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## **Economic and Societal Benefits of Peace In Space: Today and Tomorrow**

Corinne Jorgenson  
President, Advancing Space  
cmj@advancingspace.com

Marcia Smith  
President, Space and Technology Policy Group, LLC  
marcia.s.smith@gmail.com

### **INTRODUCTION**

The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies is the foundation for peaceful conduct in outer space. After addressing the role of the 1967 Treaty in maintaining peace in space, this paper will focus on the economic and societal benefits of space activities that are possible today and tomorrow because space has not become a venue for military conflict.

### **THE ROLE OF OUTER SPACE TREATY IN MAINTAINING PEACE IN SPACE**

When Sputnik was orbited in October 1957, the whole world reacted with fear of weapons of mass destruction, which created a military concern. However, scientists and engineers, who were engaged in the International Geophysical Year (IGY), explained that outer space could be used for many beneficial purposes and turned fear into hope.

The following ten years were used by nations to adapt to the outer space environment, which is quite different from Earth, air and sea. Worldwide benefits were developed in communications, transportation, weather, agriculture, medicine and many others. Nations relinquished sovereignty in outer space. The United Nations created the Committee on Peaceful Uses of Outer Space (COPUOS) with its procedure of scientific and technology review before legal analysis. Decisions are made by consensus, which ensures their compliance. In 1963, the United Nations adopted the basic tenets of what would become the Outer Space Treaty (OST) four year later. Therefore the 1967 Outer Space Treaty, or formally the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies was tested before it was adopted.

This Treaty was the first of a series of international treaties related to outer space, which contributed to the prevention of the weaponization and an arms race in space. The 1967 Treaty represents the basic legal framework for international space law. Article I of the

Treaty<sup>1</sup> preserves the fundamental principle of freedom of exploration and use of outer space by all states. Indeed space is no single country's domain and any country has the right to explore it if it is to the benefit of all mankind. Outer space shall not be used in the interest of nation states alone. Under international law, any country can conduct space research and send people into space.

Article II of the treaty forbids any government from claiming a celestial resource such as the Moon or a planet: no one owns space or part of it. Article III reiterates that "exploration and use of outer space" will be carried out "in accordance with international law, including the Charter of the United Nations..."

The key arms control provisions reside in Article IV. States Parties agreed (1) not to place nuclear or any other weapons of mass destruction in orbit around the Earth, or install them on the Moon or any other celestial body or station them in outer space, and (2) not to establish military bases or installations, test weapons of any kind; or conduct military exercises on the Moon and other celestial bodies. States Parties agreed to use the Moon and other celestial bodies exclusively for peaceful purposes. Military personnel may be used for peaceful purposes such as space exploration and the use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies shall not be prohibited.

The provisions in Article VI and VII state that countries exploring space are responsible and liable for any damage their activities may cause. With the increase in proposals by non-governmental entities to use outer space, including the Moon and other celestial bodies for purposes that may not meet the criteria essential for using the outer space environment, Article VI becomes imperative. It upholds nation-states as the bearer of responsibility for all activities in outer space, including those conducted by non-governmental entities; also all activities require "authorization and continuing supervision by the appropriate State Party to the Treaty." Article VIII maintains that a State Party has control over any object that it launches into space.

In Article IX, it is required that states "conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to corresponding interests of all other States Parties to the Treaty." States are required to act responsibly and respect the outer space activities of other states. Article IX ensures the peaceful uses of outer space exploration: if one State Party believes that the activities of another State Party "would cause potentially harmful interference" with the activities of other States Parties in outer space, "appropriate international consultations" can be called for. Countries are to avoid contaminating and harming space or celestial bodies, and space exploration is to be guided by "principles of cooperation and mutual assistance," such as obliging astronauts to provide aid to one another if needed. Article V renders "astronauts as envoys of mankind" and requires that they shall be assisted in any way by all States Parties.

The treaty forbids countries from deploying "nuclear weapons or any other kinds of weapons of mass destruction" (WMD) in outer space. The term "weapons of mass destruction" is not defined, but it is commonly understood to include nuclear, chemical, and biological weapons. Also, it repeatedly emphasizes that space is to be used for peaceful

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<sup>1</sup> United Nations Treaties and Principles on Outer Space, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, p.3-8.

purposes, leading some analysts to conclude that the treaty could broadly be interpreted as prohibiting all types of weapons systems, not just WMD, in outer space.

