# NOTE

## SOLAR POWER SATELLITES: THE RIGHT TO A SPOT IN THE WORLD'S HIGHEST PARKING LOT

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## I. INTRODUCTION

When Dr. Peter Glaser first proposed the concept of space-based solar power ("SBSP") in 1968, it was treated more like a pipe dream than a realistic proposal.[1] SBSP is a technology that harnesses the sun's energy twenty-four hours a day, that works not only when we have daylight, but also at night, during rain or snow and even on cloudy days.[2] People currently gather solar energy for electric use by placing solar panels on the ground and rooftops, but this is not necessarily the best method for gathering solar power.[3] A more efficient way to gather solar energy is to launch satellites into orbit around the Earth, where the satellites can capture solar energy, change it into another wavelength and send it to Earth where power stations convert it into usable electricity.[4] While many countries spend billions of dollars on land-based solar power, which is much less efficient than solar power systems in space, most people are unaware of SBSP technology.[5]

In the late twentieth century, studies confirming the feasibility of SBSP marked the first step toward realizing Dr. Glaser's futuristic proposal.[6] From a scientific standpoint, sending satellites into orbit and building receiving stations on the ground were both feasible because the applicable technology dates back to the 1960s.[7] Even though the science was feasible, a sustainable legal framework for implementing SBSP technology did not exist in the late twentieth century, nor does such a framework exist today.[8] SBSP necessarily involves utilizing outer space for commercial purposes, and international agreements prohibit any country from appropriating space.[9] Yet nations

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[1] *Technical Feasibility of Space Solar Power: Hearing Before the Subcomm. on Space and Aeronautics of the H. Comm. on Sci.*, 106th Cong. 35 (2000) (statement of Ralph Nansen, President, Solar Space Industries) [hereinafter Testimony of Ralph Nansen].

[2] *Id.*

[3] *Id.*at 36-37.

[4] *See id.* at 38.

[5] *See id.* at 32; Royce Jones, *Alternative Orbits: A New Space Solar Power Reference Design*, Online Journal of Space Communication, Issue 16, Dec. 1, 2010, http://spacejournal.ohio.edu/issue16/jones.html.

[6] Testimony of Ralph Nansen, *supra* note 1, at 35-36.

[7] *See id.* at 39.

[8] Fabio Tronchetti, *The Exploitation of Natural Resources of the Moon and Other Celestial Bodies: A Proposal for a Legal Regime,* STUDIES IN SPACE LAW 2-4 (F.G. von der Dunk et al. eds., 2009).

[9] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, art. I, Jan. 27, 1967, 18 U.S.T.

negotiated these international agreements when space exploration was in its infancy.[10] The commercialization of outer space supports the idea that the international community may allow the appropriation of space for the mutual benefit of the world. In particular, SBSP has benefits that may outweigh the harms of allowing the appropriation of space.

Companies that place telecommunications satellites into orbit currently depend on a system for allocating orbital slots, which is managed by the International Telecommunications Agency of the United Nations.[11] It is not clear whether this agency would, or should, be tasked with managing orbital slots for SBSP satellites. Furthermore, the current system of orbital slot allocation is inefficient and deprives willing and able nations from accessing orbital slots.[12]

One solution to the legal hurdle of orbital slot allocation described above may be to establish a new international agency to manage these satellite systems.[13] Another answer may be to require launching countries to sign a separate international agreement related to orbital slot allocation for SBSP satellites.[14] Finally, another technologically feasible alternative is to place SBSP satellites into a lower earth orbit, where slots are so abundant that they are not normally sought or allocated.[15] This alternative would avoid an international debate regarding property rights in space and thereby bypass the slot allocation issue.

Another legal concern of using SBSP is whether the satellites that beam energy to Earth are allowed under international treaties that prohibit military uses of outer space.[16] If it is possible to convert SBSP satellites into weapons that fire laser or microwave beams to the Earth, international treaties may prohibit countries from using SBSP satellites.[17] SBSP is a new technology that can help solve the energy crisis, but it may not be possible without a defined legal environment for the use of outer space. This note will discuss the above legal issues that concern operating SBSP satellites in orbit around the Earth.

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1810, 610 U.N.T.S. 2015 [hereinafter Outer Space Treaty of 1967], *available at* http://www.state.gov/www/global/arms/treaties/space1.html.

[10] *See id*. at 2-4, 172-73.

[11] *Id*. at 168.

[12] *See* discussion *infra* Parts IV-V.

[13] *See id*.

[14] *See infra* Part V.

[15] *See* discussion *infra* Part VI. *See generally* Jones, *supra* note 5.

[16] *See infra* Part VII.

[17] *Id*.

## II. PAST, PRESENT, AND FUTURE APPLICATIONS OF SBSP

### *A. The origins of SBSP and its mechanics*

Before analyzing the legal implications of SBSP, it is necessary to understand how the technology works. For the world to change currently accepted international treaties, countries must regard the concept as realistic, beneficial, and non-threatening.[18] The 1960s were only the beginning of the Space Age and space-based solar power was ahead of its time.[19] In 1964, William C. Brown demonstrated the use of microwaves to wirelessly send power by powering a miniature helicopter.[20] During World War II, Brown worked on improving the design of microwave radar.[21] At that time, he developed a microwave amplifier called the Amplitron and started experimenting with wireless power transfer.[22] Under an Air Force contract, Brown used a cavity magnetron, which is similar to the device that runs a microwave oven, to produce microwaves that he sent to a diode receiver attached to a helicopter.[23] In 1964, Brown demonstrated on the CBS Evening News with Walter Cronkite how microwaves beamed to the helicopter enabled it to fly for over ten hours.[24] Brown's experiment showed the basic premise of wireless power transmission as a transfer of energy emitted by a cavity magnetron and captured by diode receiver.[25]

Studies done in the 1980s and 1990s confirmed that a solar power satellite system is technically feasible.[26] In 2000, Ralph Nansen, the president of Solar

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[18] *See infra* Part V.3.

[19] *See* Testimony of Ralph Nansen, *supra* note 1 (stating that solar power was first conceived in 1968).

[20] *Analyzing Microwave Power Transmission & Solar Power Satellite Systems*, Aruvian's Research, RESEARCH AND MARKETS, Jan. 2011, http://www.researchandmarkets.com/reports/604386/analyzing_microwave_power_transmission_and_solar. Many people consider Brown to be the father of microwave power transmission.

[21] *Id.*

[22] *Id.*

[23] *See id.*

[24] *Id.*

[25] *Id.*

[26] The Department of Energy and NASA jointly investigated the concept of SBSP by analyzing both technical and social issues. *See Solar Power Satellites*, Office of Technology Assessment, August 1981, *available at* http://www.nss.org/settlement/ssp/library/1981-OTA-SolarPowerSatellites.pdf (analyzing the Energy Context, International and Military

Space Industries, testified before Congress that:

> No research is required to develop the energy source for SBSP satellites. It already exits. The sun is a full scale, stable, long-life fusion reactor, located at a safe distance. All that is required is to design and build a conversion system that can operate in the benign environment of space. The basic technologies are all known and proven.[27]

Nevertheless, no practical experiments were conducted because even an experimental satellite power system would have cost billions of dollars to develop.[28] The challenge was not technology but economics and legal issues.[29] Solar power involves placing satellites into space, outside the sovereign territory of any nation, to deliver energy to Earth via beams that pass through the atmosphere.[30] Therefore, countries need to coordinate international agreements that establish available microwave transmission frequencies, satellite locations, and other necessary features of space operations in order to avoid international conflicts.[31]

### *B. Solution to an international energy crisis*

There are now several companies dedicated to successfully creating a solar power satellite system. Space Energy is a company that plans to develop the first solar power satellite and transmit electricity to the Earth's surface by creating and launching a test satellite into low earth orbit.[32] If the prototype works, Space Energy seeks to enter into power supply contracts with

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Implications, public issues, and Environment and Health); *Electric Power from Orbit: A Critique of a Satellite Power System*, National Research Council of the National Academy of Sciences, 1981, *available at* http://www.nss.org/settlement/ssp/library/1981NRC-ElectricPowerFromOrbit-1.Report.pdf (analyzing the Challenges of SPS, Technological Aspects, Economic Aspects, Environmental Effects, Sociopolitical Factors, and an Examination of the Concept Development).

