SPACE SUSTAINABILITY

A PRACTICAL GUIDE

Secure World Foundation

updated 2014

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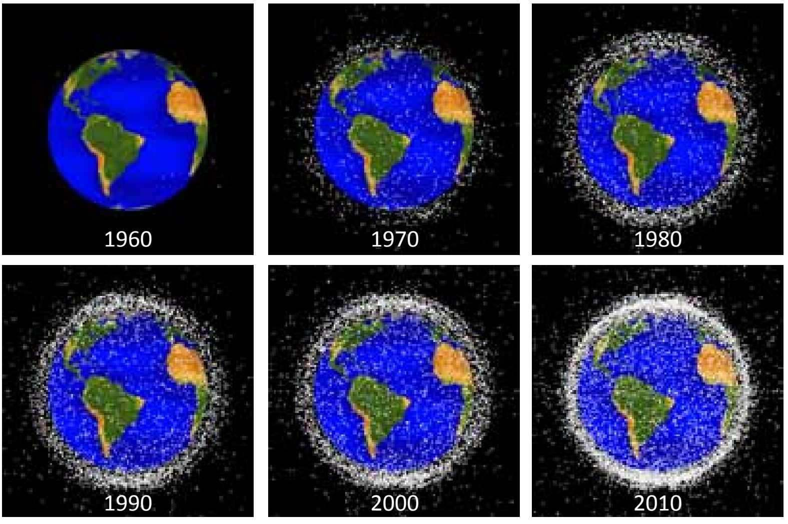
Space Sustainability is...

Ensuring that all humanity can continue to use outer space for peaceful purposes and socioeconomic benefit now and in the long term. This will require international cooperation, discussion and agreements designed to ensure that outer space is safe, secure and peaceful.

More than one thousand satellites orbit Earth providing tangible social, scientific, strategic and economic benefits to billions of individuals throughout the globe. Yet the ability to provide important benefits from outer space is now threatened by a number of challenges. One is the increasing density of debris in orbit. Some experts predict the debris population will reach a level at which it becomes self-sustaining: debris–on–debris collisions would continue to increase the amount of debris in orbit, even without new launches. This could quickly lead to a sharp decrease in the ability to sustain the benefits that space systems provide to the entire world.

Spacecraft face an especially high risk in Sun-synchronous orbits (SSO). SSOs are special orbits between 700 and 900 kilometers (km) in altitude primarily used by Earth observation satellites that collect valuable information about the world we live on.



Satellites and debris in low Earth orbit, 1960-2010. Courtesy of NASA.

The last thing we need is to create more debris up there.

Gen. Kevin Chilton,
USSTRATCOM Commander,
2007 Air Force Association Conference

Increasing crowding in key orbits also presents a challenge to space operations. For example, communication satellites in geosynchronous Earth orbit (GEO), the equatorial orbit where satellites appear to remain nearly stationary above Earth, face increased competition for orbital slots as a result of the strong demand for satellite TV and global communications. This crowding has led to the potential for radio frequency interference and a shrinking margin of error for maintaining separation between satellites.

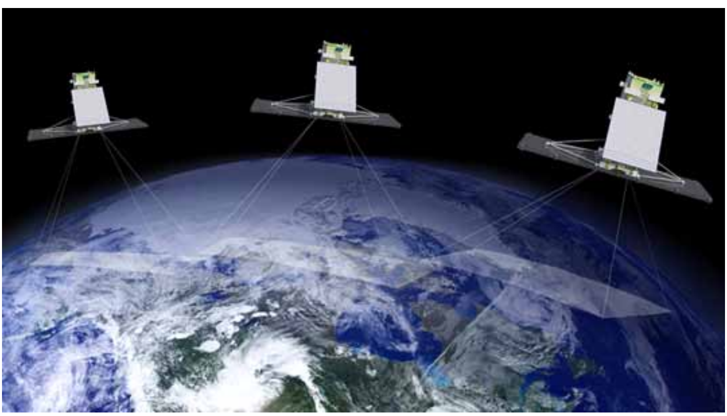
The increasing use of space also presents security challenges. As more countries integrate space into their national military capabilities and rely on space-based information for national security, there is an increased chance that any interference with satellites could spark or escalate tensions and conflict in space or on Earth.

Secure World Foundation and its partners worldwide are dedicated to the establishment of effective and efficient systems of governance for outer space and improving safety of operations in Earth orbit. This effort includes developing tools of governance that lead to reducing the threat of orbital debris, promoting international civil space situational awareness to improve knowledge and transparency, and preventing the creation of additional debris through hostile acts.

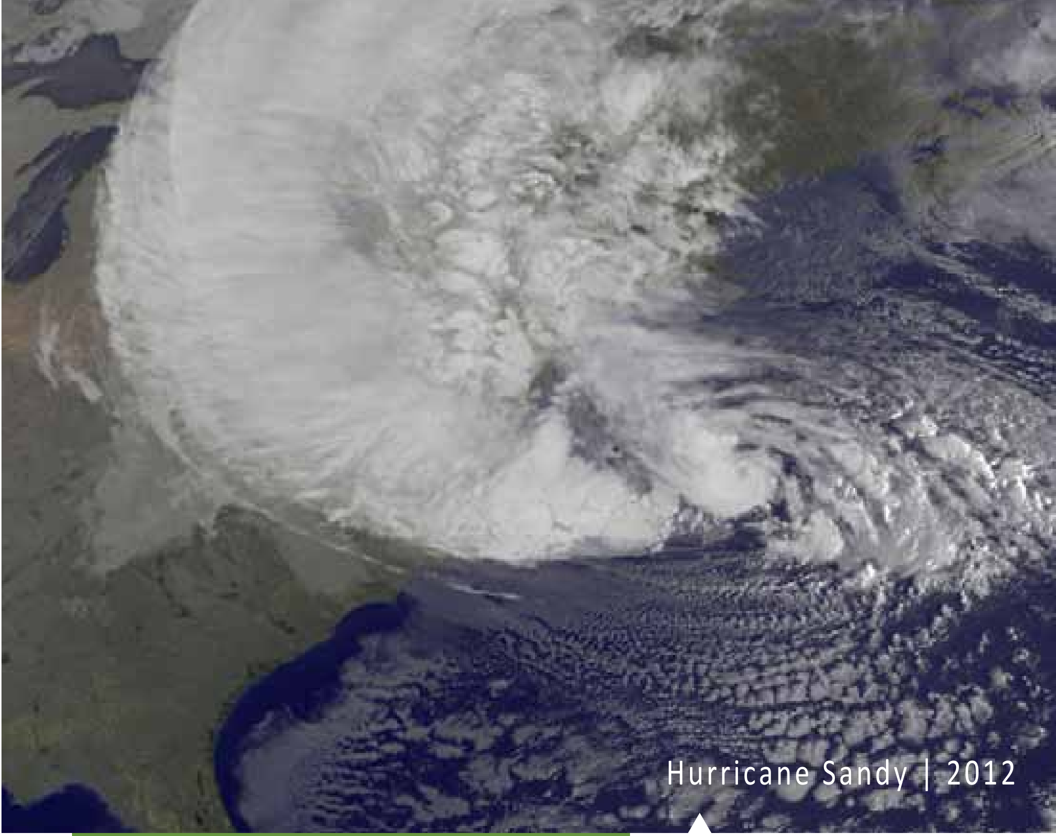
In order to further the continued utility of space activities for the benefit of Earth and its people, Secure World Foundation strongly supports efforts to work toward sustainability of activities in outer space.