## ECONOMIC AND SOCIETAL BENEFITS

Preserving peace in space has enabled its utilization to flourish. Virtually all of the inhabitants of planet Earth in countries large and small, developed and developing, benefit from satellites designed for communications, navigation, and remote sensing, and the technological developments that underpin space activities.

We also benefit from the scientific knowledge about our home – Earth – and its place in the solar system and the universe. The increasingly international character of space activities is another benefit that manifests itself through improved relationships among countries. A pricetag cannot be placed on such intangible aspects of peaceful uses of space, but they are no less important.

### **Economic Benefits**

A thriving multibillion-dollar “space economy” has grown over the past 50 years and in 2008 was valued at \$257 billion according to the Space Foundation’s “Space Report 2009.”

The largest segments of the space economy are commercial infrastructure and commercial satellite services, which together total 67 percent, compared to about 32 percent for government space spending. The largest growth sectors were space products and services, which grew 10.4 percent to \$91 billion, mainly due to direct-to-home television services, which generated \$69.8 billion in 2008. Fixed satellite services showed the strongest growth rate, with revenue up 31 percent to \$16.8 billion.<sup>2</sup>

The Organisation for Economic Co-operation and Development (OECD) noted in 2007 that while the space industry is small relative to other manufacturing sectors –

... its dynamism in terms of innovation and R&D, and its significance, gives it importance beyond its size. The orbital infrastructure of communications, precision timing, earth observation and navigation satellites that is the fruit of decades of civilian and military research and development would never have developed were it not for the efficient infrastructure on the ground. From manufacturing to satellite relays, space and earth are stitched together in the same whole infrastructure.<sup>3</sup>

The U.S. National Research Council (NRC) agrees. In its 2009 report *America’s Future in Space: Aligning the Civil Space Program with National Needs*, the NRC Committee on Rationale and Goals for the U.S. Civil Space Program concluded that while the “direct” space economy – which it valued at \$40 billion per year – represents only a small fraction of Gross Domestic Product, “... this relatively small industrial base punches far above its weight

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<sup>2</sup> The Space Report 2009 Reveals Industry Growth to \$257 Billion. The Space Foundation. Press release, Colorado Springs, CO, April 14, 2009. [Website](#) viewed November 1, 2009. Note that all comparisons are between 2008 and 2007.

<sup>3</sup> OECD Observer. Space: More than Meets the Eye. No. 263. October 2007. Available at: <http://www.oecdobserver.org/news/fullstory.php/aid/2316/Space: More than meets the eye.html>

economically, as a larger pyramid of economic activity depends on the space industrial base's products."<sup>4</sup>

Those products include not only the hardware and software associated with building and launching satellites into space, but the images and services provided by Earth orbiting satellites and sold by companies around the world. These include satellites for communications; remote sensing of the Earth (including imaging as well as weather and climate); and positioning, navigation and timing.

A thorough discussion of the peaceful uses of space would fill volumes and is outside the scope of this paper. The following paragraphs provide a very brief overview of their significance.

### *Communications Satellites*

Communications satellites are probably the best known space application and date back to the earliest days of the Space Age. Today, companies like Intelsat, SES, and Iridium own and operate fleets of satellites. Intelsat, for example, has 51 operating satellites in orbit today. SES has 40. Iridium's mobile telephone satellite system comprises 66 satellites plus in-orbit spares. Dozens of other companies and governments own one or more communications satellites, interconnecting the world and its global economy.

The largest revenue producer within the commercial satellite service sector was direct-to-home (DTH) television, which generated \$69.61 billion in 2008. Fixed satellite services constituted the second largest sector with \$16.79 billion in 2008. These industry segments together comprise 95% of commercial satellite revenues. Fixed satellite services showed the strongest growth rate, increasing 31% in 2008 to a sector with revenue of \$16.79 billion from \$12.82 billion in 2007.<sup>5</sup>

Speaking at the first in a series of "A Day Without Space" seminars sponsored by the Space Enterprise Council and the Marshall Institute, Ed Morris, then-Executive Director of the Office of Space Commerce at the U.S. Department of Commerce, commented on what would happen if there were no communications satellites.

