *See* Glen Gibbon et al., *The GNSS Quartet: Harmonizing GPS, GLONASS, BeiDou and Galileo*, INSIDE GNSS (Jan./Feb. 2013), http://www.insidegnss.com/node/3375.

[290] *See id.*

[291] *See Galileo to Augment Systems Guiding Aircraft in 2020*, ESA (Feb. 20, 2014), http://www.esa.int/Our_Activities/Navigation/Galileo_to_augment_systems_guiding_aircraft_in_2020. *See generally* FED. RADIONAVIGATION PLAN, *supra* note 12 (also supporting international standards for space-based GNSS augmentation).

[292] *See id.*

[293] *See* Glen Gibbons, *European Officials Consider Galileo Mandate for Mobile Devices*, INSIDE GNSS (Apr. 30, 2014), http://www.insidegnss.com/node/3990.

[294] *See* Peter de Selding, *Europe Weighs Galileo-Compatibility Mandate for Smartphones*, SPACE NEWS (Apr. 15, 2014), http://spacenews.com/40214europe-weighs-galileo-compatibility-mandate-for-smartphones/.

[295] *See id.*; Gibbons, *European Officials Consider Galileo*, *supra* note 293.

[296] *See* de Selding, *Europe Weighs Galileo-Compatibility Mandate*, *supra* note 294. The equipment manufacturers' plans and the EU reaction would also both be contrary to current plans in the Providers' Forum. *See infra* Section IV(C).

[297] *See* U.N. Doc. A/AC.105/1059, *supra* note 144, at 7.

[298] *See id.*

hancement of Performance of GNSS Services reported to the 2013 ICG that it had made considerable progress on interoperability of all the GNSS services.[299] Significantly, all the participants in this working group agree "that a fully interoperable GNSS space service volume would result in significant benefits for future space users, as it would allow performance that no single system could provide on its own."[300] The group is continuing its work on interoperability.[301]

3. *Working Group on Information Dissemination and Capacity Building, including GNSS Education and Training*[302]

This working group recognized the value of the UN regional centers for space science and technology as well as the special GNSS Education Curriculum now taught at these centers.[303] The working group agreed that these programs were the most effective way to train people.[304] The working group recommended that new GNSS educational opportunities be provided, in developing countries particularly.[305]

4. *Working Group on Reference Frames, Timing and Applications*[306]

This working group reported progress in establishing "geodetic and timing references," particularly related to the International Terrestrial Reference System, as well as timing references to Coordinated Universal Time.[307]

The ICG is having success in motivating countries to establish GNSS-based international reference systems for land surveys.[308] Previously, countries had national reference systems that stopped at the border, making cross-border surveys and planning difficult.[309] GNSS is a basic ingredient of the World Geo-

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299 *See id.*

300 *Id.*

301 *Id.*

302 *See id.*

303 *See generally*, Doc. ST/SPACE/59, *supra* note 270; *see also* U.N. Doc. A/AC.105/1059, *supra* note 144 at 1, 7, 10.

304 *See* U.N. Doc. A/AC.105/1059, *supra* note 144, at 7.

305 *See id.*

306 *See id.* at 8.

307 *See id.*

308 *See* Volker Schwieger & Mikael Lilje, *Innovative and Cost Effective Spatial Positioning*, FIG (INT'L FED'N OF SURVEYORS), https://www.fig.net/pub/monthly_articles/january_2014/schwieger_lilje.html (last updated Jan. 3, 2014).

309 *See, e.g.*, James E. Stern, Charting & Geologic Servs., Nat'l Ocean Serv., Nat'l Oceanic & Atmospheric Admin., Dep't of Commerce, NOAA Manual NOS NGS

detic System 1984 (WGS84), which is operationally based on the assumption that the Earth is round rather than flat, as previous surveys assumed.[310] Therefore, GNSS land surveys are now more accurate.[311] The WGS84 based on GNSS is keyed to the International Terrestrial Reference System used by the International Association of Geodesy.[312] National land surveys are being made to conform with the GNSS-based survey; for example, the U.S. land survey previous to GPS used Washington D.C. as the original reference point and assumed the Earth to be flat.[313] This resulted in subsequent land surveys in the western parts of the United States to be skewed by several feet.[314] New surveys, using GPS as reference points, corrected the erroneous surveys.[315]

5. *Conclusion on UN ICG Activities*

Mandates of the working groups overlap somewhat. Occasionally several groups join on issues of common interest.[316] Furthermore, the ICG works closely with its related GNSS interest groups, including the GNSS Providers' Forum described immediately below.[317] At its 2013 annual meeting, the ICG agreed to meet regularly with these related entities as well as with associate members and observers, enabling these groups to report to the ICG on progress made and to exchange views on GNSS issues.[318]

5: State Plane Coordinate System of 1983, 1–3 (1990), *available at* http://www.ngs.noaa.gov/PUBS_LIB/ManualNOSNGS5.pdf.

310 *See World Geodetic System 1984*, UNOOSA.ORG, http://www.unoosa.org/pdf/icg/2012/template/WGS_84.pdf (last visited Mar. 22, 2015).

311 *See id.*

312 *See* Zuheir Altamimi et al., *Role and Importance of the International Terrestrial Reference Frame for Sustainable Development*, UNSTATS.UN.ORG, https://unstats.un.org/unsd/geoinfo/RCC/docs/rccap19/Side%20events/IAG-GGOS-ITRF-report2UNRRC-10Oct2012.pdf (last visited Mar. 22, 2015).

313 *See Four Corners Monument, Ocean Shorts: Episode 7*, NAT'L OCEAN SERV., http://oceanservice.noaa.gov/podcast/mar15/os7-fourcorners.html (last updated Mar. 19, 2015); *World Geodetic System 1984*, *supra* note 310.

314 *See Four Corners Monument, Ocean Shorts: Episode 7*, *supra* note 313.

315 *See* Kund E. Hermansen, *GPS and Boundary Retracement*, UNIV. ME., http://www.umaine.edu/set/svt/Articles/GPS&BdrySurv.pdf (last visited Mar. 22, 2015); *see also* Paul B. Larsen, *Use of Global Navigation Satellite System (GNSS) Evidence for Land Surveys: Legal Acceptability*, *in* PROCEEDINGS OF THE THIRTY-EIGHTH COLLOQUIUM ON THE LAW OF OUTER SPACE: OCTOBER 2-6, 1995, OSLO, NORWAY 286–87 (1996).

316 *See* U.N. Doc. A/AC.105/1059, *supra* note 144, at 7.

317 *See id.* at 8–9.

318 *See id.* at 10.