Why Care About Space Sustainability?

In a world inundated with many complex and urgent problems, why does space sustainability matter? If outer space is not safe, secure and peaceful, the ability to use it could be denied to all. We would be unable to use the space environment for national security purposes, Earth observation, telecommunications (including financial transactions, internet, telephone, data transfer and television), navigation, scientific exploration, or economic development. Indeed, human spaceflight in Earth orbit could come to an end. Lack of sustainability would mean that emerging space countries, especially, could face insurmountable problems in using outer space effectively. Addressing the need for space sustainability now means we can prevent negative trends from becoming norms, and ensure that outer space can be used by all countries, not just technologically sophisticated ones.



The RADARSAT Constellation mission is being designed for three main uses: maritime surveillance, disaster management, and ecosystem monitoring (Canadian Space Agency, 2012).



Earth Observation Satellite: NOAA's GOES-13 satellite captured this visible image of Hurricane Sandy battering the U.S. East Coast on October 29, 2012. Sandy's center was about 500 km (310 miles) south-southeast of New York City. Tropical storm-force winds extended about 1,610 km (1,000 miles) in diameter. Courtesy of NOAA GOES Project.

One thing is already clear - the space environment is getting increasingly crowded due to the relentless growth of space debris. If the spacefaring nations of the world don't take steps to minimize the growth of space junk, we may eventually face a situation where low Earth orbit becomes a risky place to carry out civil and commercial space activities.

Former U.S. Representative
Gabrielle Giffords (D-AZ), 2009

The Persistent Problem of Orbital Debris

Both accidents and intentional destructive events can produce large quantities of orbital debris that remain as threats for years or centuries. Smaller amounts of debris are also produced through routine operations. Orbital debris is a global problem and shows the need to work together to ensure space sustainability.

The U.S. military maintains the world's most extensive orbital tracking network, recording (in 2014) some 23,000 objects in space measuring roughly 10 cm in diameter or larger. What cannot be reliably tracked yet are the objects smaller than 10 cm because these are too small to follow consistently. Scientists estimate that about 500,000 bits of junk measuring 1 to 10 cm orbit Earth and believe that many millions of pieces smaller than 1 cm exist. Because all objects in Earth orbit travel at extremely high speeds, even very small ones can cripple or destroy working spacecraft or endanger astronauts.

Knowing more about the nature of the problem is critical to space sustainability. Sharing information about orbital debris, mitigating its production and even developing capabilities to remove existing debris represent key objectives toward ensuring that conditions in outer space are favorable for continued use.

Satellites & Debris by Orbit

600 operational satellites in low Earth orbit (LEO), with approximately 17,000 pieces of trackable debris bigger than 10 cm

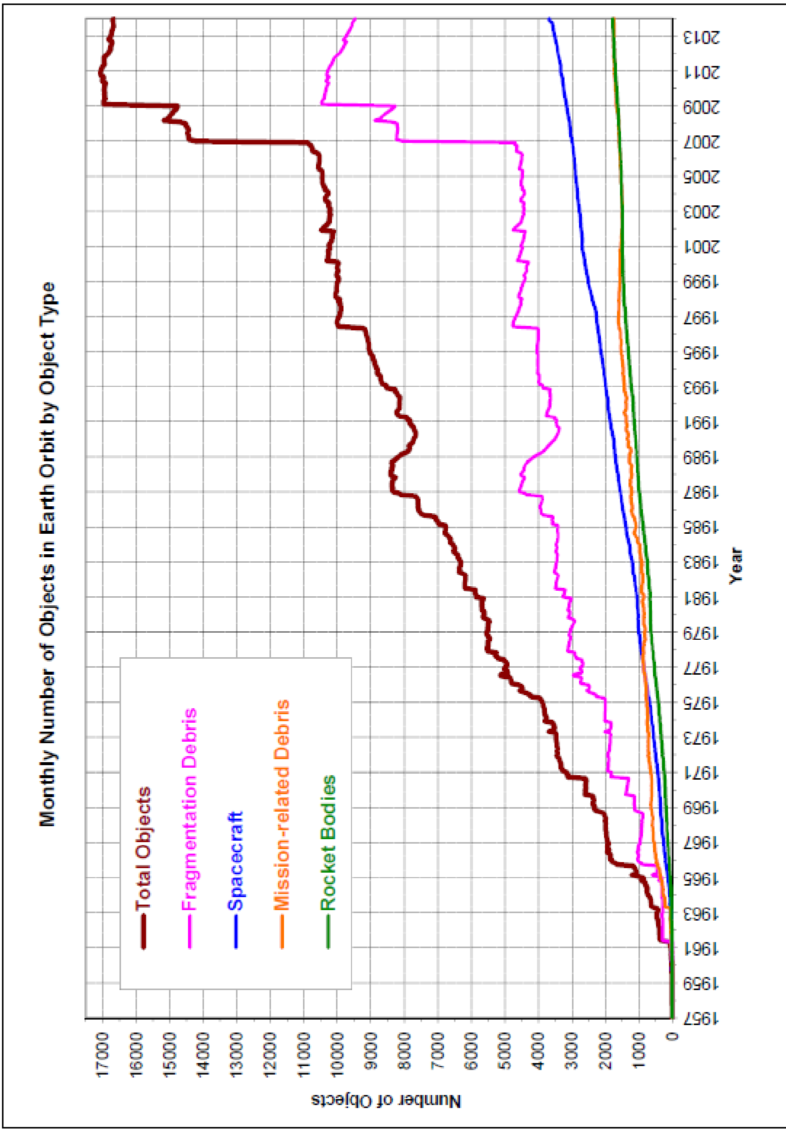
115 operational satellites in medium Earth orbit (MEO), with approximately 1,000 pieces of trackable debris

450 operating satellites in GEO, with approximately 1,000 pieces of trackable debris

Source: Union of Concerned Scientists, 2014, and European Space Agency, 2014.