[27] Testimony of Ralph Nansen, *supra* note 1.

[28] *See id*.

[29] *See id*.

[30] *Id*.

[31] *Id*.

[32] SPACE ENERGY, PROJECT OVERVIEW, http://www.spaceenergy.com/s/Projects.htm (last visited Aug. 14, 2012). Space Energy is an international company with offices in the United States and Switzerland.

customers and launch larger scale satellites into orbit around the Earth.[33] LaserMotive is a Seattle-based company that develops laser power beams to transmit electricity without wires.[34] The company boasts various applications of wireless power transmission technology including powering unmanned aerial vehicles, launching rockets via laser power and beaming energy from satellites to the Earth.[35]

In 2006, U.S. Air Force Lieutenant Colonel Michael J. Hornitschek wrote *War Without Oil*, a report on the challenges facing the world as it seeks to decrease its dependence on oil.[36] The report projects that the United States' demand for oil is expected to grow by thirty-seven percent by 2025, at which point the United States will be importing sixty-eight percent of its oil.[37] Hornitschek projects a scenario in which the world would get into an international conflict over the last remaining oil.[38] The National Security Space Office ("NSSO") of the Pentagon considered this report and analyzed ways to prevent such a scenario.[39] A 2007 NSSO study concluded that space-based solar power is a viable solution to the looming international energy crisis.[40]

People now live in a society that has a growing demand for energy, while natural resources are being depleted.[41] On November 19, 2008, James Michael Snead wrote a report, about reducing our reliance on oil and what people

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[33] *Id*.

[34] LASERMOTIVE, WELCOME TO LASERMOTIVE, http://lasermotive.com (last visited Aug. 14, 2012).

[35] *Id*.

[36] MICHAEL J. HORNITSCHEK, WAR WITHOUT OIL: A CATALYST FOR TRUE TRANSFORMATION 11 (Ctr. for Strategy & Tech., Occasional Paper No. 56 2006), *available at* www.au.af.mil/au/awc/awcgate/cst/csat56.pdf.

[37] *Id*. at 12.

[38] *Id*.

[39] NAT'L SECURITY SPACE OFFICE, SPACE-BASED SOLAR POWER AS AN OPPORTUNITY FOR STRATEGIC SECURITY, 32 (National Security Space Office, Report to the Director 2007), *available at* http://www.nss.org/settlement/ssp/library/final-sbsp-interim-assessment-release-01.pdf.

[40] *Id*. at 12-14.

[41] *See* JAMES MICHAEL SNEAD, THE END OF EASY ENERGY AND WHAT TO DO ABOUT IT 46 (Nov. 19, 2008), http://mikesnead.net/resources/spacefaring/white_paper_the_end_of_easy_energy_and_what_to_do_about_it.pdf. See Figure 2 for an analysis of United States' and worldwide energy consumption and production estimates for 2010.

would need to replace oil in the future.[42] Snead's study predicts that by 2100, the United States will need 1,754 gigawatts ("GW") of sustainable electrical power supply.[43] However, nuclear, geothermal, hydroelectric and wind energy would be able to supply only 533 GW or thirty-one percent of the energy Snead says the U.S. will need.[44] While SBSP alone would not solve the energy crisis, countries could use SBSP to supplement other forms of energy and thereby decrease the energy production gap Snead predicts.[45]

One concern that people have about SBSP is whether it is safe.[46]The physics of wireless power transfer is understood and well documented, however, and wireless power transfer is harmless to animals.[47] According to LaserMotive, the laser that the company is considering for use in SBSP satellites is so weak that it barely makes one's hand feel warm and therefore cannot be used as a weapon in space.[48] Similarly, microwaves used in SBSP are not strong enough to cause cancer or genetic damage.[49] Since the technology is not dangerous, SBSP satellites will likely not face many liability issues resulting from microwave transmission or misuse.

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[42] SNEAD, *supra* note 41, at 46. Snead is the lead for Agile Combat Support in the Aeronautical Systems Sector, Plans and Programs Directorate, Air Force Research Laboratory ("AFRL") and he is also currently the chairman of the American Institute of Aeronautics and Astronautics Space Logistics Technical Committee. SPACE ENERGY, TECHNICAL ADVISORS, http://www.spaceenergy.com/s/TechnicalAdvisors.htm (last visited Aug. 14, 2012).

[43] SNEAD, *supra* note 41, at 46.

[44] *Id*.

[45] *See id*.

[46] Kiantar Betancourt, Space Based Solar Power: Worth the Effort?, (Aug. 28, 2010), http://www.spaceenergy.com/AnnouncementRetrieve.aspx?ID=56407#_ftn36.

[47] *Id*.

[48] Surfdaddy Orca, *Beaming Laser Power: An Interview with Tom Nugent of LaserMotive*, H+ MAGAZINE, (May 13, 2010) http://hplusmagazine.com/2010/05/13/beaming-laser-power-interview-tom-nugent-lasermotive/ (quoting Tom Nugent as follows: "We're operating at about ten times sunlight. If you stick your hand in that beam, it'll feel warm and you'll want to take your hand out, but it wouldn't cause any instantaneous burns or anything. We actually had our beam focused down to 100 to 200 times sunlight, and then we were able to cook a hot dog. But it took four minutes. So that gives you a sense that it's similar to the power in your oven. Again, you don't want to stick your hand in the path of a laser for any length of time, but it doesn't cause instantaneous damage.").

[49] G. Pignolet et al., *Space Solar Power: Environmental Questions and Future Studies*, 14 J. AEROSPACE ENGINEERING 72, 73 (2001).

## III. BEFORE LAUNCHING SBSP SATELLITES INTO GEOSTATIONARY ORBIT, FIRST FIND AN AVAILABLE SLOT

Even if SBSP satellites are considered safe, organizations and countries may be discouraged from building the multi-billion dollar SBSP satellite if the satellite cannot be guaranteed a space in orbit.[50] Most SBSP systems require the satellites to be launched into an orbit that has limited capacity, known as the geostationary orbit ("GSO"). The GSO is a circular orbit 35,785 kilometers above the equator in which a satellite rotates around the Earth in twenty-three hours and fifty-six minutes.[51] According to international treaties no one can appropriate outer space, so the question becomes who can place their satellites into this orbit and under what legal authority. A satellite launched into this orbit is synchronized with Earth's rotation and appears stationary from an observer on Earth.[52] A satellite operating from GSO can continuously communicate with a station on the Earth, without the need for movable antennas.[53] Because satellites in GSO can transmit signals in an uninterrupted fashion, this orbit is often used for communications satellites, weather satellites, and global positioning satellites.[54] Since SBSP satellites will transmit energy to the earth via microwave or laser beams, they may also benefit from transmitting these waves to a fixed location on Earth's surface.[55] In this case, SBSP satellites will need to be launched into GSO.

Just as real estate in Manhattan, New York is limited, the area of space in the GSO is limited since only a limited number of satellites can occupy it at any given time.[56] The GSO is approximately 265,000 kilometers long and most geostationary satellites stay within a thirty-kilometer band that defines the satellite's geostationary position or "slot,"[57] Current technology allows up to two satellites to occupy the same slot.[58] In total, the GSO can be divided into 1,800 slots without undue risk of collision or interference between

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[50] *See* Tronchetti, *supra* note 8, at 165-75.