The ICG also encourages ICAO and IMO to participate in ICG discussions of GNSS navigation issues.[319]

D. GNSS PROVIDERS' FORUM[320]

In 2007, the ICG established a voluntary but separate GNSS Providers' Forum.[321] The ICG and the GNSS providers have much in common and can help each other remedy weaknesses in their global systems. "The objectives of the Providers' Forum are to[ ] . . . [p]romote compatibility and interoperability among current and future" GNSS providers.[322] The Providers' Forum is not intended to be a policymaking group; it is a discussion venue for the providers to coordinate agreed guidelines for open GNSS services.[323] It is a meeting place for providers to exchange information about their operative systems in order to avoid conflicts and to make them interoperable.[324] The ICG has delegated to the Forum those issues on which the ICG needs detailed GNSS information.[325] All four GNSS providers, as well as the augmentation services, participate in the Providers' Forum.[326] UNOOSA serves as the secretariat for the Providers' Forum.[327] The Forum meets at least once a year but can meet more often as need arises.[328] Although the Providers' Forum is only consultative, the GNSS industry participants are rather freewheeling and stray easily into formulation of voluntary guidance principles, which may be considered as soft law.[329]

In 2008, the GNSS providers, including the augmentation providers, agreed in the Providers' Forum that "all . . . [GNSS] signals and services must be compatible" with each other.[330] It was further agreed that all the open GNSS signal and systems should be interoperable to provide the best possible service to

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319 *Id.* at 5.

320 *See* Terms of Reference of the Providers' Forum, ICG, 11th Meeting, Nov. 9, 2013, at 1, Doc. ICG/PF/TOR/2013 (2013).

321 *See id.*

322 *Id.*

323 *Id.*

324 *See id.* at 1–2.

325 *See id.*

326 *Id.* at 2.

327 *Id.*

328 *Id.*; *see also* UNOOSA, 10 YEARS, *supra* note 268, at 6.

329 *See* UNOOSA, 10 YEARS, *supra* note 268, at 6; Shaffer & Pollack, *supra* note 242, at 715.

330 *See Providers' Forum*, *supra* note 266.

all GNSS users.[331] Thus, the Forum decided to focus on interoperability[332] and compatibility.[333]

The original members of the Providers' Forum were China, India, Japan, Russia, the United States, and the European Union.[334] Other States may also become members.[335] Each time it meets, the Forum selects a chairperson by consensus.[336] The

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[331] *See id.*

[332] *See id.* The Providers' Forum defines interoperability as follows:

> Interoperability refers to 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:
>
> (i) Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity;
>
> (ii) Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end-user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured;
>
> (iii) Geodetic reference frames realization and system time steering standards should adhere to existing international standards to the maximum extent practical;
>
> (iv) Any additional solutions to improve interoperability should be encouraged.

Id.

[333] *See id.* The Providers' Forum defines compatibility as follows:

> Compatibility refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service:
>
> (i) The International Telecommunication Union provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals;
>
> (ii) Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among providers concerned will establish the framework for determining a mutually acceptable solution;
>
> (iii) Any additional solutions to improve compatibility should be encouraged.

Id.

[334] *See* Terms of Reference of the Providers' Forum, *supra* note 320, at 1–2.

[335] *See id.* at 1.

[336] *See id.* at 2.

Forum reports its actions to the ICG.[337] The Provider's Forum is primarily concerned with improving their open signals.[338] For that purpose they agreed to coordinate in the following areas:[339]

(i) Compatibility and interoperability of GNSS systems: The Providers' Forum exchanges information about their plans and operations including the policies and procedures governing their services in accordance with the original work plan established at the initial meeting of the Providers' Forum in 2007 in Bangalore, India.[340] In brief, the providers agree to support the discussions of the ICG on compatibility and interoperability, but from the providers' point of view.[341] Each provider has agreed to prepare individual reports on their particular service and their policies and procedures for reaching their objectives.[342] These reports are being "consolidated and maintained by the ICG Executive Secretariat" for use in the Providers' Forum.[343]

(ii) Open service information dissemination: Each provider agrees to complete transparency of its systems and signals in order to enable manufacturers of receivers to build receivers that do not discriminate among the GNSS services.[344] Thus, "the Provider's Forum [plans to] develop[ ] a template for sharing and disseminating information" about all Provider signals and specifications.[345]

(iii) Service performance monitoring: The providers are developing joint plans for monitoring performance of their open signals for the purpose of improving performance of timing and positioning accuracy and the availability of service.[346] This is consonant with the GNSS providers' policy of transparency in providing the open services.[347]

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337 *See id.*

338 *See id.* at 1.

339 *See* Note by Secretariat, COPUOS, *Second Meeting of the International Committee on Global Navigation Satellite Systems*, at 7, U.N. Doc. A/AC.105/901 (Dec. 10, 2007). This document was updated in 2008. *See* Note by Secretariat, COPUOS, *Third Meeting of the International Committee on Global Navigation Satellite Systems*, at 11, U.N. Doc. A/AC.105/928 (Dec. 22, 2008) [hereinafter U.N. Doc. A/AC.105/928].

340 *See* U.N. Doc. A/AC.105/928, *supra* note 339, at 11.

341 *See id.*

342 *See id.*

343 *See id.*

344 *See id.* at 11–12.

345 *Id.*

346 *See id.* at 12.

347 *Id.* at 11–12

(iv) Spectrum protection: In detection of interference and mitigation of radio interference, providers agree to use domestic rules and regulations to protect the GNSS radiofrequency.[348] Their spectrum protection activities may include resort to the ITU for better spectrum protection.[349] The Providers will also support "the ICG working group on compatibility and interoperability."[350]

The 2013 meeting of the Providers' Forum was held in conjunction with the regular ICG meeting in Dubai, thereby illustrating the close relationship between the two groups.[351] Noticeably, the working groups of the ICG and the Providers' Forum work on similar and related issues. The Providers' Forum reports to the ICG and its working groups.[352] Clearly the Providers' Forum is valuable support for the ICG.

E. THE INTERNATIONAL GNSS SERVICE

Under the auspices of the International GNSS Committee, the IGS participants have established a global voluntary monitoring and tracking scheme for all the GNSS systems.[353] The International GNSS Service (IGS) includes more than 200 government and private institutional bodies.[354] The participants maintain coordinating reference points and monitoring stations, including an archive that tracks GNSS activities all over the world.[355] In order to enable all four main providers, as well as GNSS augmentation providers, to operate accurately, the IGS participants have established a voluntary international network of reference and monitoring stations.[356] The network currently includes 400 stations around the globe, which track the services of the GNSS providers, such as GPS and GLONASS, and check

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348 *See id.* at 12.

349 *See id.*

350 *Id.*

351 *See* ICG, *Summary of the Eleventh Meeting of the Provider's Forum Held in Conjunction with the Eighth Meeting of the International Committee on Global Navigation Satellite Systems (ICG) 9,11 and 12 November 2013 Dubai, United Arab Emirates, available at* http://www.unoosa.org/pdf/icg/2013/PF-11/PF-11_Report.pdf (last visited Mar. 22, 2015) [hereinafter ICG, *Summary*].