Our long-distance phone calls go through satellites. TV entertainment, both live and recorded, is routinely relayed from studio to station via satellite. Even your local news channels use satellites to deliver live reports on location. Without space, we would lose all of this. All international calls and data traffic would be re-routed through terrestrial or undersea lines, stretching their capacity to the limits and possibly preventing calls from going through. In regions where there is no terrestrial infrastructure, such as rural Africa or China, telecommunications would be impossible. International financial transactions would be disrupted. Our embassies would lose their ability to communicate securely with Washington and news updates from Baghdad and Islamabad would be severely limited. TV stations would be limited to broadcasting recorded content from the local archives. People who live or work in remote areas and depend on satellites for TV, radio, and internet access would lose all service. Trucking and shipping companies would not be able to track their fleets. Some gas stations would lose the ability to authorize credit card transactions,

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<sup>4</sup> National Research Council. Committee on Rationale and Goals for the U.S. Civil Space Program. *America's Future in Space: Aligning the Civil Space Program with National Needs*. Washington, D.C., National Academies Press, 2009. pp. 31-32.

<sup>5</sup> Space Foundation. *The Space Report 2009*. Executive Summary (available for free at <http://www.thespacereport.org/files/09executivesummary.pdf>)

eliminating the option to pay at the pump and causing delays as people line up at the cash register.<sup>6</sup>

### *Navigation Satellites*

More properly referred to as “PNT” satellites, for Positioning, Navigation and Timing, the U.S. Global Positioning System (GPS) is by far the best known and frequently used navigation satellite system in the world, though Russia has its GLONASS system and Europe and China are developing their own.

Developed, owned and operated by the U.S. Department of Defense, GPS’ civilian uses are ubiquitous, from providing timing signals that enable cell phone systems to operate, to telling farmers where to fertilize their crops for maximum effectiveness, to navigating ships and aircraft, to leading hungry automobile drivers to the nearest restaurant. The Space Report 2009 estimates the revenue from GPS equipment and services in 2008 at \$56 billion a year.<sup>7</sup>

Noting that GPS timing signals are used for everything from coordinating and managing telecommunications networks to the electrical grid and financial systems, the National Research Council concluded “From that perspective, the entire economy relies on the space infrastructure.”<sup>8</sup>

### *Remote Sensing of the Earth for Science and Applications*

“Remote sensing” covers a broad range of space applications that use satellites to look down at Earth producing images or collecting data that feed into weather forecasts or climate studies, for example. According to The Space Report 2009, it was a \$7.5 billion market in 2008.<sup>9</sup> Though that market is much smaller than communications or navigation, remote sensing satellites are a crucial national and international resource.

Growing concern about global climate change, whatever its causes, has highlighted the critical role that satellites play in monitoring Earth’s climate. The international Group on Earth Observations (GEO) is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS) that will use sensors on land and sea, in the air, and in space to “revolutionize our ability to understand and manage the planet.”<sup>10</sup>

Buoys floating in the oceans monitor temperature and salinity; meteorological stations and balloons record air quality and rainwater trends; sonar and radar systems estimate fish and bird populations; seismic and Global Positioning System (GPS) stations record movements in the Earth’s crust and interior; more than 60 high-tech environmental satellites scan the planet from space; powerful computerized models generate simulations and forecasts; and early warning systems issue alerts to vulnerable populations. GEOSS promises to make these and other technologies fully “interoperable”.<sup>11</sup>

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<sup>6</sup> *A Day Without Space: Economic and National Security Implications*, sponsored by the Space Enterprise Council and the Marshall Institute. October 16, 2008. Transcript available at: <http://www.marshall.org/pdf/materials/695.pdf>.

<sup>7</sup> Space Foundation. *The Space Report 2009*. Colorado Springs, Colorado. p. 20. (Full report available for purchase at: <http://www.thespacereport.org/>)

<sup>8</sup> National Research Council, *op cit.*, p. 35.

<sup>9</sup> *The Space Report 2009*, *op cit.*, p. 20.

<sup>10</sup> The Global Earth Observation System of Systems. Information Sheet 1. Updated 1 April 2009. Available at: [http://www.earthobservations.org/documents/200904\\_geo\\_info\\_sheets.pdf](http://www.earthobservations.org/documents/200904_geo_info_sheets.pdf).