[51] *Geostationary Orbit*, *in* BRITANNICA ONLINE ENCYCLOPEDIA http://www.britannica.com/EBchecked/topic/230367/geostationary-orbit (last visited Aug. 14, 2012). There are only twenty-three hours and fifty-six minutes in a day, but we round that number to twenty-four hours and compensate by having a leap year every four years.

[52] *Id.*

[53] Tronchetti, *supra* note 8, at 165.

[54] *Id.*

[55] *See id.*

[56] *Id.* at 167.

[57] *Id.* at 166.

[58] *Id.*

satellites.[59]

### A. *Sharing the GSO*

While space may be vast and never-ending, the GSO is finite; it presents an international problem of access and ownership. International law has long recognized that some property is held in common ownership for the benefit of all and is "*res communis,*" while other property cannot be claimed even if no country currently owns it and is "*res nullis*."[60] The *res communis* concept rests on the premise that certain property belongs to the common heritage of mankind, like the high seas.[61] *Res nullis,* on the other hand, presupposes that property can be acquired by those who take control of it.[62] The philosopher John Locke argued that a person could acquire the right to any property in the public domain by adding his or her labor to the property.[63] Locke stressed that this was an *exclusive* right to the newly acquired property as opposed to a more limited right to only use the land.[64]

Some countries have described outer space, including the GSO, as res *communis*, while others assert that it is *res nullis*. The distinction is significant because *res nullis* property, such as undiscovered islands, can be acquired by occupation, while *res communis* property can be used but can never acquired by any country.[65] Some countries argue that outer space should be treated as *res communis* because Article 1 of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (the "Outer Space Treaty") states that outer

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[59] *Id*.

[60] R. Bender, *Launching and Operating Satellites: Legal Issues, in* 18 UTRECHT STUDIES IN AIR AND SPACE LAW 1, 41 (G.C.M. Reijnen et al. eds. 1998).

[61] *See id*.

[62] *Id*.

[63] JOHN LOCKE, SECOND TREATISE ON PROPERTY, § 27, *available at* http://press-pubs.uchicago.edu/founders/documents/v1ch16s3.html ("Though the earth, and all inferior creatures, be common to all men . . . Whatsoever then he removes out of the state that nature hath provided, and left it in, he hath mixed his *labour* with, and joined to it something that is his own, and thereby makes it his *property*").

[64] *Id*. ("It being by him removed from the common state nature hath placed it in, it hath by this *labour* something annexed to it, that excludes the common right of other men: for this *labour* being the unquestionable property of the labourer, no man but he can have a right to what that is once joyned to . . .").

[65] *See* Bender, *supra* note 60, at 42.

space is the "province of all mankind."[66] However, the treaty does not explicitly define the phrase "province of all mankind." Other countries argue that the Outer Space Treaty only suggests that space should not be misused to the detriment of others.[67] There are scholars that support each of these views, but a third group of professors argues that recent technological developments warrant a new international policy that allows countries and private individuals to acquire property rights in space.[68] These scholars also assert that nations should abolish the Outer Space Treaty because it was based on principles established at the beginning of the Space Age that are now outdated.[69]

### *B. Sovereignty over the high seas – an apt analogy to the GSO*

The high seas, or international waters, are held for the common use of all mankind, much like outer space.[70] Developed countries argue that even if space is held in common ownership for all, it should be used on a first come, first served basis, much like other *res communis* property on Earth, like the high seas.[71] International treaties on the high seas prevent countries from interfering with other countries' ships but do not require countries to keep the high seas open, even if they are crowded, or to ensure that developing countries can use the high seas.[72] The 1958 Convention on the High Seas states that all countries are required to allow any other country's ships equal access to navigate, fish, lay submarine cables, and fly over the high seas.[73] International law recognizes that no country can claim sovereignty over the high seas, but at the same time ensures that no country is prevented from using the resources of the high seas.[74]

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[66] Outer Space Treaty of 1967 *supra* note 9, at art. I. See *infra* Part V.3. for an explanation of the Outer Space Treaty and a listing of its signatories.

[67] *See* Bender, *supra* note 60, at 42.

[68] *See* Tronchetti, *supra* note 8, at 216.

[69] *See id.* at 217.

[70] *See* 1958 Convention on the High Seas, art. 2, Apr. 29, 1958, 13 U.S.T. 2312, 450 U.N.T.S. 11, *available at* http://untreaty.un.org/ilc/texts/instruments/english/conventions/8_1_1958_high_seas.pdf. The 1958 Convention on the High Seas defines the term "high seas" to mean "all parts of the sea that are not included in the territorial sea or the internal waters of a State." *Id.* at art. 1.

[71] *Id. See* Bender, *supra* note 60, at 42 – 43.

[72] *See generally* 1958 Convention on the High Seas, *supra* note 70.

[73] *Id.* at art. 2.

[74] *See* 1958 Convention on the High Seas, *supra* note 70*;* Bender, *supra* note 60, at 43.

If the GSO is divided and slots are reserved for developing countries, GSO resources would be wasted to the detriment of countries that have the capability of using them.[75] Just like the high seas, the GSO could continue to be used by more developed countries. An equal access approach to GSO slot allocation is a more efficient use of the empty space because SBSP will provide clean energy and reduce greenhouse gas emissions, whereas keeping GSO slots vacant would not bring the same benefits.[76] An equal access approach would still allow developing countries to use the GSO in the future.[77]

### *C. If the high seas can be mined, then the GSO can be allocated*

Public rights to an orbit in space are similar to rights to international waters. The United Nations Convention on the Law of the Sea of December 10, 1982 ("Convention") supersedes the 1958 treaties on the Law of the Sea and defines the rights and responsibilities of nations with respect to how they may use the oceans around the world.[78] As of November 15, 2010, one hundred and sixty-one countries had joined the Convention but 16.2% of United Nations members, including the United States, had not yet ratified this international agreement.[79]

In the early 1980s, President Ronald Reagan vowed to participate in the Convention on the Law of the Sea, but after reviewing an early version of the treaty, he was unsatisfied with the *res communis* provisions that limited deep seabed mining.[80] Over the next twelve years, United Nations Secretaries-General Javier Perez de Cuellar and Boutros Boutros-Ghali consulted with

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[75] Bender *supra* note 60, at 43.

[76] *See infra* Part V.3.

[77] *See infra* Part V.3.

[78] The United Nations Division for Ocean Affairs and the Law of the Sea, The United Nations Convention on the Law of the Sea: A Historical Perspective, (1998), http://www.un.org/Depts/los/convention_agreements/convention_historical_perspective.htm .

[79] The United Nations Division for Ocean Affairs and the Law of the Sea, Chronological Lists of Ratifications of, Accessions and Successions to the Convention and the Related Agreements as at [sic] 03 June 2011, http://www.un.org/Depts/los/reference_files/chronological_lists_of_ratifications.htm. *See* Matt Rosenberg, Members of the United Nation: 193 Member Countries with Their Date of Admission (Sept. 2, 2011), http://geography.about.com/od/politicalgeography/a/unmembercountries.htm.

[80] U.S. NAVY JUDGE ADVOCATE GENERAL'S CORPS, THE CONVENTION ON THE LAW OF THE SEA, http://www.jag.navy.mil/organization/code_10_law_of_the_sea.htm (last visited Aug. 14, 2012).

United States presidents and ultimately developed the 1994 Agreement on Implementation of the Seabed Provisions of the Convention on the Law of the Sea ("1994 Agreement"), which reflected American interests in deep-sea mining.[81] The executive branch of the United States pushed for the ratification of the Convention of the Law of the Sea treaty only after the Convention was modified to allow the United States to mine the deep seas.[82] This treaty and the 1994 Agreement demonstrate a widely shared belief that *res communis* property should be appropriated for the benefit of each individual country.[83] If nations can agree to allow industrialized nations to mine the high seas for minerals, perhaps all nations can reach an agreement to allow developed countries to utilize GSO positions to mine our orbit for solar energy.