352 *See* Terms of Reference of the Providers' Forum, *supra* note 320, at 2.

353 *See About*, INT'L GNSS SERV., http://igs.org/about (last visited Aug. 20, 2015).

354 *Id.*

355 *See id.*

356 *See id.*

the quality of GNSS receivers and other GNSS products.[357] The accumulated information is essential for navigation and positioning safety and is also a check on GNSS signal quality.[358] NASA's Jet Propulsion Laboratory in California provides a headquarters for the international GNSS Service.[359] The IGS system is intended to support all the GNSS services, including GLONASS.[360] In 2013, a special checking and monitoring service was arranged for GLONASS.[361] The voluntary IGS "is fully committed to expand to a true multi-GNSS service."[362]

1. *IGS Multi-GNSS Project*[363]

The IGS is currently conducting its Multi-GNSS Experiment (MGEX) for the purpose of transitioning the IGS into a more permanent global tracking and testing organization to standardize and test all aspects of GNSS.[364] Signal standardizing, testing, and monitoring is particularly important at this point in time when new GNSS systems, Galileo, BeiDou, GAGAN, and other systems (including space-based augmentation systems) are coming on line and the existing systems, GPS and GLONASS, are being updated.[365]

Based on its long experience in checking, monitoring, and archiving GNSS performance data, the IGS has now established

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357 *See id.*

358 *See id.*

359 *See International GNSS Service: Formerly the International GPS Service*, IGS CENTRAL BUREAU, http://igscb.jpl.nasa.gov (last updated Aug. 28, 2014).

360 *See* Divis, *Russians Consider IGS*, *supra* note 62.

361 *Id.*

> On April 1, 2013, the IGS launched its Real-Time Service (RTS) for GLONASS as a beta service with full operational capability expected by the end of [2013]. The RTS will provide free access to and free use of real time GLONASS orbital ephemerides and clock products.
>
> It [is]possible to use the real-time GLONASS observations collected by IGS to improve instantaneous estimates of the onboard clock offset [effect] . . . ."

Id.

362 *See* Montenbruck et al., *supra* note 284. "This article is based on a paper presented at the 4th International Colloquium on Scientific and Fundamental Aspects of the Galileo System held in Prague, Czech Republic, December 4 –6, 2013." *Id.*; *see also MGEX*, INT'L GNSS SERV., http://igs.org/mgex (last updated Oct. 10, 2014).

363 *See* Montenbruck et al., *supra* note 284.

364 *See id.*

365 *See id.*

a comprehensive all-inclusive international GNSS service.[366] On that basis, it has started the MGEX, which is being coordinated by its Multi-GNSS working group.[367] This kind of cooperation among the GNSS services is necessary in order to fully realize and enjoy the advantages of all GNSS systems supplementing and supporting each other in building the most dependable international positioning navigation and timing service. The multiplicity of GNSS signals leads to less ambiguity from the signals.[368] Furthermore, "the simple increase in the number of available satellites not only enhances navigation applications, but also offer[s] an increased number of signals for space weather applications that employ occultation techniques and ray tracing of the neutral atmosphere and ionosphere."[369]

Currently, the main objective of the IGS and of the Providers' Forum and its ancillary bodies is to support the ICG in promoting interoperability, as well as the ability of the four GNSS systems to supplement each other and to provide back-up support when other GNSS systems fail.[370] It is possible that ultimately the ICG should establish a world service standard that can be used to monitor all GNSS systems and that can become the common standard for all GNSS operations. Such a standard, even if voluntary, could be as important as the common performance standards maintained by the ICAO for aviation operations.[371]

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366 *See id.*

367 *Id.* It was thus the obvious alternative for Russian GLONASS to resort to when GLONASS was unable to build its own GLONASS monitoring stations in the United States. *See* Warren Ferster, *U.S. Sanctions, Russian Response Fraying Once-Strong Space Ties*, SPACE NEWS (May 16, 2014), http://spacenews.com/40593us-sanctions-russian-response-fraying-once-strong-space-ties/.

368 *See* Montenbruck et al., *supra* note 284.

369 *Id.*

370 *See About*, *supra* note 353; *Providers' Forum*, *supra* note 266.

371 *See* Montenbruck et al., *supra* note 284. It is with the objective of becoming a multi-GNSS service that the IGS is initiating its MGEX experiment. *See id.* The project is coordinated by an IGS working group. *See id.* The project is informational and educational. *See id.* It has established a GNSS network for the purpose of tracking, and it is additional to independent tracking and monitoring systems maintained by the GNSS providers themselves. *See id.* The need for tracking and monitoring arises not only from the increasing multitude of GNSS operators and satellites, but also from the individual GNSS systems themselves, which are becoming more complex. *See id.* For example, both GPS and GLONASS are adding a frequency for search and rescue services. *See* Yoan Gregoire et al., *MEOSAR: New GNSS Role in Search & Rescue*, INSIDE GNSS (Nov./Dec. 2014), http://www.insidegnss.com/node/4274. Initially the new signals will be ambiguous, but through testing and monitoring these signals will become more accurate. *See id.*

Specifically, the MGEX working plan is to create a comprehensive GNSS support system that will expand tracking; include more GNSS constellations; develop a multi-GNSS multi-signal differential code; standardize GNSS antennas; "establish common . . . standards for orbit and clock products"; and develop quality control tools.[372]

The MGEX plans illustrate that the GNSS industry needs standards to achieve maximum accuracy, safety, and efficiency. Interestingly, the standardization initiatives originate directly from participants who tend to represent industry rather than government;they tend to be technical rather than political. The initiatives constitute guidance leading to international technical uniformity. This kind of regulation, when observed internationally by the GNSS industry, can constitute soft international GNSS law.

F. Conclusions on UN Regulation

The case-in-point about GLONASS monitoring illustrates the need for international checking and monitoring of GNSS. GLONASS sought and was denied monitoring stations in the United States.[373] The participants in the UN International Committee on GNSS and its closely related GNSS Providers' Forum and the International GNSS Service are sensitive to the needs for international monitoring.[374] They are motivated to engage in transparent international checking and monitoring of global GNSS.[375] Thus, they collect and analyze data on the various GNSS systems, including GLONASS.[376] In doing so, they are establishing international practices approximating standards. They are establishing international soft law on GNSS.[377] The States can establish hard law, such as the U.S. statutes preventing GLONASS monitoring stations in the United States; of course, the soft law has to accommodate the hard law.[378] But the

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372 *Id.*

373 *See* Divis, *Russians Consider IGS*, *supra* note 62.

374 *See About*, *supra* note 353; *Providers' Forum*, *supra* note 266; UNOOSA, *ICG*, *supra* note 36.

375 *See About*, *supra* note 353; *Providers' Forum*, *supra* note 266; UNOOSA, *ICG*, *supra* note 36.