The following pages provide more details of two recent events that contributed greatly to the increase in orbital debris.

Number of Objects in Earth Orbit by Object Type



This chart displays a summary of all objects equal to or larger than 10 cm in Earth orbit officially catalogued by the U.S. Space Surveillance Network. “Fragmentation debris” includes satellite breakup debris and anomalous event debris, while “mission-related debris” includes objects dispensed, separated or released as a part of a planned mission. Many more objects are tracked but only those that can be attributed to a specific launch and launching state(s) are catalogued. Courtesy of NASA.

On January 11, 2007, as China's inoperable Fengyun-1C weather satellite passed overhead, a modified Chinese ballistic missile was launched from China's Xichang Satellite Launch Center and streaked toward the satellite, deliberately colliding with tremendous force and creating thousands of small pieces. This cloud of debris quickly spread out across a large region of Earth orbit, covering between 300 and 2,000 km in altitude. Many of these pieces remain in the original polar orbit, the prime location for most Earth observation satellites, including weather and climate satellites operated by the world's space agencies. The deliberate satellite destruction created more than 3,000 trackable pieces of orbital debris (larger than about 10 cm). NASA's debris experts estimate that the test created perhaps as much as 150,000 pieces of debris too small to track. Most of these will remain in orbit, posing a serious threat to working satellites in LEO for decades.

Debris-generating kinetic-kill anti-satellite (ASAT) weapons like this Chinese example have become a major international concern, primarily because of the large amounts of debris they create. During the 1970s and 1980s, the former Soviet Union and the United States tested their own forms of these ASATs, but decided that they were of limited tactical or strategic use, in part because of the potential collateral damage to their own satellites from the large amounts of orbital debris generated.

2007 Chinese ASAT Test

Fengyun 1C
Defunct Chinese weather satellite

SC-19
Modified Chinese ballistic missile with kinetic-kill vehicle

Debris produced by collision
3,000 trackable pieces (10 cm or larger),
150,000 untrackable pieces

Impact velocity
About 10 km per second

Accidents in outer space must be avoided in order to prevent loss of life and creation of damaging orbital debris.

On February 10, 2009, two satellites collided accidentally, creating a large amount of debris circling 800 km above Earth.

Nearly 2,000 parts of the two satellites—chunks of metal, foil and plastic—now circle Earth in spreading orbits, posing a collision threat to other satellites and the International Space Station. One satellite was already out of service, but the other helped provide worldwide telephone services. Although the collision might have been predicted, it is unclear whether or not it could have been avoided. At the time neither Russia nor the United States was actively screening these two satellites for potential collisions. Also, with today's technology, satellite operators cannot predict with high certainty whether or not two objects will collide in orbit.

Since this collision, the U.S. military and the satellite communications industry have developed additional procedures to try and prevent future collisions. Nevertheless, more needs to be done to ensure that all satellite operators are aware of potential threats in orbit and have the information to act responsibly.

2009 Iridium-Cosmos Collision

Iridium 33
Active commercial communications satellite operated by U.S.-based Iridium Satellite LLC

Cosmos 2251
Inactive communications satellite once operated by the Russian Ministry of Defense.

Debris produced by collision
2,000 trackable pieces of debris (10 cm or larger).

Impact velocity
About 10 km per second.

Source:
NASA Orbital Debris Program Office

Radio Frequency Interference

Radio frequency (RF) communications are essential to satellites. As part of the electromagnetic spectrum, radio waves are used by satellites to receive commands from ground controllers (uplink) and relay information about their health and status in return (downlink). Many satellites also use radio waves as an important element in their functioning, including retransmitting television broadcasts or transmitting imagery or scientific data that they have collected. Unintentional RF interference can arise from a number of sources. Natural interference can be caused by solar storms and other forms of space weather, interaction with the Earth's atmosphere, and sometimes even clouds and rain. Unintentional human-generated interference can result from a satellite transmitting too close to another satellite on the same frequency or from terrestrial communications systems operating on the same or similar frequency to space systems.

Intentional RF interference, often referred to as jamming, is a way of temporarily or reversibly disrupting the normal functioning of a satellite without resorting to actual destruction of the satellite and the chance of creating long-lived space debris. Intentional interference is also relatively easy to accomplish, often requiring nothing more than an antenna and a transmitter. Applications for jamming range from blocking undesirable radio and television broadcasts from being transmitted into a country to blocking satellite navigation signals to prevent an employer from tracking movements, to degrading the ability of an adversary to use precision munitions, among others.

International and national mechanisms currently exist to regulate RF communications. However, these mechanisms focus more on the allocation of spectrum and assignment of frequencies than on the prevention of interference. They also lack enforcement powers. As the instances of unintentional and intentional RF interference increase due to crowding and congestion on orbit, these regulatory shortcomings present a significant challenge to the long-term sustainable use of space.

Galaxy 15 "Zombiesat"

In April 2010, a malfunction caused Intelsat S.A. to lose contact with Galaxy 15, a geosynchronous satellite. The malfunction prevented Intelsat from maneuvering Galaxy 15 and the spacecraft started to drift slowly past other operational satellites in the region.

Galaxy 15's receiver and transmitter equipment was still functioning, meaning it could pick up and re-broadcast signals aimed at other satellites as it drifted past, potentially causing serious radio frequency interference.

In December 2010, Intelsat was able to regain control of Galaxy 15, but only the close communication and cooperation between satellite operators prevented any significant harmful effects.

Artist's rendering of the Galaxy 15 satellite.
Courtesy of Intelsat.