If nations cannot agree on a way to use the GSO for SBSP satellites, the laws of property with regard to GSO access and ownership can be interpreted in three ways: (1) the GSO is available to all countries on a first come, first served nondiscriminatory basis; (2) the GSO must be divided and allocated among countries regardless of whether the slots are used or countries have the requisite technology to use them; (3) the GSO can be used on a first come, first served basis, but the use must benefit all countries, and may have to be regulated by an international agency.[84] A United Nations agency currently administers GSO locations and frequencies and has been tasked to resolve the above three issues.

## IV. THE INTERNATIONAL TELECOMMUNICATION UNION

The International Telecommunication Union ("ITU"), an agency of the United Nations ("UN"), allocates GSO slots and satellite frequencies.[85] The ITU first began as the International Telegraph Union in 1865, dealing

[81] Bernard H. Oxman, *The 1994 Agreement and the Convention*, 88 AM. J. INT'L L. 687, 688 (1994) ("The purpose of the 1994 Agreement is to enhance the prospects for widespread ratification of the Convention by responding to problems with the deep seabed mining regime . . . particularly those that troubled industrial states, including the United States").

[82] *The Convention on the Law of the Sea, supra* note 80.

[83] Oxman, *supra* note 81, at 692 ("The new Agreement contains special voting rules that facilitate a decision to approve an application to explore or exploit minerals [in the deep sea]. In the Legal and Technical Commission, only a simple majority is required for recommending approval").

[84] *Id.*

[85] Proceeding on the Plenipotentiary Conference of the Int'l Telecomm. Union in Nice, France, 3 F.C.C.R. 4478, 4478 (1988).

particularly with radio.[86] In 1927, the International Telecommunication Convention emerged as the combination of radio, telegraph, and telephone regulations.[87] Finally, in 1947, the ITU was formed as the "United Nations specialized agency for telecommunications," and the United States joined as one of 164 countries that ratified the ITU Convention of 1982 and accepted the regulations set therein.[88] The history of the ITU as a modern communications agency shows that the United Nations created this agency for the express purpose of regulating telecommunications in international space.[89] Therefore, whether the ITU would have jurisdiction to regulate satellites that are not for the purpose of telecommunication is unclear.

SBSP satellites will need a slot in the GSO and perhaps a designated microwave frequency so that the satellites do not interfere with others in orbit.[90] Yet SBSP satellites are not launched for the purpose of telecommunication, and some SBSP satellites may not even be using microwaves but may transmit energy by high-powered laser beams.[91] Hence, the history of the ITU does not entirely support the proposition that it should regulate GSO for non-telecommunication satellites.

### *A. Possible legal authority to regulate SBSP satellites in GSO*

Even though the ITU was an agency established to regulate telecommunication satellites in orbit, the ITU may have the power to regulate SBSP satellites because they may interfere with the telecommunication satellites already in orbit.[92] Article I, section 2 of the ITU Constitution demonstrates that the ITU was created mainly to foster international

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[86] *Id*.

[87] *Id*.

[88] *See* ITU CONST. of 2007 art. VI § 1, *available at* http://www.itu.int/net/about/basic-texts/constitution/chapteri.aspx ("The Member States are bound to abide by the provisions of this Constitution, the Convention and the Administrative Regulations in all telecommunication offices and stations established or operated by them which engage in international services or which are capable of causing harmful interference to radio services of other countries, except in regard to services exempted from these obligations in accordance with the provisions of Article 48 of this Constitution"); Proceeding on the Plenipotentiary Conference of the Int'l Telecomm. Union in Nice, France, *supra* note 85.

[89] ITU CONST. art. VI, § 1.

[90] *Id*. at art. I § 2(a).

[91] *See* OFFICE OF TECH. ASSESSMENT, SOLAR POWER SATELLITES 78 (1981), *available at* http://www.nss.org/settlement/ssp/library/1981-OTA-SolarPowerSatellites.pdf.

[92] *See* ITU CONST. art. VI, § 1.

cooperation in the provision of telecommunication services; in order to do so, the ITU must have the power to allocate radio frequencies and orbital positions in the GSO.[93] The purposes of the ITU are to "promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services," and to "promote the use of telecommunication services with the objective of facilitating peaceful relations."[94] Article I, section 1 of the ITU Constitution is consistent with the ITU's historical role as an agency that promotes telecommunication.[95] To achieve these goals, the ITU has the power of "*allotment* of radio frequencies and the registration of radio-frequency assignments and, for space services, *of any associated orbital position in the geostationary-satellite orbit* or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference between radio stations of different countries."[96] Article 1, section 2 of the ITU Constitution affirms that the ITU manages the GSO and other orbits in order to improve the efficiency and organization of these orbits.[97] Through Article I of the ITU Constitution, the ITU has the power to allocate radio microwave frequencies and orbital positions along the GSO to ensure that satellites do not collide with each other or cause interference.[98] For these reasons, both Article I of the ITU Constitution and ITU's primary purpose suggest that the ITU may be the appropriate agency for regulating all satellites that are located in the GSO.

### *B. ITU currently allocates all slots in GSO*

As just discussed, while the ITU currently regulates *all* applications for GSO, it is not clear that an international *telecommunications* agency like the ITU should regulate *energy* satellites placed in the GSO. Countries that intend to launch SBSP satellites into the GSO may have to notify the ITU, so that they may take proper precautions to assure there will be no interference with

[93] *Id.* at § 1. art. I(2)(a) ("[T]he [International Telecommunications] Union shall in particular: (a) effect allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and . . . any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference between radio stations of different countries. . . .").

[94] *Id.* at §1.

[95] *Id.*

[96] *Id.* at art. I, § 2(a) (emphasis added).

[97] *Id.* at § 2(b).

[98] *See id.*

telecommunication satellites currently in the GSO.[99] However, the fact that SBSP satellites are placed into the GSO and produce waves that may interfere with telecommunication satellites does not mean that the ITU is the best agency to manage SBSP satellites.

The ITU Constitution provides that the ITU's purpose is to promote telecommunications.[100] The United States raised the issue of whether the ITU should have the power to allocate frequency positions for SBSP satellites at the ITU's 1979 World Administrative Radio Conference.[101] Notably, none of the 164 countries that ratified the ITU in 1982 have rejected the agency.[102] This suggests that they currently accept the Constitution of the ITU, which provides that this telecommunications agency is the specialized, sole agency in charge of allocating orbital positions and frequencies along the GSO.[103] As a result, countries or private companies that wish to launch SBSP satellites into space will likely first need to get ITU approval.

## V. HOW SBSP SATELLITES WILL CHANGE THE GSO SLOT ALLOCATION REGIME

### *A. Demand for SBSP satellites will overcrowd the amount of available GSO slots*

Since the GSO is limited and SBSP may require access to the GSO, there should likely be a system for owning or allocating slots to launching countries. SBSP will do much more than simply influence the allocation of orbital positions in the GSO by crowding the orbit; SBSP will inundate the GSO so that communication satellites may be among the least common satellites in orbit.[104] SBSP satellites produce electricity at rates much cheaper than other

[99] ITU CONST. art. I § 2(b).

[100] *See id*. at art. I § 1 ("Purposes of the Union are: (a) to maintain and extend international cooperation . . . and rational use of *telecommunications* of all kinds. . . (c) to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of *telecommunication* services; (d) to promote the extension of the benefits of the new *telecommunication* technologies . . . ; (e) to promote the use of *telecommunication* services . . . .").

[101] OFFICE OF TECH. ASSESSMENT, *supra* note 91, at 156.