376 *See About*, *supra* note 353; *Providers' Forum*, *supra* note 266; UNOOSA, *ICG*, *supra* note 36.

377 *See* Shaffer & Pollack, *supra* note 242, at 715; *"Soft Law" in Outer Space*, *supra* note 70.

378 *See* Shaffer & Pollack, *supra* note 242, at 714–15; *"Soft Law" in Outer Space*, *supra* note 70.

GNSS experience shows that the soft law, established in the United Nations can accommodate the hard law. The soft law approach is flexible and can often circumvent and accomplish what the hard law cannot accomplish.

The United Nations fora are uniquely suited to formulate soft law GNSS standards. Whether those standards can eventually approach the mandatory standards formulated by ICAO for aviation remains to be seen. Military acceptance of civilian coordination and monitoring in the civilian ICG is yet another issue. The military has grown to tolerate civilian coordination of non-sovereign airspace by ICAO, including mandatory standards.[379] The civilian standards apply only to civilian aviation but the military accepts them.[380] A similar military attitude might develop for civilian soft law rules for international GNSS.

V. BILATERAL COORDINATION AND AGREEMENTS

A. BILATERAL COORDINATION BETWEEN THE UNITED STATES AND THE EU[381]

In 2004, the United States and the EU agreed to coordinate on a range of GNSS issues.[382] Four working groups were established: (1) "Radio frequency compatibility and interoperability"; (2) "Trade and civil applications"; (3) "Design and development of the next generation of systems"; and (4) "Security issues related to GPS and Galileo."[383] The two parties have met many more times since 2004 in the established working groups and in plenary to update existing coordination and begin new ones.[384]

B. BILATERAL COORDINATION BETWEEN THE UNITED STATES AND RUSSIA[385]

In 2004, the United States and Russia initiated coordination talks with the objective of establishing interoperability between GPS and GLONASS.[386] The parties established two working groups: (1) one on "radiofrequency compatibility and interoper-

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379 *See generally* ICAO, *Civil/Military Cooperation in Air Traffic Management*, at 4–5, 22, 24–42, ICAO Doc. Cir 330, AN/189 (2011), *available at* http://www.icao.int/apac/meetings/2012_cmc/cir330_en.pdf.

380 *See id.*

381 *See International Cooperation*, *supra* note 13.

382 *See id.*

383 *Id.*

384 *See id.*

385 *See id.*

386 *See id.*

ability"; and (2) another on "technical interoperability" of search and rescue GNSS activity.[387]

C. Bilateral Coordination Between the United States and China[388]

Technical discussions between the United States and China regarding compatibility and/or use of radiofrequency between GPS and BeiDou concluded in 2010.[389] In 2014, a special United States–China working group on GNSS cooperation was created.[390] The working group will coordinate interoperability, monitoring of GNSS services, signal interference, and protection of the spectrum and GNSS civil aviation issues.[391]

D. Other Bilateral Arrangements

The United States has also made bilateral arrangements with India, Japan, the United Kingdom, and others.[392]

VI. GREATER PARTICIPATION OF GNSS USERS IN INTERNATIONAL ORGANIZATION AND REGULATION OF GNSS SERVICES

The GNSS users represent a large variety of users ranging from airlines to surveyors.[393] They are not necessarily all interested in the same aspects of GNSS services.[394] Some are more interested in accuracy, others in keeping the common signals free of charge.[395]

The purpose of civilian GNSS is to meet the needs of GNSS users; therefore, GNSS interphase with users is very important.[396] The largest of the GNSS providers, GPS, holds active

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387 *Id.*

388 *See id.*; *see also* Gibbons, *China Plans to Complete BeiDou*, *supra* note 39.

389 *See International Cooperation*, *supra* note 13.

390 *See* Ran Chengqui, Dir., China Satellite Navigation Office, & Kenneth Hodgkins, Dir., Office of Space & Advanced Tech., U.S. Dep't of State, Joint Statement U.S.-China Civil Global Navigation Satellite Systems (GNSS) Cooperation (May 19, 2014), *available at* http://www.gps.gov/policy/cooperation/china/2014-joint-statement/.

391 *See id.*

392 *See International Cooperation*, *supra* note 13.

393 *See, e.g.*, *GPS Applications*, *supra* note 7.

394 *See, e.g.*, *GPS Applications*, *supra* note 7.

395 *See, e.g.*, Press Release, European Comm'n, *supra* note 34.

396 *See Civil GPS Service Interface Committee*, GPS.gov, http://www.gps.gov/cgsic/ (last updated Sept. 18, 2014).

public meetings with civilian users.[397] The GPS interphase is both national and international.[398] The Civil GPS Service Interface Committee (CGSIC) and the International Information Subcommittee (IISC) are unique GPS outreach efforts that provide points of contact, conduct studies, and establish excellent support for GPS management.[399]

The GNSS users, such as airlines and maritime operators, mostly express their views and exert their influence through their trade associations.[400] The airlines express their views in ICAO and their wishes are indicated in the ICAO Charter.[401] The maritime operators express their views in IMO.[402] Other users also act through their trade associations.[403] GNSS users have participated less actively in the UN International Committee on GNSS than the GNSS providers because the participation in those meetings is mostly by governments, although some governments include GNSS experts, such as manufacturers of GNSS equipment (in particular GNSS receivers), in their delegations.[404] The Providers' Forum is primarily for discussion of issues facing the GNSS providers.[405] However, the Providers' Forum could become a model for a similar institutional exchange of views with GNSS users and consideration of their interests. The International GNSS Service, which is a voluntary organization for both governmental and non-governmental bodies, is not particularly a forum for the GNSS users.[406]

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397 *See id.*

398 *See Civil GPS Service Interface Committee: International Information Subcommittee*, GPS.GOV, http://www.gps.gov/cgsic/international/ (last updated Sept. 15, 2014).

399 *See Civil GPS Service Interface Committee*, *supra* note 396; *Civil GPS Service Interface Committee: International Information Subcommittee*, *supra* note 398.

400 *See, e.g.*, *About ICS*, INT'L CHAMBER OF SHIPPING, http://www.ics-shipping.org/about-ics/about-ics (last visited Aug. 20, 2015); *About Us*, IATA, http://www.iata.org/about/Pages/index.aspx (last visited Aug. 20, 2015).

401 *See generally* ICAO Assemb. Res. A32-19, *supra* note 78; *see also, e.g.*, *IATA at 38th ICAO Assembly*, IATA, http://www.iata.org/policy/icao-assembly/Pages/index.aspx (last visited Aug. 20, 2015).

402 *See, e.g.*, Press Release, Int'l Chamber of Shipping, ICS Board Prepares for Important IMO Meeting (Feb. 11, 2014), http://www.ics-shipping.org/news/press-releases/view-article/2014/02/11/ics-board-prepares-for-important-imo-meeting.