Strategic Stability and Outer Space

The military use of space includes the use of spacecraft designed to support terrestrial military and intelligence operations, such as global positioning systems (GPS), communications, intelligence, reconnaissance, and surveillance satellites. These space technologies are generally agreed to have many peaceful applications and play an increasingly important role in both national and international security.

However, as more countries integrate space into their national military capabilities and rely on space-based information for national security, there is an increased chance that any interference with satellites could spark or escalate tensions and conflict in space or on Earth. This is made all the more difficult by the challenge of determining the exact cause of a satellite malfunction: whether it was due to a space weather event, impact by space debris, unintentional interference, or deliberate aggression.

Some states are developing or have developed a range of ASAT capabilities, including ground and space-based weapons, that could be used to deceive, disrupt, deny, degrade, or destroy elements of space systems. Developing and testing ASAT capabilities would likely undermine political and strategic stability, especially without clarity of intent. Further, testing or using debris-generating weapons could contaminate the orbital environment for decades to centuries, significantly affecting all space actors and severely undermining the long-term sustainability of space.

It is very difficult to ban the technologies used to conduct hostile activities since many of them are also used for peaceful purposes, a characteristic called “dual-use.” Verifying the existence of ASAT capabilities or attributing their use is also very challenging. Thus, an important step forward in addressing these challenges is the development of norms of behavior that delineate responsible and irresponsible activities in space. Improved SSA for all actors to enable the detection and attribution of irresponsible behavior is also essential. Transparency and confidence building measures (TCBMs), such as clarification of existing international law applicable to satellites and outer space, can also increase strategic stability and security.

In February 2008, the United States decided to destroy USA 193, an ailing national security satellite that carried substantial amounts of highly toxic hydrazine fuel and was destined to re-enter the Earth's atmosphere within a few months. Officials opted to shoot it down using a modified Aegis SM-3 missile, launched by the USS Lake Erie (pictured) to ensure that the hydrazine would disperse harmlessly on re-entry. In this case, the United States announced the event ahead of time and deliberately struck the ailing satellite when it reached a very low orbit to assure that most debris re-entered quickly.

The United States specifically designed the intercept to generate as little debris as possible and gave international briefings on the operation, in accordance with international agreements. Within 18 months, the few hundreds of pieces of resultant debris re-entered the atmosphere. Despite assurances by U.S. officials that the intercept was specifically designed to reduce the risk to public safety, many people nevertheless saw this event as an example of how a U.S. anti-ballistic missile defense system can be modified into an ASAT weapon. This concern increases with planned upgrades in the Aegis interceptor that will make it even more powerful and thus able to reach higher orbits in the future.

Aegis SM-3 missile launch, courtesy U.S. Navy

The United Nations and Space

Although some may think space is ungoverned, there are in fact a number of existing international treaties that provide a legal framework. The United Nations plays a significant role in the governance of space activities and the negotiation and adoption of international treaties and other agreements on space, but there are other bodies that play a role as well.

The United Nations General Assembly (UNGA) is composed of 193 Member States (as of 2013). Six permanent committees help the UNGA manage its work on global issues; for space matters, two committees are especially important. The First Committee deals with disarmament and security matters, and the Fourth Committee focuses on special political matters, including outer space. The Committee on the Peaceful Uses of Outer Space (COPUOS) is the UN body responsible for developing policies related to outer space on behalf of the UN Member States. It does not deal with military space issues. COPUOS reports each year to the UNGA via the Fourth Committee. The Office of Outer Space Affairs (OOSA) is the secretariat for COPUOS and carries out COPUOS policies as part of the larger UN secretariat. The Conference on Disarmament (CD), which is not a UN organization but works under the UN auspices, is the international forum for work on disarmament, and for matters related to weapons in space and other space security issues. The CD reports its annual findings to the UNGA via the First Committee.

Composed of 74 Member States and 29 permanent observers (including SWF), COPUOS is the premier international forum for working out issues of space governance. Its work is divided between two subcommittees: the Scientific and Technical Subcommittee and the Legal Subcommittee. Matters that come before COPUOS are deliberated first in working groups within one of the subcommittees and, when agreement is reached, the matter is presented to the full committee as a report of the subcommittee. After additional deliberation, COPUOS will prepare a report and possibly a resolution for presentation to the General Assembly for its approval as a UN resolution.