<sup>11</sup> *Ibid.*

While earth science and applications remain primarily a government responsibility, remote sensing imagery has moved into the commercial realm, albeit heavily subsidized directly or indirectly by governments. Commercial satellite imagery is becoming almost as common as GPS units through applications such as Google Earth. Consumers may be as unaware of the origin of the images they see on Google Earth as they are of the origin of GPS signals, but their utilization of and reliance on such space applications continues to grow. As Ed Morris of the U.S. Department of Commerce noted at the “Day Without Space” symposium

... a surveyor may not care whether a given plot of land was imaged today or six months ago. However, a farmer battling blight may need to know within 24 hours whether the crop treatments he applied are having an effect. A border patrol officer may require daily updates to properly monitor crossings; in such cases, aerial photography is not really a reliable alternative unless the satellite outage was known in advance so an overflight could be ordered.

... If an earthquake, tsunami, forest fire or other natural disaster occurred on a hypothetical day without space, we would have no ability to photograph it quickly from space and assess the damage. We would have no satellite imagery to assist in planning relief efforts and guiding rescue workers to the areas of greatest need. Here again, aerial photography would still be possible, but without GPS to geolocate precisely where the airborne cameras are pointing, the raw images would be hard to match against the map, especially if known landmarks are no longer present.<sup>12</sup>

### *Technology Development*

Space programs are a driver of new technology development. Space is a harsh environment and developing systems that can survive the radiation and vacuum of space and function for many years is a challenging task. This is particularly true for systems intended to support humans in space.

While initial technology developments are designed to enable or enhance space missions, they often have secondary uses that were not envisioned at the time of the development – spinoffs. These are technologies that “through productive partnerships with industry, entrepreneurs, universities and research institutions have resulted in products and services that elevate health and public safety, augment industrial productivity, computer technology, and transportation; and enhance daily work and leisure.”<sup>13</sup>

Since 1976, NASA has published an annual Spinoff book<sup>14</sup> that details what the agency considers to be key spinoffs. Medical devices such as rechargeable pacemakers are oft-cited examples. There are many critics of claiming economic benefits from space program spinoffs on the basis that the technologies, if needed, would be developed whether or not there is a space program or that it is often impossible to trace the heritage of a technology purely to a space activity.<sup>15</sup> Nonetheless, the more than 1,600 technologies catalogued in NASA’s Spinoff books over the years cannot be easily ignored.

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<sup>12</sup> *A Day Without Space*, op. cit.

<sup>13</sup> Spinoff 2009. Washington DC, NASA, 2009. p. 7.

<sup>14</sup> The 2009 version is available at: <http://www.sti.nasa.gov/tto/>.

<sup>15</sup> Critics often point out, for example, that the three best known “space spinoffs” did not, in fact, come from the space program: Tang, Velcro and Teflon. All existed prior to the space program.

## **Societal Benefits**

The benefits of space exploration and utilization that are enabled by maintaining peace in space are not all about money. Peace in space also yields societal benefits such as expanding our knowledge of the universe, fostering international cooperation and good will, and inspiring people throughout the world about limitless possibilities.

### *Space Science*

Space science missions have greatly expanded our understanding of our planet, its place in the solar system, and the universe, solving some mysteries and discovering new ones. It is impossible to put a price tag on the value of images from the Hubble Space Telescope or the travels of rovers on the surface of Mars, but the number of hits on websites showcasing their discoveries are testament to the public interest they inspire.

The space program has its roots in the 1957-1958 International Geophysical Year in which scientists from 60 countries worked together to study Earth's geophysical phenomena. The United States and Soviet Union each vowed to launch satellites in support of the IGY and they did, first the Soviets with Sputnik and then the United States with Explorer 1.

Dr. Eilene Galloway, in whose honor this symposium is being held, often commented that after an initial reaction of shock to the Soviet launch of Sputnik, members of the United States Senate were relieved when IGY scientists testified to a Senate committee about the peaceful uses of outer space: "Fear of war changed to hope for peace."<sup>16</sup> Space science could hardly have a more dramatic impact than that.

### *Human Space Flight*

Maintaining peace in space also permits human space flight missions. Many have tried to articulate the value to a particular country or to humanity in general of human trips into space, but most find it difficult to explain why such expensive undertakings are worth the cost and risk.