403 *See, e.g.*, Dee Ann Divis, *GPS Industry Launches New Association: New Washington D.C. Group Is Backed by Coalition to Save Our GPS and GPS Industry Council*, INSIDE GNSS (Feb. 7, 2013), http://www.insidegnss.com/node/3416.

404 *See* UNOOSA *ICG Members*, *supra* note 36.

405 *See Providers' Forum*, *supra* note 266.

406 *See About*, INT'L GNSS SERV., *supra* note 353.

The kinds of issues of particular concern to GNSS users tend to be matters such as signal interference and availability and strength of the GNSS signals.[407] For example, users are very interested in the significantly greater strength of the third generation of GNSS satellites (for instance GPS III).[408] They have a fundamental interest in dual use because they fear that military authorities may terminate civilian uses of GNSS.[409] They favor guaranteed continuity of GNSS.[410] The users are interested in whether the providers will charge for their services, favoring not being charged.[411] The users are also interested in whether they can hold the providers liable for injury and damages caused by defective GNSS signals.[412]

International governance of GNSS could benefit from more sustained focus on the interests of GNSS users. Such focus could take the form of a special GNSS Users Forum. General consensus on the need for a special GNSS users' forum is forming within the ICG and its related bodies.[413] Both the ICG and the Providers' Forum would benefit from better understanding of the users' needs and requirements.

VII. APPRAISAL OF GNSS ALTERNATIVES

A. Is Separation of the GNSS Dual Use Functions a Realistic Alternative?

GNSS systems are dual use (with the exception of Galileo); they are built to serve both military and civilian purposes.[414] Being linked to military uses subjects civilian GNSS users to military dangers and policies. The U.S. military use of GPS was a motivation for the EU to develop its own separate GNSS (Galileo).[415] The EU was not willing to have its important navigation and position needs dependent on U.S. military policies.[416] This view is not changed by the fact that the volume of

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[407] *See, e.g., GPS Jamming and Interference Sparks UK Concerns, Technical Solutions,* Inside GNSS (Mar. 2, 2010), http://www.insidegnss.com/node/1979.

[408] *See Space Segment, supra* note 241.

[409] *See, e.g.,* Larsen, *Issues Relating to Civilian, supra* note 19, at 111.

[410] *See* Press Release, European Comm'n, *supra* note 34.

[411] *See id.*

[412] *See* Euro. Space Agency, *supra* note 194; Larsen, *Issues Relating to Civilian, supra* note 19, at 111.

[413] *See* ICG, *Summary, supra* note 351.

[414] *See* Larsen, *Issues Relating to Civilian, supra* note 19, at 111; Press Release, European Comm'n, *supra* note 34.

[415] *See* Larsen, *Issues Relating to Civilian, supra* note 19, at 114.

[416] *See id.*

civilian GNSS functions now significantly exceeds military functions.[417] GNSS is basically a free government-provided service and the military continues to be the provider.[418] There are efforts at partial separation of civilian and military GNSS functions.[419] Military functions are increasingly encrypted while civilian functions are not encrypted.[420] However, *de facto* signal separation is now occurring;[421] civilian and military users increasingly use different radiofrequency.[422] Decision-making regarding military GNSS uses is less frequently extended to the civilian sector.[423] Furthermore, increasingly civilian international coordination and interoperability is possible and is taking place in the United Nations and in bilateral arrangements.[424] But the control of GNSS still remains with the military authorities.[425]

Total separation of GNSS dual use functions is unlikely to happen for political, military, and financial reasons. GNSS continues to be very valuable to the military; provider countries, such as the United States, are therefore willing to provide generous financing for their GNSS.[426] These very same provider countries, again with the exception of Galileo, are unlikely to be equally generous with separate civilian GNSS.[427]

B. Possible Stronger UN Management Role

There are several arguments for stronger UN management of multiple GNSS systems. Primarily, the multiplicity of GNSS systems, the need of GNSS providers to know about the existence

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417 *See* NDP Consulting Grp., *supra* note 2.

418 *See* 2010 Nat'l Space Policy, *supra* note 11, at 5; de Selding, *China Official Beidou Gear, supra* note 177; GPS.gov, *supra* note 6; *Russian Global Positioning Satellites: GLONASS GPS, supra* note 23; *Satellite Wars: China Unveils 'Cheaper' Answer to GPS, supra* note 85.

419 *See, e.g.*, Larsen, *Issues Relating to Civilian, supra* note 19, at 112; *GNSS Frequently Asked Questions–GPS*, FAA, http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/faq/gps/ (last updated Jan. 14, 2015).

420 *See* Sherman Lo et al., *Signal Authentication: A Secure Civil GNSS for Today*, Inside GNSS (Sept./Oct. 2009), http://www.insidegnss.com/node/1633.

421 *See, e.g., GNSS Frequently Asked Questions–GPS, supra* note 419.

422 *See id.*

423 *See* Larsen, *Issues Relating to Civilian, supra* note 19, at 114.

424 *See* Larsen, *Issues Relating to Civilian, supra* note 19, at 113–14.

425 *See* GPS.gov, *supra* note 6; *Russian Global Positioning Satellites: GLONASS GPS, supra* note 23; *Satellite Wars: China Unveils 'Cheaper' Answer to GPS, supra* note 85.

426 *See, e.g., Fiscal Year 2015 Program Funding, supra* note 3.

427 *See, e.g., id.*; Divis, *Congress Slashes Civil GPS Funding, supra* note 3.

and capabilities of each other in order to avoid collisions and experience radio interference with GNSS signals, the need of GNSS users to have available a seamless web, the need for maximum known availability of each GNSS system to back up the other systems, and the general need for space situational awareness all make international coordination and interoperability very important.[428] Each GNSS provider and user needs cooperation for greater operating efficiency and accuracy. The more efficiently GNSS is centrally coordinated and administered, the greater its effectiveness.

Second, there is a need for impartial adjustment of GNSS signals to effect greater accuracy. Without reference towers on Earth's surface around the globe, GNSS is not sufficiently accurate to allow airplanes to land at major cities.[429] Central management of reference and monitoring towers around the globe benefits GNSS accuracy. A stronger UN management role would resolve uncertainties and would coordinate GNSS services.

Third, interoperability requires a stronger unified management role: Both the GNSS providers and GNSS users need a central point at which to coordinate in order to create a seamless web of satellite positioning, navigation, and timing. The ICG, Providers' Forum, and the IGS show that the UN can provide such a coordination forum.[430]

Fourth, considering that GNSS is virtually operated by the military, it would be difficult for the military authorities to cede to civilian authorities the establishment of uniform international operating standards, recommended practices, and procedures. GNSS satellites are subject to many national restrictions because of their military value.[431] Thus, establishment of binding international standards and recommended practices and procedures are unlikely to be negotiated.

However, a stronger UN management role is subject to the same resistance that occurred when the issue of a possible separation of civilian and military GNSS arose. Military GNSS author-

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[428] *See* ICAO Doc. 9750-AN/963, *supra* note 75, at 35, 37.