Committee on the Peaceful Uses of Outer Space

Fourth Committee

Conference on Disarmament

First Committee

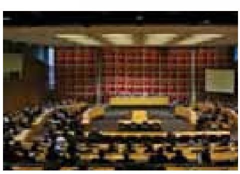
GENERAL ASSEMBLY

SECURITY COUNCIL

Office of Outer Space Affairs

SECRETARIAT

TRUSTEESHIP COUNCIL



ECONOMIC AND SOCIAL COUNCIL

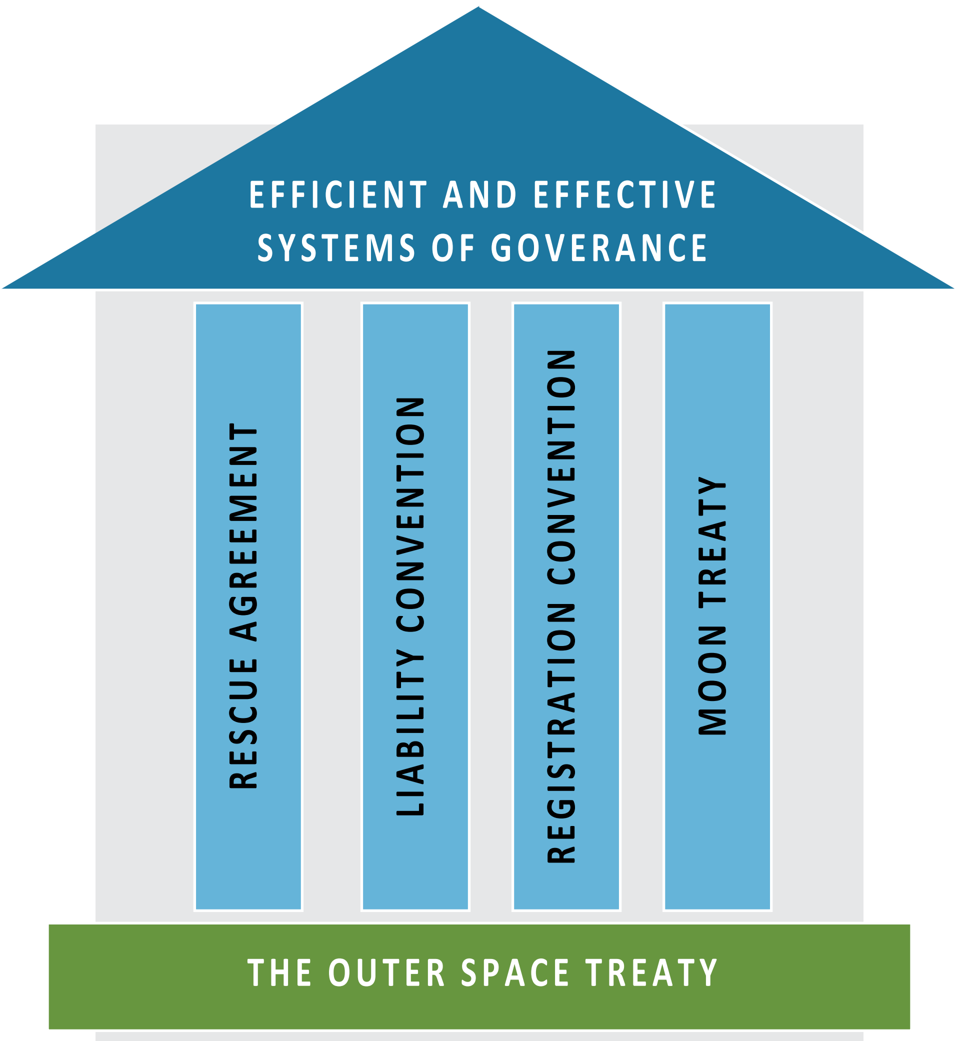
INTERNATIONAL COURT OF JUSTICE

The CD is the international forum for negotiating arms control and disarmament matters. One of its core focus areas is the prevention of an arms race in outer space (PAROS). As such, the subject of space and security weapons falls under its purview. The UN Institute for Disarmament Research (UNIDIR) helps provide decision-level information to the CD and identifies potential flashpoints that may lead to an arms race.

The UN OOSA is responsible for carrying out space-related resolutions passed by the UNGA and maintains the Register of Objects Launched into Outer Space.

The Space Treaties

COPUOS was responsible for the crafting of the five treaties that address activities in outer space. The 1967 Outer Space Treaty (OST) sets out the foundations of outer space law elaborated upon in the later agreements. Additional non-binding agreements for outer space have been developed by COPUOS to address orbital debris mitigation, cooperative arrangements for sharing remote sensing data, and other related matters.



THE OUTER SPACE TREATY was opened for signature in 1967 and entered into force the same year. Over one hundred States have ratified the treaty, which provides the basic framework for international space law. Key principles include: the exploration and use of outer space for peaceful purposes by all States for the benefit of humankind regardless of their level of development; the barring of national appropriation or claims of sovereignty of outer space or celestial objects; the banning of placing weapons of mass destruction in orbit or on celestial bodies; assigning States the responsibility for and requirement of supervising the activities of their national space activities, whether carried out by governmental or nongovernmental entities; establishing that States are liable for damage caused by their space objects; and pronouncing that States shall avoid harmful contamination of space and celestial bodies.

RESCUE AGREEMENT (1968) Requires States to take steps to rescue and assist astronauts in distress and return them to the launching state, and assist launching states in recovering space objects that return to Earth outside the territory of the launching state.

LIABILITY CONVENTION (1972) Outlines the liability of Launching States for damage caused by their space objects on the Earth or in space, and procedures for the settlement of claims for damages.

REGISTRATION CONVENTION (1976) Directs launching States to maintain a registry of their space objects and provide the UN with information on the objects they launch into outer space.

MOON TREATY (1984) Reaffirms and elaborates OST provisions applied to appropriation and exploration of the Moon and exploitation of resources found on the Moon. Though technically in force, this treaty has been ratified by relatively few countries and is ignored by most.

ELEMENTS OF SPACE GOVERNANCE also include COPUOS endorsement of voluntary guidelines for orbital debris mitigation, negotiations to deal with space weapons and space security at the UN Conference on Disarmament, UN efforts to establish a plan to address the threat of a potentially hazardous asteroid, negotiations between public and private entities on international civil space situational awareness, and other efforts.

Establishing the elements of systems of governance for outer space translates the basic framework of international space policy into practical, coordinated and integrated legal infrastructures.

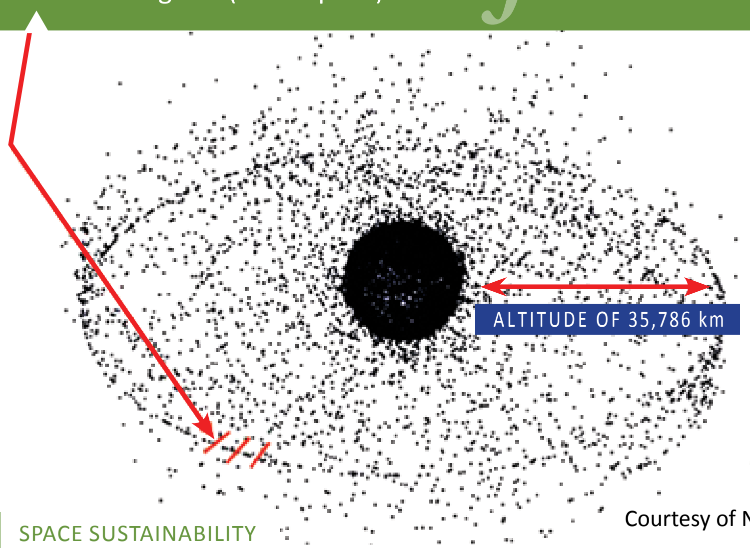
ITU and IADC—Dealing with Orbital Crowding and Debris

During the late 1950s it became clear that the public and private use of RF spectrum by satellites would need to be regulated using an international system agreed upon by stakeholder nations. **The International Telecommunication Union (ITU),** established in 1865 to develop international radiocommunication standards, held a special conference in 1963 to allocate frequency bands for space applications. Initially this effort focused primarily on satellites in GEO, but in 1998 that authority was extended to other orbits as well. The ITD's Radiocommunication Sector (ITU-R) is responsible for both allocation and allotment of frequency bands used for space applications and assignment of specific frequencies to national administrations for use by specific satellites. This happens after a process of advanced publication, coordination, notification and recording procedures applying the so-called "first come, first served" principle. Within each Member State, a designated national administration is responsible for licensing and regulating the activities of governmental and private sector actors.