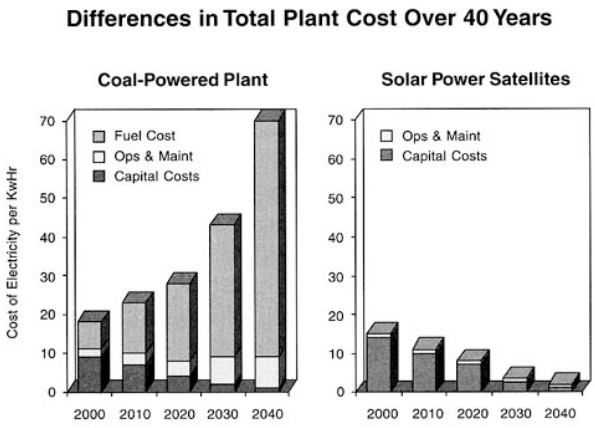
[102] *See Membership*, INTERNATIONAL TELECOMMUNICATIONS UNION, http://www.itu.int/cgi-bin/htsh/mm/scripts/mm.list?_search=ITUstates&_languageid=1) (last visited Aug. 14, 2012).

[103] ITU CONST. art. I.

[104] *See infra* text accompanying notes 109-12.

alternatives, such as coal-powered plants.[105] It is estimated that by the year 2030, solar power electricity will cost three times less than coal power electricity.[106] By the year 2070, electricity derived from solar power is expected to be seventy times cheaper than coal power.[107]

**Figure 1**[108]




Although "[t]he evidence is there, the technical ability is there and the funding capability is within reasonable and achievable levels," one reason why we do not currently have SBSP satellites in orbit is that there is no viable legal system that regulates these satellites in space and no one is willing to spend billions of dollars on a satellite that they may not be able to launch into orbit.[109] Currently, the United States invests large sums of money on land-based solar energy. On July 3, 2010, President Barack Obama announced that the Department of Energy would receive nearly two billion dollars in commitments from solar power companies to build one of the world's largest solar power plants in Arizona.[110] The European Union Commission plans to

[105] *See* Ralph Nansen, *Sun Power: The Global Solution for the Coming Energy Crisis*, NATIONAL SPACE SOCIETY Figure 1 (1995), *available at* http://www.nss.org/settlement/ssp/sunpower/sunpower10.html.

[106] *Id.*

[107] *Id.*

[108] *Id.*

[109] *Id.*

[110] *Weekly Address: President Obama Touts Nearly $2 Billion in New Investments to*

spend sixteen billion Euros over the next ten years to build solar power stations and an additional fifty billion Euros over the next ten years to develop technologies that will help cut greenhouse gas emissions by eighty percent by 2050.[111] This increase in use of solar power technology may increase investment in solar power satellites and thereby cause overcrowding of the GSO.[112]

Rather than spending millions on land-based solar power projects, it would be much more profitable if these nations invested in SBSP satellites for two reasons. First, although SBSP satellites are much more expensive at the outset, the cost of initial investment is returned in a period of time comparable to what it would take to recoup the investment cost of a land-based solar farm.[113] Second, SBSP satellites generate about eight to ten times as much power as land-based solar farms.[114] This means that after one and a half years, SBSP satellites would generate eight to ten times the revenue of a land-based solar farm. As a result, countries that currently rely on coal, nuclear or other types of non-clean, non-renewable energy may look to SBSP for their energy needs, and consequently generate a significant spike in demand for orbital locations on the GSO. This increased demand will raise two issues: (1) whether a GSO orbital slot can be owned, and, (2) if not, whether there is a way to allocate the right to access GSO orbital slots for a period of time. A viable legal framework could address both of these issues in a clear and precise manner. The ITU currently allocates slots for telecommunications satellites, but the increased demand for slots in GSO for SBSP satellites may force countries to reevaluate ITU's authority to regulate SBSP satellites.

### *B. An unsuccessful attempt to appropriate GSO slots*

The ITU allocation is one way to solve the problem, but given the physical

*Help Build a Clean Energy Economy*, THE WHITE HOUSE, (July 3, 2010), *available at* http://www.whitehouse.gov/the-press-office/weekly-address-president-obama-touts-nearly-2-billion-new-investments-help-build-a- (last visited Mar. 23, 2012).

[111] Pete Harrison, *Europe to Throw $73 Billion Behind Energy Research*, REUTERS (Oct. 5, 2009, 9:05 AM), http://www.reuters.com/article/idUSTRE5942I920091005.

[112] *See supra* notes 106-11 and accompanying text.

[113] NATIONAL SECURITY SPACE OFFICE, SPACE-BASED SOLAR POWER AS AN OPPORTUNITY FOR STRATEGIC SECURITY 32 (Report to NSSO Director: Interim Assessment 2007), *available at* http://www.nss.org/settlement/ssp/library/final-sbsp-interim-assessment-release-01.pdf.

[114] Mark Wallach, *Legal Issues for Space Based Solar Power*, 16 ONLINE JOURNAL OF SPACE COMMUNICATION (2010) http://spacejournal.ohio.edu/issue16/wallach.html.

limitations of the GSO, there is an underlying conflict between the goals of fair and equitable access on one side and the GSO's efficient use on the other.[115] The conflict arises when developed countries receive priority to access the GSO because they have the demand, infrastructure, and funding to put satellites into orbit, while developing countries without viable satellites also want access the GSO.[116] This *a posteriori* approach to GSO property rights favors those who are first to apply for frequency and orbital slots and protects those applicants from interference by later users.[117] At the same time, developing countries do not favor such a "free-market-approach" to GSO access; on the contrary, they would like a multilateral approach that distributes access to the GSO equitably among all nations.[118] "As feared by the developing States, this *a posteriori* system [has] provided a few industrialized and rich States with the opportunity of temporarily unlimited use of registered frequencies and orbit positions."[119] Developing countries feel that they should have equal access to these frequencies and orbital slots.[120]

These countries have tried to gain leverage over the GSO resource by advocating for the creation of an administrative agency that would allocate a part of the GSO to each country. In 1976, eight developing countries above the equator claimed sovereign right over the parts of the GSO lying over their territories and called for the administration of the rest of the GSO.[121] The Declaration of the First Meeting of Equatorial Countries (the "Bogota Declaration") asserted that these countries had the right to parts of the GSO because the orbit should be considered part of the earth and not outer space.[122] These countries argued that the gravitational force that produces the GSO was defived from their land.[123] Both developed and developing countries rejected

[115] Tronchetti, *supra* note 8, at 169.

[116] *Id*. at 170; OFFICE OF TECH. ASSESSMENT, *supra* note 91, at 156.

[117] Tronchetti, *supra* note 8, at 170.

[118] *Id*.; OFFICE OF TECH. ASSESSMENT, *supra* note 91, at 156.

[119] Tronchetti, *supra* note 8, at 171.

[120] OFFICE OF TECH. ASSESSMENT, *supra* note 91, at 156.

[121] *See* Declaration of the First Meeting of Equatorial Countries: Bogota Declaration, Dec. 3, 1976, ITU DOC. WARC-BS-81-E [hereinafter "Bogota Declaration"], *available at* http://www.jaxa.jp/library/space_law/chapter_2/2-2-1-2_e.html.

[122] *Id*. at § 1 ("[T]he geostationary synchronous orbit is a physical fact linked to the reality of our planet because its existence depends exclusively on its relation to gravitational phenomena generated by the earth, and that is why it must not be considered part of outer space. . . .").