In 1989, President George H.W. Bush announced a new program to return astronauts to the Moon and then go on to Mars. Although that program did not reach fruition, the words he used when making his announcement resonate still today as to why nations aspire to send humans into the unforgiving environment of space. His statement, not surprisingly, was aimed at a U.S. audience, but it spoke to at least one country's rationale for such a bold undertaking:

Why the Moon? Why Mars? Because it is humanity's destiny to strive, to seek, to find. And it is America's destiny to lead.<sup>17</sup>

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<sup>16</sup> Eilene Galloway. Sputnik and the Creation of NASA: A Personal Perspective. In: NASA. 50 Years of Exploration and Discovery. Washington, D.C., 2008. p. 48

<sup>17</sup> President George H. W. Bush. Remarks on the 20<sup>th</sup> Anniversary of the Apollo 11 Moon Landing. July 20, 1989. Available on the website of the George H.W. Bush Presidential Library and Museum: [http://bushlibrary.tamu.edu/research/public\\_papers.php?id=712&year=1989&month=all](http://bushlibrary.tamu.edu/research/public_papers.php?id=712&year=1989&month=all)

Critics of human space flight argue that robotic missions are cheaper and do not risk human lives. That is true. Nonetheless, the pride and prestige and inspiration associated with human space flight has not diminished with the passage of time as demonstrated by the 36 countries that have sent their representatives into space.<sup>18</sup>

### *International Cooperation*

Both space science and human space flight missions involve strong international cooperation today.

NASA has pursued international cooperation for all of its 51 years as encouraged by Section 205 of the 1958 National Aeronautics and Space Act. That section of the NASA Act was written by Dr. Galloway when she was at the Legislative Reference Service and working with then-Senate Majority Leader Lyndon B. Johnson on the U.S. response to Sputnik. It was Dr. Galloway's strong belief that by working together in space activities, countries would be drawn to work together on other critical issues and hence facilitate world peace. It is difficult to prove that point – the inverse may be more accurate, that when countries are working together on other critical issues it leads to increased space cooperation – but the symbolic value of international cooperation in space should not be dismissed.

On a more practical level, international cooperation enables some space programs that are too expensive for one nation alone to pursue. While it is probably true that international cooperative projects cost more overall, the cost to each participant is less than if they attempted to do the mission alone. A list of international cooperative space programs involving just the United States, not to mention all the other international programs that have been conducted – especially in Europe where the European Space Agency itself is a prime example of such cooperation – would be far too extensive to include in this paper.

As Dr. Galloway wrote last year: "Space exploration became the beacon for our hope, the symbol of national and international achievement, and now we celebrate 50 years of progress and peace."<sup>19</sup>

## **FUTURE BENEFITS**

Maintaining peace in outer space will open new opportunities for governments and the private sector to explore and utilize space for the benefit of all. If peace is not maintained and space becomes a venue for conflict, the multitude of benefits of space exploration and utilization described above will be lost. Satellites – which are very vulnerable to debris, electronic interference, electromagnetic radiation and other hazards of space warfare – will no longer be dependable for providing the services to which the world has become accustomed. The two examples below are illustrative of future benefits that could be achieved as long as space remains peaceful.

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<sup>18</sup> Bill Harwood. CBS Space News Statistics: General Demographics. <http://www.cbsnews.com/network/news/space/spacestats.html#GENERALDEMO>. Note that the United States, Russia and China are the only countries that can launch people into space. China has launched only Chinese citizens. All the other countries' spacefarers have flown on U.S. or Russian spacecraft.

<sup>19</sup> Eilene Galloway, op cit.

## **Energy**

The world's growing appetite for electricity continues unabated. The environmental consequences of relying on fossil fuels are well known. Nuclear fission power creates radioactive waste for which no safe, cost effective, long term solution has been found. Renewable energy sources alone cannot generate sufficient power. New energy sources are needed and two candidates require access to space: Space Solar Power Systems (SSPS) and nuclear fusion. SSPS has been studied for several decades and would use solar arrays in Earth orbit, lunar orbit or on the lunar surface to collect solar energy and beam the power back to Earth.<sup>20</sup> Considerable research also has been done on fusion reactors and one promising fuel is helium-3, which is scarce on Earth but comparatively abundant on the Moon. The concept of mining helium-3 on the Moon and using it for fusion reactors on Earth is championed by Apollo 17 astronaut Harrison Schmitt.<sup>21</sup> Technological, economic, and other challenges remain to be resolved, but SSPS and fusion power could be solutions for the world's energy needs in the decades ahead.