The ITU assigns GEO slots to the Member States by considering three factors:

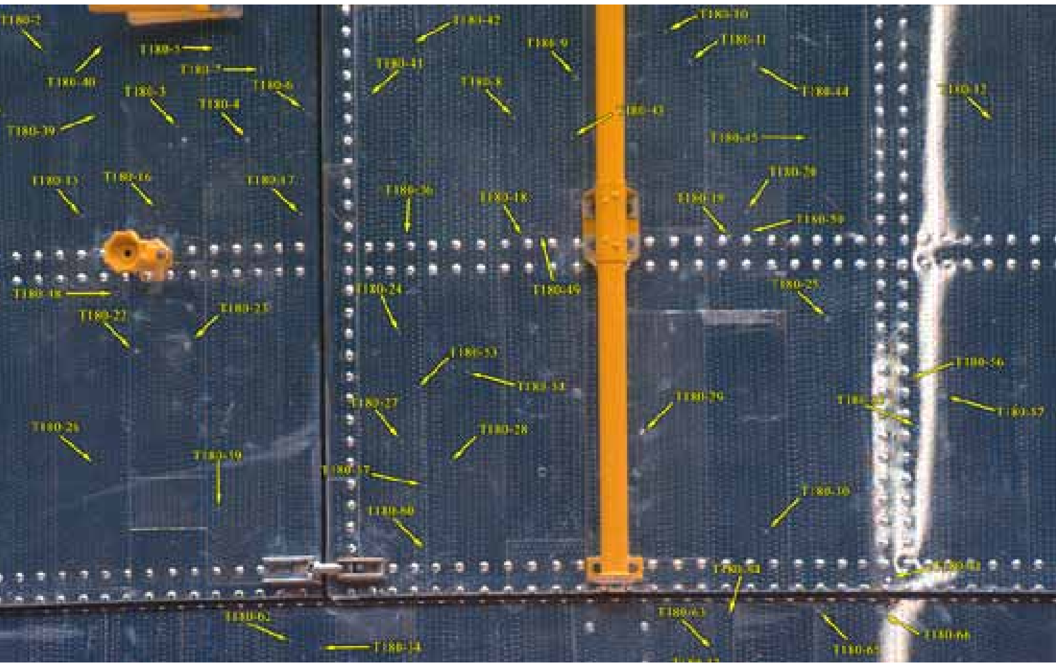
1. Orbital parameters (west or east degrees longitude). ITU definition for GEO altitude is 35,786 km.
2. Type of frequencies used.
3. Covered regions (or footprint).

3 factors



Courtesy of NASA

The Inter-Agency Space Debris Coordination Committee (IADC) is an international forum of governmental bodies for the coordination of activities related to the issues of natural and human-generated debris in space. The primary purposes of the IADC are to exchange information on space debris, to research activities between member state agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options.



After in-space repairs to the Hubble Space Telescope, the returned parts show many orbital debris impacts. Courtesy of NASA

The IADC has published a set of voluntary guidelines designed to reduce the creation of orbital debris. In 2008 most of these guidelines were included in a resolution proposed by COPUOS and passed by the UNGA. Guidelines include:

1. Limit production of debris during routine operations.
2. Minimize the potential for accidental on-orbit breakups.
3. Dispose of spacecraft post-mission.
4. Prevent on-orbit collisions.
5. Avoid intentional destruction and other harmful activities.

International Initiatives to Ensure Space Sustainability

Growing awareness of the threats to the long-term sustainability of space has prompted governments to take action at both the national and international level.

Over the last few years, three new international initiatives have been created to deal with some of the challenges posed by space sustainability. These initiatives differ from historical efforts in that they are "bottom-up" initiatives that seek to develop voluntary guidelines or norms of behavior, and in some cases involve input from non-State actors. While all of these initiatives are voluntary and non-legally binding, there is broad recognition that they represent an important first step to building consensus on important issues among many countries and space actors.

Group of Governmental Experts

In 2010, Russia proposed that the UN Secretary General appoint a Group of Governmental Experts (GGE) to explore possible transparency and confidence-building measures (TCBMs) for outer space. The UNGA adopted this proposal and 15 states proposed experts to take part in the GGE. Its objectives are to improve international cooperation and reduce the risks of misunderstanding and miscommunication in outer space activities. The ultimate goal is to produce a consensus report that outlines conclusions and recommendations on TCBMs that can help ensure stability in the space domain. The GGE began a series of meetings in July 2012 and delivered its report to the Secretary General in July 2013.

> *We must take action now and pursue TCBMs in space. These TCBMs will enhance the long-term sustainability, stability, safety, and security of the space environment. Protecting the space environment for future generations is in the vital interests of the United States and the entire global community.*
>
> Frank Rose, Deputy Assistant Secretary, Bureau of Arms Control, Verification and Compliance, U.S. Department of State. July 24, 2013.

Space Code of Conduct

In 2010 the European Union introduced a "Draft International Code of Conduct on Outer Space Activities" for consideration by the world community. The draft code is an attempt to spell out a broad set of best practices or norms of behavior for operating in outer space. Several countries have, in principle, agreed to work with the European Union to develop appropriate wording for such a code. Discussions on the details of such an agreement are ongoing.

UNCOPUOS Long-Term Sustainability Working Group

In 2009, the French delegation proposed the creation of a UN COPUOS Working Group on the Long Term Sustainability of Space Activities (LTSSA). UN COPUOS adopted this proposal, formed a Working Group and adopted Terms of Reference for the effort in 2011. It decided to group the work into four Expert Groups:

1. Sustainable space utilization supporting sustainable development on Earth;
2. Space debris, space operations and tools to support collaborative space situational awareness;
3. Space weather;
4. Regulatory regimes and guidance for actors in the space arena.

State delegations were invited to nominate experts to each Expert Group and work has been underway since 2011. The Expert Groups have recommended a set of draft guidelines to the Working Group which is scheduled to complete its work and submit a report with consensus guidelines to COPUOS in June 2015.