[429] *See* Schmitt & Schmidt, *supra* note 25.

[430] *See About*, *supra* note 353; *Providers' Forum*, *supra* note 266.

[431] *See* Dee Ann Divis, *U.S. Eases Export Regulations for GPS Receivers*, INSIDE GNSS (May 31, 2014), http://www.insidegnss.com/node/4051. International trade in GPS technology is restricted by the U.S. International Trade in Arms Regulations (ITARs). *See id.* These restrictions are now being revised and become less strict. *See id.* Much GNSS technology is being moved from the strict U.S. Munitions List (USML) to the U.S. Department of Commerce Control List (CCL). *See id.*

ities are reluctant to relinquish total control because such relinquishment would interfere with possible unilateral control of GNSS for military operations.[432]

In conclusion, the "soft law" coordination, guidance, and practices gradually developing within the UN framework fill a need and can be a stepping stone to more international coordination.

C. Continued National GNSS but Subject to Uniform International Standards on the ICAO Model[433]

Virtually all countries are members of, and participate in, ICAO.[434] The Convention on International Civil Aviation provides ICAO with the mandate to promote safety of flight in international air navigation .[435] Furthermore, the Convention's Article 37 gives ICAO the function of establishing uniform international standards and recommended practices and procedures.[436] A similar central regime for GNSS could establish uniform operating international standards for GNSS. Under this model, standards and recommended practices and procedures for GNSS would be established centrally. It is significant that the Chicago Convention governs only civilian flight.[437] It does not govern military flight.[438] Nevertheless, the military services adhere to the civilian ICAO flight standards.[439] Similarly, civilian GNSS standards and recommended practices might be observed by the military.

The existing regulatory framework for GNSS is weak; in the long run, a much stronger international coordination structure, more like ICAO, is needed—one that can establish and enforce uniform standards for GNSS.

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[432] *See* Larsen, *Issues Relating to Civilian*, *supra* note 19, at 113–14.

[433] ICAO is a sub-agency of the UN. *See About ICAO*, ICAO, http://www.icao.int/about-icao/Pages/default.aspx (last visited Aug. 20, 2015).

[434] *See Member States*, ICAO (Oct. 31, 2013), http://www.icao.int/Member-States/Member%20States.English.pdf.

[435] Chicago Convention, *supra* note 69, art. 44(h).

[436] *See id.* art. 37.

[437] *Id.* art. 3.

[438] *See id.*

[439] *See generally* ICAO, *supra* note 379, at 4–5, 22, 24–42.

D. INTERNATIONAL GNSS COORDINATION: VOLUNTARY INTERNATIONAL STANDARDS, RECOMMENDED PRACTICES AND PROCEDURES ON THE INTERNET MODEL

One may look to the Internet for a model. Both GNSS and the Internet have military origins.[440] GNSS, like the Internet, is increasingly like a public utility. Furthermore, it is free of charge like the Internet. There are significant differences between GNSS and the Internet, so an analogy is not easy, but there are similarities. Could the similarity between these two utilities and the way the Internet developed be a guide for future International GNSS coordination and regulation? Despite its military origin, the Internet has a significant history of self-regulation in the sense that the organizations and persons involved in its development have continued to exercise strong influence on its regulation.[441] The non-profit civilian Internet Corporation for Assigned Names and Numbers (ICANN) coordinates the databases for assignment of names (e-mail addresses) on the Internet.[442] It performs the technical administration of assigning names both for Internet uses in the United States and in the remainder of the world.[443] It thus has a central role in maintaining stability of the Internet itself.[444]

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[440] *See* Elizabeth Palermo & Lauren Cox, *Who Invented the Internet?*, LIVE SCIENCE (Jan. 15, 2014), http://www.livescience.com/42604-who-invented-the-internet.html.

[441] *See id.*; Senator Brian Schatz, *Open Internet that Works for Everyone*, HUFFINGTON POST (Feb. 4, 2015, 3:00 p.m.), http://www.huffingtonpost.com/sen-brian-schatz/an-open-internet-that-wor_b_6612798.html.

[442] *See Resources: Beginner's Guides*, ICANN.ORG, https://www.icann.org/resources/pages/beginners-guides-2012-03-06-en (last visited Aug. 20, 2013).

[443] *See id.*

[444] *See Bylaws for Internet Corporation for Assigned Names and Numbers: A California Nonprofit Public-Benefit Corporation*, art. I, ICANN.ORG (July 30, 2014), https://www.icann.org/resources/pages/governance/bylaws-en [hereinafter *Bylaws*]; *see also ICANN*, WIKIPEDIA, http://en.wikipedia.org/wiki/ICANN (last modified Mar. 15, 2015). Different international and national agencies, other than ICANN, are also involved in the administration of the Internet. *See, e.g.*, *ICC to Administer New Internet Name Disputes*, INT'L CHAMBER OF COMMERCE (June 13, 2012), http://www.iccwbo.org/News/Articles/2012/ICC-to-administer-new-Internet-domain-name-disputes/; *Internet Policy*, NTIA, http://www.ntia.doc.gov/category/internet-policy (last visited Aug. 20, 2015). The Internet uses radiofrequency allocated by the ITU. *See Radiocommunication Sector*, ITU, http://www.itu.int/net/about/itu-r.aspx (last updated Mar. 23, 2015). Those are distributed by national governments. *See, e.g.*, *Radio Spectrum Allocation*, FCC.GOV, http://www.fcc.gov/encyclopedia/radio-spectrum-allocation (last visited Aug. 20, 2015). In the United States they are allocated by the FCC. *See id.* Currently the FCC is involved in deciding whether the access to the Internet should be based on the principle of net neutrality. *See*

Represented in ICANN is a cross section of the Internet community.[445] ICANN consists of the Internet stakeholders: ICANN brings all the stakeholders together in order to agree on basic regulatory policies for its assigned Internet responsibility.[446] Consequently, instead of a top-down regulation of the Internet, ICANN is able to provide bottom-up policy making and administration.[447] Granted, this arrangement is by agreement with the U.S. Department of Commerce; however, the Department of Commerce intentionally turned this Internet responsibility over to the stakeholders.[448] ICANN assumed responsibility for establishing policy for distribution of domain name spaces (DNS), subject ultimately to Department of Commerce oversight.[449]

ICANN's governing board is selected by the Internet stakeholders.[450] Additionally, ICANN relies on receiving advice and information from supporting organizations, including (1) the Governmental Advisory Committee, representing a multitude of national governments; (2) the At-Large Advisory Committee, which represents interested groups from a large number of countries; (3) the Root Server System Advisory Committee, which provides technical advice; (4) the Security and Stability Advisory Committee, which gives advice on security; and (5) the Technical Liaison Group, which represents international technical bodies concerned with the internet.[451]

Senator Schatz, *supra* note 441. Net neutrality means that all users can access the Internet on equal terms. *See id.* Large volume users would not be able to enter the Internet faster by paying more for access than others if the principle of equality is adopted. *See id.* Other countries control Internet access. *See* Mark Scott, *Europe Takes Another Look at Net Neutrality*, N.Y. TIMES (Nov. 25, 2014, 12:16 PM), http://bits.blogs.nytimes.com/2014/11/25/europe-takes-another-look-at-net-neutrality/?_r=0. China claims respect for its national sovereign rights to regulate the Internet within its borders. *See* Paul Mozur & Jane Perlez, *Gregarious and Direct: China's Web Doorkeeper*, N.Y. TIMES (Dec. 1, 2014), http://www.nytimes.com/2014/12/02/world/asia/gregarious-and-direct-chinas-web-doorkeeper.html. China restricts the Internet flow of information and maintains censorship. *See id.*

[445] *See Bylaws*, *supra* note 444, art. XI.