One of the challenges for mining helium-3 will be establishing a governance structure for utilization of lunar resources. Much is made of the alleged restrictions imposed on commercial endeavors in outer space including the Moon and other celestial bodies by the Outer Space Treaty. Some argue that the Outer Space Treaty inhibits commercial activities on the Moon because companies cannot own property there. Yet a burgeoning commercial marketplace exists in Earth orbit even though companies cannot own orbital slots or frequencies. They use the slots and frequencies as assigned by the International Telecommunication Union (ITU) and their national administrations. Why the Moon is viewed as so different from Earth orbit in this regard is unclear. Perhaps the IISL could focus one of its sessions, or a session of the Scientific-Legal Committee, on how to establish a mechanism akin to the ITU for determining permissible uses of the Moon, possibly including lunar orbit, on an international basis. The ITU is far from perfect and is often criticized for practices that lead to companies filing applications for satellites they do not intend to build ("paper satellites") simply to frustrate other applicants or to preserve future rights, but an ITU-like organization as one model is at least a place to start. Others, such as the World Trade Organization, also could be studied.

## **Tourism**

Whether viewed as an activity to inspire ordinary citizens and give them a glimpse of their home planet from the lofty vantage point of space, or purely as a commercial endeavor to make money, space tourism has arrived. Although very few can afford the \$20 million or more tickets to the International Space Station offered by Russia, the unveiling of Virgin Galactic's SpaceShipTwo on December 7, 2009 opens opportunities for those who have \$200,000 to spare for such a unique experience. More than 300 passengers reportedly already have paid deposits<sup>22</sup> for trips and the company expects that thousands ultimately will fly. That would be a good business for Virgin Galactic, but the greater benefits may

<sup>20</sup> See for example: Michael Lemonick, *Solar Power from Space: Moving Beyond Science Fiction*. *Environment* 360, August 31, 2009. <http://e360.yale.edu/content/feature.msp?id=2184>

<sup>21</sup> See for example: Harrison Schmitt, *Return to the Moon: Exploration, Enterprise, and Energy in the Human Settlement of Space*. Praxis Publishing, 2006, 335 pp. An interesting review of the book and the concept of mining helium-3 on the Moon by Paul Spudis is available on the American Scientist's website: <http://www.americanscientist.org/bookshelf/pub/mining-the-moon>.

<sup>22</sup> SpaceShipTwo Christened VSS Enterprise. *Wired*, December 7, 2009. <http://www.wired.com/autopia/2009/12/spaceshiptwo-christened-as-vss-enterprise/>

come from affording so many inhabitants of our Pale Blue Dot the opportunity to see the planet from that new perspective.

Regulatory and governance issues also will be important for this new commercial space activity. The United States already has passed a law to regulate space tourism, the 2004 Commercial Space Launch Act Amendments, but it will be important for other administrations also to establish mechanisms to protect the safety of crew, passengers, and third parties to the maximum extent possible. Also, as pointed out by Dr. Kai-Uwe Schrogl of the European Space Policy Institute in testimony to the Committee on Science and Technology of the U.S. House of Representatives, it is important for the international space community to work to prevent countries that do not want to adhere to international norms from acting as “flags of convenience.”<sup>23</sup> A review of space tourism regulations in the United States and elsewhere and an identification of issues that remain to be resolved could be the topic of an IISL session at a future colloquium.

### CONCLUSION

It is essential that the Outer Space Treaty remains in force and continues to provide the fundamental tenets to preserve peace in space. Additional agreements may be required to clarify specific points or new governance mechanisms maybe needed for lunar resource utilization, for example, but the Outer Space Treaty stands the test of time.

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<sup>23</sup> Kai-Uwe Schrogl. Prepared statement for the U.S. House of Representatives Committee on Science and Technology. The Growth of Global Space Capabilities: What’s Happening and Why it Matters. Hearing, November 19, 2009. [http://democrats.science.house.gov/Media/file/Commdocs/hearings/2009/Space/19nov/Schrogl\\_Testiomny.pdf](http://democrats.science.house.gov/Media/file/Commdocs/hearings/2009/Space/19nov/Schrogl_Testiomny.pdf)