[123] *Id*.

the Bogota Declaration's arguments because its claims were weak: the gravity that produces the orbit (1) is produced by the entire earth, not just these eight nations, and (2) produces all orbits, not just the GSO.[124]

Another of the arguments in the Bogota Declaration was that there is no legally defined boundary as to where an atmosphere ends and space begins.[125] Furthermore, the Bogota Declaration declared that even the Outer Space Treaty, which provides the basic outline for the peaceful exploration and use of outer space, does not address the issue.[126] While there is no definition that all countries in the world accept regarding the boundary of space, the International Aeronautic Federation recognizes the Karman Line as the edge of the atmosphere and the beginning of space.[127] The International Aeronautic Federation is a non-governmental organization founded in 1905, for the purpose of encouraging aeronautical and astronautical activities worldwide.[128] It has 100 member countries, including the United States, United Kingdom, Spain, Sweden, South Africa, Mongolia, Korea, Israel, Iran, as well as many others.[129] For the preceding reasons, the International Aeronautic Federation portrays a widely held view concerning the definition of space. The Karman line is one hundred kilometers above sea level, and that is where the atmosphere becomes so thin that an airplane cannot fly and a spaceship is needed for flight.[130] The GSO lies more than 35,000 kilometers above sea level, which is approximately 34,900 kilometers higher than the Karman line. Therefore, GSO is well above the demarcation of space that is internationally recognized. For this reason and others, most countries did not accept the Bogota Declaration. Accordingly, the Bogota Declaration was an unsuccessful attempt to appropriate GSO slots.

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[124] Tronchetti, *supra* note 8, at 176.

[125] Bogota Declaration, *supra* note 121, at § 1.

[126] Outer Space Treaty of 1967, *supra* note 9.

[127] S. Sanz Fernández de Córdoba, *Presentation of the Karman Separation Line, Used as the Boundary Separating Aeronautics and Astronautics*, FAI ASTRONAUTIC RECORDS COMMISSION (June 21, 2004), http://web.archive.org/web/20110726044644/http://www.fai.org/astronautics/100km.asp (last visited Mar. 23, 2012).

[128] *About the FAI*, FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE, , http://www.fai.org/about-fai (last visited Mar. 16, 2012).

[129] *FAI Members*, FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE, http://www.fai.org/members (last visited Mar. 23, 2012).

[130] Nick Allen, *Tips for Space Tourists*, BBC NEWS (Jan. 19, 2006) http://news.bbc.co.uk/2/hi/uk_news/magazine/4625150.stm (last visited Mar. 23, 2012).

*C. Space law must allow appropriation of space for the good of everyone*

The Bogota Declaration was ultimately a failure because it violated internationally accepted principles. According to the Outer Space Treaty of 1967, GSO orbital positions and frequencies cannot be appropriated because no country can appropriate or own space.[131] Ninety-one states have signed this treaty, including the United States, the United Kingdom, Ukraine, Japan, Greece, Denmark, Spain, Uganda, Afghanistan, Iraq and many others.[132] The treaty specifies that outer space is the "province of mankind" and that all activity should be done for the benefit of all of humanity.[133] It would then seem that no country could have exclusive ownership over an orbital position in the GSO or any orbit.[134]

Even if the Outer Space Treaty of 1967 prohibits countries from owning orbital slots in the GSO, the slots should still be allocated to countries that will use them, on a first-come, first-served basis. SBSP has so much potential to benefit all of mankind that if even a single country uses a GSO slot to gather power, the advantage of developing the technology of SBSP may outweigh the argument that all nations should have equal access to space.[135] Countries like Tonga that have no capability of sending satellites into orbit should not be able to claim GSO slots because this would prohibit developed countries from placing satellites into orbit that can benefit the whole world.[136]

The Outer Space Treaty of 1967 likely permits the allocation of GSO slots to individual countries on the condition that the slots are used for SBSP satellites that benefit all mankind.

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[131] Outer Space Treaty of 1967, *supra* note 9, at art. I-II ("The exploration and use of outer space, including the moon and other celestial bodies, 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 . . . [O]uter space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.").

[132] Signatory List, Outer Space Treaty, *available at* http://www.state.gov/t/isn/5181.htm#treaty.

[133] Outer Space Treaty of 1967, *supra* note 9.

[134] *Id.* at art. II.

[135] *See* Michael J. Hornitschek, *War Without Oil: A Catalyst for True Transformation*, CENTER FOR STRATEGY AND TECHNOLOGY, 11, 36, 62 (Feb. 17, 2006), www.au.af.mil/au/awc/awcgate/cst/csat56.pdf.

[136] *See* NANDASIRI JASENTULIYANA, INTERNATIONAL SPACE LAW AND THE UNITED NATIONS 308-10 (Kluwer Law International 1999); *supra* Part III-III.1; discussion *infra* Part V.5 and notes 155-60.

Countries with orbiting SBSP satellites could meet such conditional requirements in three ways. First, they could be required to provide power to less developed countries. Second, launching countries can help decrease global warming because SBSP satellites provide clean energy. Third, launching countries can lower the cost of solar power systems as they become cheaper and more affordable with time so that many less developed countries around the world will be able to access solar power from space. By satisfying any of these conditions, deployment of SBSP satellites would qualify under the treaty as "use of outer space . . . carried out for the benefit and in the interests of all countries."[137] The universal benefits provided by SBSP satellites would therefore be consistent with the treaty's requirement that the use of outer space "shall be the province of all mankind." [138] Thus, while the Outer Space Treaty of 1967 may prohibit ownership of GSO slots, the temporary allocation of GSO slots for the use of SBSP satellites would be compatible with the goals of the treaty. ."

As a result of the need to allow SBSP to have access to the GSO, there will need to be some sort of regulatory structure to GSO slot allocation. If a regulatory organization, such as the ITU, allows licensees to use a particular GSO position and microwave frequency, for a limited period of time, this would appear to satisfy the current international regime under the Outer Space Treaty of 1967. In order to comply with the treaty, countries would not have to surrender their slot or frequency, as they could simply allow other countries to lease the power satellites from them for a period of time. SBSP satellites in GSO would fall within the "province of mankind" requirement of the Outer Space Treaty of 1967 because SBSP can decrease global warming and help less developed countries by providing them with electricity in areas lacking infrastructure. Furthermore, SBSP satellites in GSO would satisfy the "peaceful purposes" requirement of the Outer Space Treaty of 1967 because the satellites are used for commercial power production and cannot be converted into weapons.[139]

### *D. The inefficiencies of paper satellites*

Determining the conditions of occupying a GSO slot and the period of time for each allotment will require a new legal framework. Granting access to the GSO will be more efficient if an organization only grants slots to countries that

[137] Outer Space Treaty of 1967, *supra* note 9, art. I.

[138] *Id.*

[139] *See* Outer Space Treaty of 1967, *supra* note 9; *infra* Part VII.

will use the slots in the near future.[140] The international regulatory agency for the GSO could establish a process that prohibits countries from reserving GSO slots and then leaving them vacant.[141] One way to solve this problem would be to require countries to launch a satellite into their newly registered GSO slot within a year or forfeit that slot. Another way to approach this issue is to raise the cost of registering GSO slots, so that only countries that expect to profit from that slot will apply for slots. The money collected could be refunded to the country after a country launches and begins to operate the satellite in GSO.

In 1997, the ITU reviewed its process for managing the GSO and determined that one of the most important problems was "the reservation of orbit capacity without actual use," or the "phenomenon of paper satellites."[142] A paper satellite occurs when a country files an application for a GSO slot with the ITU, receives a slot registered in the country's name, but ultimately leaves the slot unoccupied because the physical satellite is never launched for financial, technical or other reasons.[143]

Paper satellites frustrate access to the GSO because they reserve orbital slots and frequencies for nine years or more, depriving other countries of the opportunity to use those slots.[144] Australia has suggested that countries pay a $5 million refundable deposit on an application for a GSO slot to show good faith.[145] Countries may also be required to show that they have a "credible design and adequate initial funding."[146] A successful international regulatory agency for the GSO should consider all of these restrictions to ensure that countries are only granted GSO slots if the countries will use the slots and that the agency is free to reallocate unused slots to other countries.[147]

### *E. Tonga: Inefficiencies in the current system of GSO allocation.*

A new legal framework for access to the GSO should also prohibit countries without a space program from securing orbital slots. Currently, countries that wish to place satellites into orbit in the GSO must submit an application to the ITU prior to launching those satellites.[148] In 1990, Tonga applied for thirty-

[140] *See* JASENTULIYANA, *supra* note 136, at 308.