> ***The negotiations of a space Code of Conduct... offer an opportunity to undertake serious negotiations on outer space issues for the first time in decades. This opportunity should not be wasted.***
>
> Dr. Ajey Lele, Research Fellow at the Institute for Defense Studies and Analyses. July 26, 2012

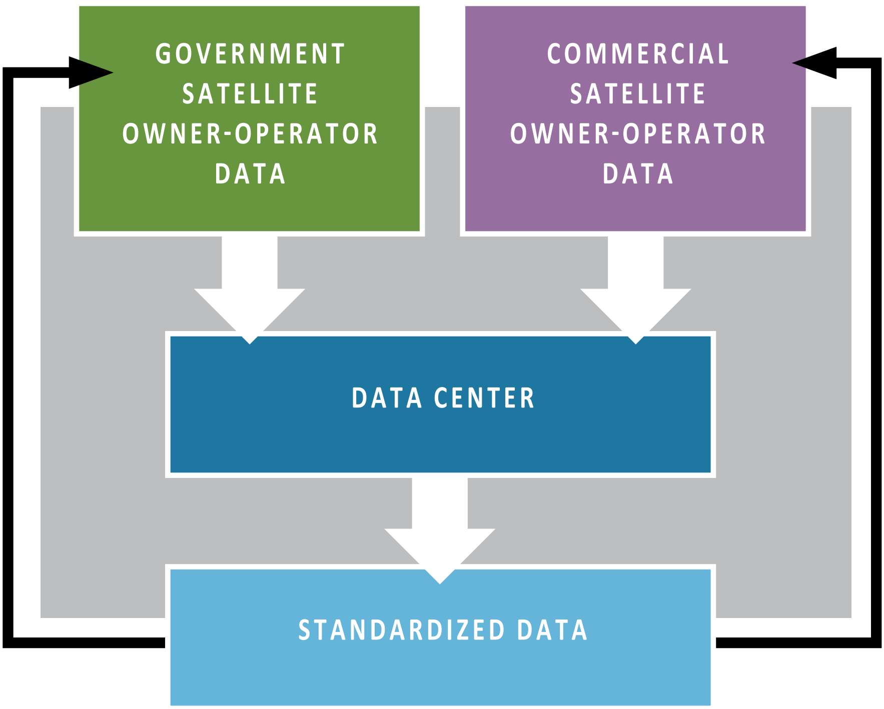
Improving Space Situational Awareness

Orbital debris and orbital crowding mean that owners and operators of satellites and spacecraft need information on the objects orbiting nearby in order to avoid collisions like that experienced between Iridium 33 and Cosmos 2251. Several States and satellite owner-operators monitor the location of objects in space, but only in limited ways—the "big picture" is not fully known by all.

The most robust understanding of the near-Earth space environment is obtained by the United States military's Space Surveillance Network, which tracks about 23,000 human-generated objects in Earth orbit (as of 2014). Because of national security sensitivities, the United States has been reticent to allow owner-operators around the world to access the information; however, it does provide some services to share SSA information and to provide warnings of potential collision to satellite operators throughout the world. In order to enable many safety and sustainability initiatives to be effective, a certain amount of orbital data will need to be available to all users of Earth orbit.

Concerned about satellite operational safety and reliability, satellite communication companies Inmarsat, Intelsat, and SES in 2010 formed a non-profit entity called the Space Data Association (SDA) to provide services to participating operators for collision warning and mitigating radiofrequency interference. Today, both private and governmental satellite operators, responsible for more than 300 operational satellites, are members. Each member satellite operator contributes information on the positions and other aspects of its satellites to the SDA, which in turn provides operators with operational data critical to safe and efficient satellite operations.

> *For Europe, space is a crucial region. Space-based systems have become indispensable to many services critical to Europe's economies and governmental functions, including those related to security, and this dependency will only increase in the future .... The SSA programme will help ensure that the reliability, availability and security of Europe's space-based services are strengthened.*
>
> European Space Agency, "What is SSA?" www.esa.int/SPECIALS/SSA



The SDA space data center serves participating satellite owner-operators with data on satellite positions and top-level maneuvering plans to help prevent misunderstandings and collisions.

The Global Nature of Space Activities

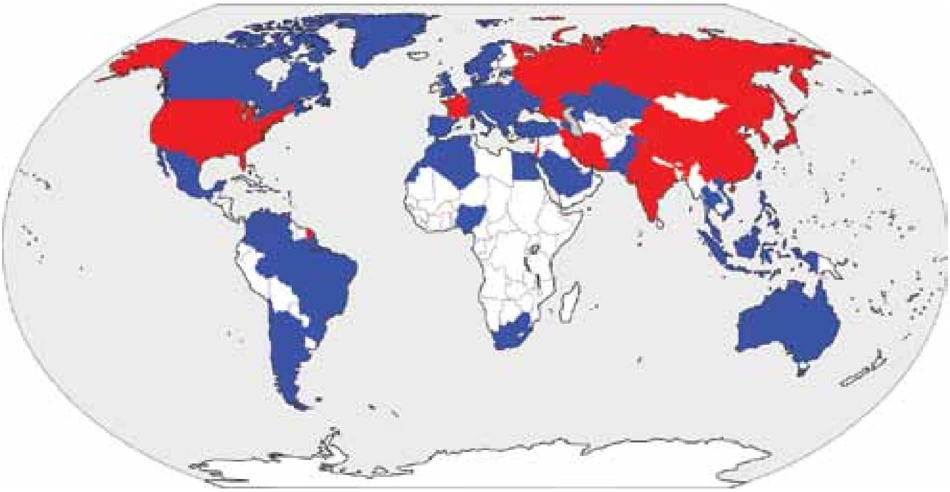
The United States, Russia, China, Europe, India, Japan, and Israel represent the most established space powers, each with indigenous orbital launch capability and a long track record of operating satellites. North Korea recently demonstrated its capacity to launch satellites, and South Korea has as well. To date, over 50 countries operate spacecraft in orbit and many companies around the world contribute directly to the global space industry.

Emerging space States recognize the importance of space systems for telecommunications, environmental monitoring, resource management, infrastructure development and national security, not to mention national prestige. With increasing interest in space and the proliferation of technologies enabling the utilization of space by a growing number of players, it is clear that greater cooperation on space governance is necessary.