[446] *See id.* art. X.

[447] *See id.*

[448] *See* Press Release, John Murphy, Vice President for Int'l Affairs, U.S. Chamber of Commerce, U.S. Chamber Statement on Department of Commerce's Transition of ICANN (Mar. 20, 2014), *available at* https://www.uschamber.com/press-release/us-chamber-statement-department-commerce-s-transition-icann; *ICANN*, NTIA, http://www.ntia.doc.gov/category/icann (last visited Aug. 20, 2015).

[449] *See ICANN*, *supra* note 448.

[450] *Bylaws*, *supra* note 444, art. VII.

[451] *See id.* arts. XI, XI-A.

ICANN's functions have not been without controversy, and many users want UN bodies to take over ICANN's functions.[452] The United States may be inclined to modify or relinquish its Internet oversight over DNS.[453] In April 2014, Brazil convened a "Global Multistakeholder Meeting on the Future of Internet Governance" with participation from 850 delegates, among them delegates from the United States.[454] The United States expressed willingness to relinquish its ICANN oversight role.[455] Several options are under consideration. Russia, China, and several other States favor UN oversight, but others including the United States fear that that option could lead to restrictions on freedom of expression on the Internet.[456] India and others want the Internet to be internationalized, subject to international oversight, and Brazil proposes an international code for use of the Internet to ensure free access to the Internet, subject to net neutrality.[457] Thus, an international rather than a U.S. oversight of the Internet may be forthcoming.[458]

The Internet is inherently global in nature. Likewise, the GNSS would not be nearly as useful and important if it covered only part of the globe. Both are natural international public utilities on which the whole world has become fundamentally dependent. GNSS differs from the Internet in that there is only one Internet while there are four global GNSS services.[459] GNSS suffers the additional problem of making the four GNSS services

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[452] *See* Larry Downs, *Why is the UN Trying to Take Over the Internet?*, FORBES (Aug. 9, 2012), http://www.forbes.com/sites/larrydownes/2012/08/09/why-the-un-is-trying-to-take-over-the-internet/2/.

[453] *See* Press Release, John Murphy, *supra* note 448.

[454] *See Global Multistakeholder Meeting on the Future of the Internet Governance*, NETMUNDIAL (Nov. 26, 2013), http://netmundial.br/blog/2013/11/26/global-multistakeholder-meeting-on-the-future-of-the-internet-governance/; Michael Daniel et al., *A Major Win for the Open Internet*, DIPNOTE: DEP'T OF STATE OFFICIAL BLOG (Apr. 29, 2014), https://blogs.state.gov/stories/2014/04/29/major-win-open-internet.

[455] *See* Leo Kelion, *Future of the Internet Debated at NetMundial in Brazil*, BBC NEWS (Apr. 23, 2014), http://www.bbc.com/news/technology-27108869.

[456] *See id.*

[457] *See Brazil: Internet 'Bill of Rights' Approved in Key Vote*, BBC NEWS (Mar. 27, 2014), http://www.bbc.com/news/blogs-news-from-elsewhere-26771713; Mahima Kaul, *India Fails to Throw Weight Behind NETmundial*, INDEXONCENSORSHIP .ORG (May 1, 2014), http://www.indexoncensorship.org/2014/05/india-fails-throw-weight-behind-netmundial/.

[458] *See Global Multistakeholder Meeting on the Future of the Internet Governance*, *supra* note 454.

[459] *See* Montenbruck et al., *supra* note 284.

act as one global service like the Internet.[460] The existence of the four systems makes the coordination problem substantially more difficult.[461] But that only means that there are more problems to resolve. That does not change the fundamental issue, which is to make GNSS into a useful international public utility like the Internet.

The ultimate question, then, is whether order in international GNSS can best be established from the bottom up, that is, to give maximum room for the stakeholders to establish universal order of the GNSS, or whether order can best be established from the top-down, that is, for the governments to dictate international order in GNSS. Both the Internet and GNSS are very rapidly developing technologies in need of considerable flexibility to accommodate the changing technology. Leaving maximum room for the stakeholders themselves to participate in and influence the decision-making is therefore valuable in shaping and thus promoting GNSS technology. The history of the Internet and ICANN's role in regulating the day-to-day Internet problems show the advantages of the bottom-up approach to GNSS regulation.[462] The current arrangement of the voluntary ICG, its related groups of stakeholders in the Providers' Forum, and the IGS and its further offshoot, the MGEX, provide considerable promise for bottom-up establishment of order on a voluntary basis of consensus.[463] The stakeholders have a strong motivation to coordinate and establish international order because the alternative is chaos, which is contrary to the interests of the GNSS stakeholders.

The military aspect of GNSS is the big factor in the equation.[464] Because the military authorities control and use GNSS for different purposes than the civilian users, the military has different priorities.[465] The example of the U.S. legislation restricting deployment of Russian GLONASS monitoring towers in the United States shows that the military interest must be considered, even though the civilian GNSS use vastly exceeds the mili-

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460 *See id.*

461 *See id.*

462 *See Bylaws, supra* note 444, art. I; Palermo & Cox, *supra* note 440; Senator Schatz, *supra* note 441.

463 *See About, supra* note 353; *Providers' Forum, supra* note 266; UNOOSA, *ICG, supra* note 36.

464 *See* Larsen, *Issues Relating to Civilian, supra* note 19, at 114, 116–17.

465 *See id.*

tary use.[466] Thus, the stakeholders must be flexible enough to take into consideration not only GNSS technical aspects, but also the military policy interests. The Internet experience (ICANN) has been to allow room for the military interests and to still coordinate and regulate the civilian aspects of the Internet. Likewise, the current strong stakeholder influence on establishing order in global GNSS must allow adequate flexibility for the military interests to exercise their special prerogatives. The ability of GLONASS to arrange global monitoring through the IGS is an indication of needed military flexibility.