[141] *Id.*

[142] *Id.*

[143] *Id.* at 309.

[144] *Id.*

[145] JASENTULIYANA, *supra* note 136, at 309.

[146] *Id.*

[147] *See supra* notes 142-46 and accompanying text.

[148] *See* ITU CONST. art. 1.

one orbital slots in the GSO and the ITU approved six of those slots.[149] Tonga left one slot unused, rented one slot to an American company for $2 million, auctioned two other slots and used the proceeds to purchase two Russian satellites and move them to the two remaining slots.[150]

Indonesia argued that the slot assignments to Tonga were "wrong in law" and moved its satellite to the vacant slot without coordinating its action with the ITU.[151] Tonga's claim and Indonesia's unilateral action caused uproar in the international community and raised concerns that the ITU was unable to adequately coordinate and regulate the GSO.[152] Countries must agree to follow internationally accepted guidelines for space activities, both to avoid international conflict and to decrease interference that may be caused by placing two satellites too close together.[153]

## VI. AN ALTERNATIVE, PRACTICAL SOLUTION TO THE GSO PROBLEM FOR SBSP SATELLITES

Some potential solutions to the overcrowding of the GSO problem include reforming the legal regime in space, allowing appropriation of GSO slots, or at least allowing developed nations to use the slots for SBSP satellites on a first-come, first-serve basis. These changes are warranted because space technology has changed so much since the passage of the Outer Space Treaty of 1967, and SBSP satellites also offer a highly efficient solution to the increased demand for clean energy due to population growth.[154] But there is another solution to our energy crisis that still involves using SBSP satellites and bypasses the legal hurdles that the GSO poses. While most studies of space SBSP satellites have focused on systems that require a satellite to be stationed in GSO, a lesser-known design promises to reduce both costs and political drama by placing the satellite into a highly elliptical Lower Earth Orbit ("LEO") around the Earth.[155]

When SBSP satellites were originally designed, they were very large and required a two-stage Earth-to-orbit transportation system in which hundreds of

[149] JASENTULIYANA, *supra* note 136, at 309.

[150] *Id*. at 309–10.

[151] *Id*. at 310.

[152] *Id*.

[153] *See id*. at 310.

[154] SNEAD, *supra* note 41.

[155] Royce Jones, *Alternative Orbits: A New Space Solar Power Reference Design*, 16 ONLINE JOURNAL OF SPACE COMMUNICATION (2010) http://spacejournal.ohio.edu/issue16/jones.html.

astronauts assembled the satellite in space before sending it into GSO.[156] The original satellite design was prohibitively costly and large. The problem with launching SBSP satellites into GSO is that the GSO is approximately thirty six thousand kilometers away, so SBSP systems require satellites with large microwave transmitters on the satellite and receiving stations on Earth.[157] Decreasing the size of the solar power satellite and placing it into an orbit closer to Earth would reduce construction and launch costs and allow for a smaller receiving antenna ("rectenna") to be built on Earth.[158] More importantly, if a solar power satellite could be placed into an LEO and function efficiently, countries would not be concerned with obtaining the right to own or access a GSO slot or with interference that may result to neighboring telecommunications satellites. There is currently no system of registration or allotment that limits access to LEO.

One of the few benefits of placing a satellite in GSO, on the other hand, is that GSO satellites stay over one area of Earth's surface.[159] LEO's elongated, elliptical orbit is advantageous because long dwell times over the receiver during the approach to and descent from the apogee allow the satellite to transmit signals to the ground receiver in a manner similar to SBSP satellites beaming from GSO.[160] SBSP satellites could operate from a three-hour LEO, where SBSP satellites would slow down near the apogee and speed up near the perigee.[161] A three-hour LEO would provide a dwell time of about two hours over the receiving station on Earth; satellites in this orbit would orbit the Earth eight times in a twenty-four hour period.[162]

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[156] *Id.*

[157] *Id.* ("Power beaming from geostationary orbit by microwaves has the added difficulty that the required "optical aperture" sizes must be very large. The 1978 NASA SPS study required a 1km diameter transmitting antenna, and a 10 km diameter receiving rectenna, for a microwave beam at 2.45 GHz frequencies.").

[158] Jones, *supra* note 155.

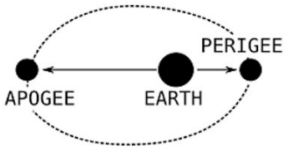
[159] *Id.*

[160] *Id. See* OCEANSIDE PHOTO AND TELESCOPE, APOGEE AND PERIGEE, Figure 2 (Jan. 02, 2011), http://www.optcorp.com/edu/articleDetailEDU.aspx?aid=2281 (last visited Mar. 23, 2012).

[161] OCEANSIDE PHOTO AND TELESCOPE, *supra* note 160; Jones, *supra* note 155.

[162] OCEANSIDE PHOTO AND TELESCOPE, *supra* note 160; Jones, *supra* note 155.

**Figure 2**[163]




SBSP satellites placed into LEO will only be able to beam seventy percent of the power that they collect because they will be out of contact with the rectenna when they travel in the perigee in contrast, satellites in GSO are in constant contact with the rectenna.[164] Yet satellites placed into LEO are also much closer to Earth than those placed in GSO, so both the satellites and the receiving stations can be made significantly smaller.[165] Since the mass of the solar power satellite is directly proportional to the distance between the transmitter and receiver, LEO satellites can be half the size of GSO-based SBSP satellites, and LEO rectennas can be ninety percent smaller than GSO-based rectennas.[166] Consequently, SBSP satellites placed into LEO will be much more affordable than large GSO satellite systems. In sum, a solar power satellite system based around the LEO would be much more economically and legally viable because LEO satellites are cheaper and do not require launching countries to use a limited slot in outer space.

## VII. SBSP: COMMERCIAL OR MILITARY INSTALLATION?

Numerous international treaties mandate that space be used for peaceful, non-harmful purposes, and SBSP systems likely satisfy the requirements of those treaties. The Outer Space Treaty of 1967 requires member States to conduct their space activities for "peaceful purposes" but does not define this term.[167] Thus, even if a launching country obtains a slot for its SBSP satellite, it may still be unable to launch the SBSP system if SBSP is considered a weapon in Space. Some consider operation of SBSP satellites to be a peaceful

[163] OCEANSIDE PHOTO AND TELESCOPE, *supra* note 160.

[164] *See* Jones, *supra* note 155. In GSO, satellites are not 100% efficient because they lose power during eclipses.

[165] *Id*.

[166] *Id*. ("LEO satellite system ground receivers using the Sunflower concept will require more or less 4 square kilometers of space, costing a small fraction of the [GSO] system ground receiver").

[167] *See* Outer Space Treaty of 1967 *supra* note 9.

use of space because the satellites are used primarily, if not exclusively, —for a domestic purpose: to generate power that will be used by residents of cities, towns and villages.