The United States and Russia, responsible for ushering in the Space Age during the Cold War, remain the preeminent space powers in terms of budget and number of assets employed in outer space. The United States in particular has the largest space budget and is home to some of the largest space companies in the world.

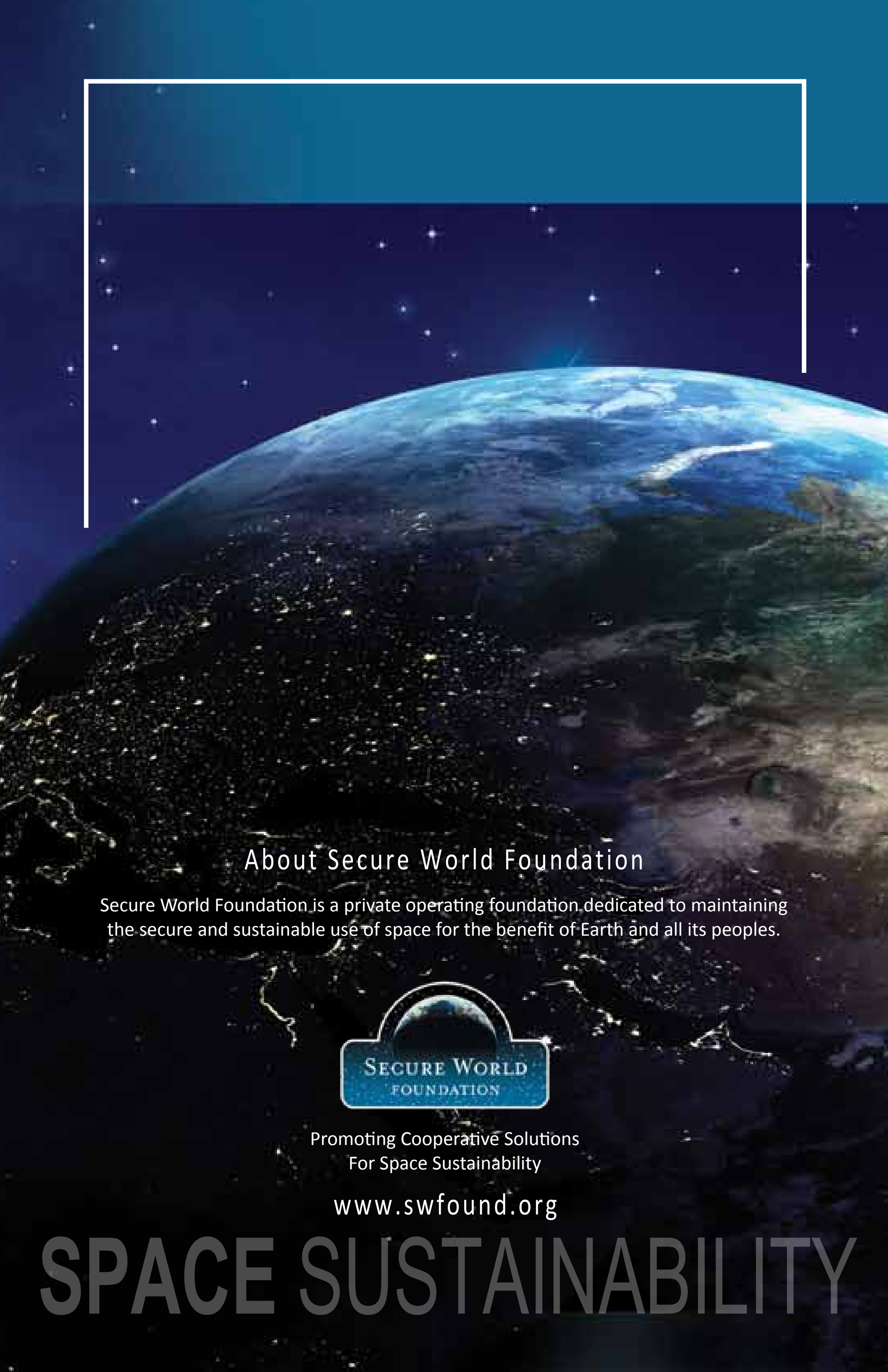
China's Tiangong 1 Spacecraft. Image from www.cmse.gov.cn

Satellite Launching and Operating States



This map shows current States with independent launch capability and those States that have operated or are operating satellites of their own. States with the capability to launch payloads into orbit include the United States, Russia, France (as majority shareholder in Arianespace, which also launches payloads for the European Space Agency), China, Japan, India, Israel, Iran, Ukraine, North Korea, and South Korea.

States that have notified the UN of their launched space objects: the Soviet Union (1957), the United States (1958), the United Kingdom (1962), Canada (1962), Italy (1964), France (1965), Australia (1967), Germany (1969), Japan (1970), China (1970), Poland (1973), Netherlands (1974), Spain (1974), India (1975), Indonesia (1976), Czechoslovakia (1978), Bulgaria (1981), Brazil (1985), Mexico (1985), Sweden (1986), Israel (1988), Luxembourg (1988), Argentina (1990), Pakistan (1990), Russia (1992), South Korea (1992), Portugal (1993), Thailand (1993), Turkey (1994), Ukraine (1995), Chile (1995), Malaysia (1996), Norway (1997), Philippines (1997), Egypt (1998), Singapore (1998), Taiwan (1999), Denmark (1999), South Africa (1999), Saudi Arabia (2000), United Arab Emirates (2000), Morocco (2001), Algeria (2002), Greece (2003), Nigeria (2003), Iran (2005), Kazakhstan (2006), Colombia (2007), Mauritius (2007), Vietnam (2008), Venezuela (2008), Switzerland (2009), Belarus (2012), Hungary (2012), North Korea (2012), Poland (2012), Romania (2012), Austria (2013), Azerbaijan (2013), Ecuador (2013), Estonia (2013), Qatar (2013). Note the increasing number of States in recent years. Map courtesy of Secure World Foundation.


About Secure World Foundation
Secure World Foundation is a private operating foundation dedicated to maintaining the secure and sustainable use of space for the benefit of Earth and all its peoples.
Secure World Foundation
Promoting Cooperative Solutions
For Space Sustainability
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SPACE SUSTAINABILITY