The current strong stakeholder input into Internet order through ICANN is somewhat similar to GNSS order through the IGS and its related groups. But can that arrangement adequately resolve coordination problems? As described above, there is international pressure on ICANN right now for greater and more efficient order through the United Nations.[467] GNSS international coordination and interoperability is already under the umbrella of the United Nations.[468] The United Nations has the IGS and its offshoot, the MGEX;[469] therefore, the pressure for international stakeholder participation is less an issue for GNSS than for the Internet.[470] This situation favors continuation of and further development of the existing system of international coordination and interoperability. In the long term it is likely that international standards and recommended practices (SARPS) for various aspects of international GNSS will be necessary.

In this context, it is also important to draw attention to the existing United Nations involvement in GNSS.[471] The heavy dependence of GNSS on radiofrequency has already necessitated deferral to a UN agency: the issue of allocation of GNSS radiofrequency and related satellite orbital locations to the ITU.[472] ITU is a sub-agency of the United Nations.[473] Some aspects of

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466 *See* NDP Consulting Grp., *supra* note 2; Schmitt & Schmidt, *supra* note 25.

467 *See* Downs, *supra* note 452; Kelion, *supra* note 455.

468 *See, e.g., Providers' Forum*, *supra* note 266; UNOOSA, *ICG*, *supra* note 36.

469 *See MGEX*, *supra* note 362.

470 *See* Kelion, *supra* note 455.

471 *See* ITU, *Legal Framework*, *supra* note 69.

472 *See About ITU: Overview*, *supra* note 131. Radiofrequencies are subject to the ITU radio regulations. *See* ITU, *Legal Framework*, *supra* note 69; *see also supra* Section III(G).

473 *See About ITU: Overview*, *supra* note 131.

GNSS will have to be arranged through international rulemaking.[474]

VIII. CONCLUSION

The dual-purpose aspect of GNSS technology is a sensitive political issue. Being largely in control of military authorities, (except for Galileo) it is difficult for civilians to regulate new development and new situations. New soft law is developing in UN fora to minimally regulate this important utility.[475] Consequently, international civilian authorities have managed to establish some order in this confusing field.[476] However, development of soft law regulation is limited, as shown by the case of the GLONASS request for monitoring and reference stations on Earth arose, and the hard law used to counter this request.[477] This, in turn, led international coordinators to agree on establishing monitoring and reference stations within the UN framework.[478]

The existing international coordination of GNSS within the International Committee on GNSS is entirely voluntary, but it is motivated by necessity because it is in the self-interest of the providers to know about each other and to some extent help each other.[479] They need each other in order to operate effective and accurate global systems. The more they cooperate, the

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[474] *See* Press Release, Office of the Spokesperson, U.S. Dep't of State, Outcomes from the International Telecommunication Union 2014 Plenipotentiary Conference in Busan, Republic of Korea (Nov. 10, 2014), *available at* http://www.state.gov/r/pa/prs/ps/2014/11/233914.htm. At its 2014 Plenipotentiary Conference, the ITU declined to become more involved in regulation of the Internet. *See* Danielle Kehl, *Final Dispatch from Busan: Closing the Books on the 2014 ITU Plenipotentiary Conference*, OPEN TECH. INST. (Nov. 10, 2014), http://www.newamerica.org/oti/final-dispatch-from-busan-closing-the-books-on-the-2014-itu-plenipotentiary-conference/. At the Conference, the United States expressed opposition to ITU regulations that would "inhibit[ ] free flow of data;" that would "regulate[ ] Internet content and service companies;" and that would "undermine[ ] the [present] multi-stakeholder" oversight. *See* Press Release, Office of the Spokesperson, *supra* note 474.

[475] *See* ICAO Assemb. Res. A32-19, *supra* note 78, at V-3; Montenbruck et al., *supra* note 284; UNOOSA, *ICG*, *supra* note 36.

[476] *See* Montenbruck et al., *supra* note 284; UNOOSA, *ICG*, *supra* note 36.

[477] *See* Schmitt & Schmidt, *supra* note 25.

[478] *See id.* However, what comes around goes around; Russia retaliated by terminating "10 [U.S.] GPS signal-reception stations" on Russian territory. *See* Ferster, *supra* note 367. Russia found another "soft" law approach to resolve this problem in the United Nations. *See* Divis, *Russians Consider IGS*, *supra* note 62; *see also supra* Section IV(B).

[479] *See* UNOOSA, *ICG*, *supra* note 36.

more accurate they can become, and accuracy is the essence of GNSS positioning navigation and timing. All the benefits of GNSS flow from the increased accuracy and safety of the GNSS operations. It is interesting that the spirit of voluntary cooperation exists not only among the governments in the ICG, which is UN-based, but also in the IGS, which is an auxiliary but voluntary association of more than 200 agencies and private institutional bodies formed for the purpose of creating the highest standards of GNSS.[480] The IGS is now creating the MGEX for the purpose of establishing a global GNSS tracking organization with the goal of standardizing GNSS operations.[481] It is amazing that the urgent need for international GNSS coordination has materialized into the kind of organization needed for effective GNSS operation. However praiseworthy this effort is, it does encounter hard law limits as presented by the national law limiting coordination.[482] Nevertheless, voluntary coordination is currently the most beneficial tool for future development of GNSS.

Need for international coordination is driven by the urgency of greater space situational awareness.[483] The increasing congestion of outer space traffic—whether it is scarcity of radio frequencies, danger of space debris, or desire to avoid dangerous encounters—calls for transparency in outer space.[484] UN coordination provides desired transparency.[485] It also provides for greater over-all safety.[486]

Alternative strategies are possible. States could allow the UN GNSS committees (ICG, Providers' Forum, ICS, as well as COPUOS) to develop further soft law regulation, as need arises. That could involve greater participation of the users of GNSS. Another alternative would be an international organization for GNSS on the model of ICAO that could formulate international GNSS standards and recommended practices. A more far-fetched alternative would be to treat GNSS as a public utility like the Internet giving the stakeholders authority to administer and

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480 *See About, supra* note 353; UNOOSA, *ICG, supra* note 36; UNOOSA *ICG Members, supra* note 36.

481 *See* Montenbruck et al., *supra* note 284.

482 *See* Schmitt & Schmidt, *supra* note 25 (U.S. Congress effectively denying GLONASS monitoring stations in the United States).

483 Paul B. Larsen, *Outer Space Traffic Management: Space Situational Awareness Requires Transparency, in* PROCEEDINGS OF THE INTERNATIONAL INSTITUTE OF SPACE LAW 2008 338 (Corinne M. Jorgenson ed., 2009).

484 *See id.* at 343–44.

485 *See id.* at 343–44, 348.

486 *See id.* at 343–44, 349.

allocate the benefits of the utility. Any of these alternatives would have to accommodate the fact that GNSS is dual use provided by the military but most heavily used by civilians. It must be recognized that we have become dependent on GNSS as we have become dependent on the Internet. Necessity will therefore drive change.