In addition, the 1977 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques ("1977 Convention") does not allow activities that cause a change in the "dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere."[168] Some SBSP satellites may cause changes in the weather, but Article III §1 of the 1977 Convention would allow the satellites so long as they modify the atmosphere for "peaceful purposes." [169] The term "peaceful purposes" likely includes residential and commercial energy transmission.[170]

In contrast, the United States Department of Defense has expressed an interest in using SBSP satellites to power military operations abroad, especially in rural, desert, oceanic or other isolated regions with limited energy sources.[171] The terminology in the Outer Space Treaty of 1967 is vague, so it is not clear whether SBSP satellites are still used for "peaceful purposes" when they supply significant energy to military operations.[172] While international treaties may not clearly define SBSP satellites as peaceful uses of outer space, countries have long permitted other satellites that help the military.[173]

SBSP satellites are not likely to be rejected by the international community for the sole reason that they assist the military because many GSO satellites currently assist the military.[174] For decades the military has used spy and telecommunication satellites for navigation, tracking, bomb and missile guidance, rescue, map updating and facility management.[175] One example is

[168] Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, art. II, May 18, 1977, *available at* http://www.un-documents.net/enmod.htm.

[169] *Id.*

[170] *Id.*

[171] NATIONAL SECURITY SPACE OFFICE, U.S. DEPARTMENT OF DEFENSE, SPACE-BASED SOLAR POWER AS AN OPPORTUNITY FOR STRATEGIC SECURITY 5-6 (2007), *available at* http://www.nss.org/settlement/ssp/library/final-sbsp-interim-assessment-release-01.pdf.

[172] *See* Outer Space Treaty of 1967, *supra* note 9.

[173] *See* GEOSPATIAL MEDIA AND COMMUNICATIONS, GPS: A MILITARY PERSPECTIVE (Nov. 8, 2010), http://www.gisdevelopment.net/technology/gps/techgp0048a.htm (last visited Mar. 23, 2012).

[174] *Id.*

[175] *Id.*

soldiers' use of GPS devices to determine their locations during combat.[176] GPS devices were arguably used in a "military" fashion for many years, and it is unlikely that the international community would disallow yet another type of satellite that helps military operations by classifying it as a non-peaceful use of space.

The Outer Space Treaty explicitly prohibits "nuclear weapons or other weapons of mass destruction" from being placed into orbit but no other weapons are banned from orbit.[177] This limitation suggests the Outer Space Treaty drafters did not intend to outlaw the use of orbiting satellites for military reconnaissance or coordination of military communications for land, ocean and air-based defensive systems."[178] SBSP satellites are clearly not nuclear weapons but if they are construed as weapons of mass destruction, international treaties could prevent SBSP satellites from being placed into orbit.[179] While stray high-powered laser beams from the satellites may cause damage, the alternative of using microwave beams allows for safe transmission and cannot be used as a weapon.[180] Furthermore, the space solar power study commissioned by the Pentagon specifies SBSP satellite designs that avoid the risk of "hijacking for improper use."[181] Also, SBSP satellites would not violate the Outer Space Treaty even though they may be used to power military operations because many satellites currently assist the military in everything from communication to missile guidance systems, without any objection from the international community.

[176] *Id*. ("The necessity of knowing their own position by troops during war was very clearly highlighted during the Gulf War (1990) and the Kargil conflict (1999). This can be judged from the fact that initially about 1000 GPS receivers were issued for use during the Gulf war but by the end nearly 9000 handheld devices were in use.")

[177] *See* Bender, *supra* note 60, at 285.

[178] *Id*.

[179] *See id*.

[180] NATIONAL SECURITY SPACE OFFICE, *supra* note 171, at 27 ("the distance from the geostationary belt is so vast that beams diverge beyond the coherence and power concentration useful for a weapon").

[181] *Id*. ("the beam can also be designed in such a manner that it requires a pilot signal even to concentrate to its very weak level. Without the pilot signal the microwave beam would certainly diffuse and can be designed with additional failsafe cut-off mechanism").

## VIII. CONCLUSION

As the demand for oil increases and countries around the world seek clean energy, SBSP may be a highly efficient solution to this energy problem.[182] Studies and experiments have shown that SBSP is technologically feasible and profitable.[183] Nevertheless, SBSP may not be possible without a legal framework that for granting countries a location for their SBSP satellites in the GSO.[184] Space technology has changed significantly since the Outer Space Treaty of 1967 was passed.[185] Whereas outer space was largely used for exploration and experimentation during the 1960s, outer space is now highly commercialized.[186] Nonetheless, commercialization has not created a well-defined legal regime for property rights in space. A new legal system for allocating property rights in the GSO will likely encourage countries to build, launch and operate SBSP satellites in outer space.[187]

Before SBSP satellites can be developed or launched into an orbit, deploying the satellites must be a permissible peaceful use of outer space under the Outer Space Treaty of 1967.[188] SBSP meets the "peaceful purpose" requirement of the Outer Space Treaty of 1967 because power transmission is a peaceful purpose and the satellites cannot be converted into weapons.[189] SBSP satellites are also not likely unlawful under the treaty for the reason that they may power military operations because many telecommunications satellites in GSO currently assist the military, and the international community has not protested their existence.[190] Furthermore, the Outer Space Treaty of 1967 bans nuclear weapons and other weapons of mass destruction from our orbits, but SBSP satellites are neither nuclear nor weapons of mass destruction.[191] Thus, SBSP satellites are permissible under the current legal regime, which allows for the peaceful use of space.[192]

International treaties may still effectively prohibit SBSP satellites by preventing launching countries from acquiring slots in GSO, which may be

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[182] *See supra* Part II.2.

[183] *Supra* Part II.2.

[184] *See supra* Part III.

[185] *Supra* Part III.

[186] *Supra* Part III.

[187] *See supra* Part III.

[188] *See* Outer Space Treaty of 1967, *supra* note 9; *supra* Part VII.

[189] *See* Outer Space Treaty of 1967, *supra* note 9.

[190] *See supra* Part VII.

[191] *See* Outer Space Treaty of 1967, *supra* note 9.

[192] *See supra* Part VI.

necessary for SBSP satellites to function.[193] International law has long recognized that some property is held in common ownership for the benefit for all, while other property can be acquired by those who take control of it.[194] Currently, international treaties consider outer space to be property that cannot be appropriated by any country, much like the high seas, which are held for the common benefit of all.[195] The positive benefits of clean energy and energy access in less developed countries suggest that countries may be willing to allow the appropriation of outer space for the mutual benefit of everyone, notwithstanding international treaties that limit the ownership of outer space. If countries can agree that *res communis* property like the high seas can be mined for minerals, countries could agree to allocate GSO slots to countries that have the resources to launch SBSP satellites.[196]

The most defined way to allow SBSP satellites access to the GSO would be to establish an agency similar to the ITU to manage access to the GSO for energy purposes.[197] Nevertheless, this would only be a temporary solution because, even if countries had rights to slots in the GSO, many countries would not have the capacity to accommodate many satellites. A more viable, permanent solution that allows all countries equal access to outer space sidesteps the legal issue of property rights altogether. Instead of placing SBSP satellites into GSO, launching countries could position SBSP satellites in a highly elliptical LEO.[198] Although such satellites would not be in constant contact with the receiving station on Earth, the satellites and stations could be made significantly smaller and cheaper.[199] More importantly, satellites in LEO do not require assigned slots.[200] A SBSP system based in LEO would allow significantly more countries to have access to SBSP, without the need to reform property rights in space or to establish a new agency to manage access to the an orbit in space.[201] An LEO SBSP system is more economically and legally viable than any system based in the GSO because LEO satellites are cheaper and do not require a highly desired slot in outer space. SBSP satellites can provide highly efficient, clean energy to the world. Launching countries

[193] *See supra* Parts III, V.

[194] *See supra* Part III.1.

[195] *See supra* Parts III.2., 3.

[196] *See supra* Parts III.2., 3.

[197] *See supra* Part V.3.

[198] *See supra* Part VI.

[199] *Supra* Part VI.

[200] *Supra* Part VI.

[201] *Supra* Part VI.

can take advantage of SBSP satellites by placing them into a highly elliptical LEO where, unlike GSO, there is no controversy over legal ownership of outer space.[202]

[202] *See supra* Part VI.