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POSITING A CONCRETE REGULATORY FRAMEWORK FOR COMMERCIALIZATION OF SPACE: THE INDIAN PERSPECTIVE

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ABSTRACT

India is one of the select few countries to have realized the immense positive potential of space technology in national development and in establishment of peace in the sub-continent, resulting in a growing sense of appreciation and confidence in the private sector and the efforts of the National Space Agency to ensure participation of industry in umpteen space activities. The nineties were marked with the launch of more ASLV and PSLV missions whilst the new millennium with the success of the GSLV and EDUSAT projects. Recently India has had the exceptional record of sending ten satellites at a time and also the shining feather in the history of our national glory namely, Chandrayan. Despite these developments in the field of technology however, India has been a laggard behind in restructuring its legal framework to respond to the consequential issues, concerns and challenges.

In view of the aforesaid developments, the paper shall seek to trace the developments in the field of commercialization of space industry, like the joint ventures entered into by the Antrix Corporation [The commercial wing of the Indian Space Research Organization (ISRO)] and the need for privatization of the space industry. The paper will attempt to discuss the allied legal questions, namely; threat to national security, launching of private satellites, licensing of the private partners, space related IPR issues, FDI in the space industry, inter-departmental coordination and conflict resolutions, among others. It will further propose the imperative for a comprehensive domestic legislative framework for effective regulation of relevant issues at hand.

INTRODUCTION*

Indian Space Research Organisation or the Bharatiya Antariksh Anusandhan Sangha (ISRO), is India`s national space agency, headquartered at Bangalore. Around 20,000 people are employed at ISRO with a budget of around Rs. 65 billion, directed towards developing the technologies related to space and their application to the nation`s development. Besides domestic payloads, it also offers international launch services and lately is launching satellites using the Polar Satellite Launch Vehicle and the GSLV for geo-stationary satellites.

The history of space research in India has its roots in the ancient era. In fact the military use of rockets dates back to the times of Tipu Sultan during the Mysore War. During the British era, William Congreve was inspired to discover the Congreve rocket that is the predecessor of modern artillery rockets in 1804. After India gained independence in 1947, Indian scientists and politicians recognized the prospective of rocket technology in both defence applications and for research and development.

Dr. Vikram Sarabhai founded the Indian space program and after the launch of Sputnik in 1957, India`s first Prime

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* Monterey Institute Of International Studies Center For Nonproliferation Studies
Critical Issues Forum 2006-2007 Space: Forum For Cooperation Or Next Frontier For Wmd Proliferation?

Minister, Jawaharlal Nehru, placed space research under the jurisdiction of the Department of Atomic Energy (DAE) in 1961. The Indian Space Research Organisation (ISRO) was created on August 15, 1969 from the INCOSPAR programme under the DAE and continued to work under the Space Commission and finally the Department of Space, shaped in June 1972.

Several satellites have been launched by ISRO. Amongst these the first satellite to be launched was Aryabhatta in 1975 from Kapustin Yar using a Soviet Cosmos-3M launch vehicle. By 1979 the ISRO was ready to launch SLV from the second launch site - Satish Dhawan Space Centre (SDSC). In 1980 the first indigenous satellite,

called Rohini-1, was launched by India. At the same time, designing of the Polar Satellite Launch Vehicle (PSLV) was underway and it worked as India's workhorse launch system. The Augmented Satellite Launch Vehicle (ASLV) tested technologies like strap-on boosters and new guidance systems, so that experience could be gained before the PSLV started with full production. Time and again ISRO has proved itself by completing several projects that were designed for the welfare of the nation.

ISRO has also entered the beneficial market of launching payloads of other nations. Prominent projects among them include the launches of Israel Space Agency's TecSAR spy satellite, and the Israeli Tauvex-II satellite module. The CARTOSAT-2 was launched on the July 2006 and carried a small Indonesian payload of 56 kg. Indian Space Research Organisation associated itself with Tata motors to develop a prototype hydrogen passenger car for the Indian market. RH-200 - Active and RH-300 - Active are the two sound emitting rockets of ISRO.

On April 28, 2008 it successfully launched 10 satellites in a single assignment, further enhancing its capabilities in space. These satellites comprised the 690 kg CARTOSAT-2, 83 kg mini Indian satellite, IMS-1, and eight other nano-satellites manufactured by various universities and research and development institutions in Canada and Germany that were offered the Indian Department of Space. On October 22, 2008 ISRO successfully launched its first unmanned moon mission - Chandrayaan-1, positioned on PSLVC11 at 0622 hrs IST.

The success of Chandrayaan-1 has encouraged the confidence of Indian Space Research Organisation's scientists to look beyond the moon. This organisation has also planned a project called Bhuvan that aims to make the maps publicly available and thus become a competitor of Google Earth. Besides these the organisation has also planned several upcoming projects that include Chandrayaan-2 and the spacecraft, Aditya.

ISRO operates three launch stations, namely the Shriharikota Rocket Launching Station (Andhra Pradesh), Thumba Equatorial Rocket Launching Station (Kerela) and Balasore Rocket Launching Station (Orissa), along with many more located all over India.

Scientific and technical requirements to develop a space program

Development of the space program, especially a manned spacecraft, is very much a challenge. Such an effort would require major work in a number of scientific and technology fields[†]:

- attitude control systems (gyroscopes, accelerometers, visual guidance systems);
- engines;
- propulsion systems;
- wind tunnels;
- advanced computing systems, software tools and mathematical tools, including mathematical modeling services, numerical methods;
- life support systems;
- crew escape systems;
- recoverable spacecrafts;
- launch sites (spaceports);
- advanced structures and materials;
- advanced thermal protection and regulation systems;
- advanced power systems (solar and nuclear power systems);
- communications systems;
- remote-sensing systems;
- electronics, informatics, medicine, biology, chemistry, physics, mathematics, and many others;
- multi-disciplinary subjects, such us biomimetics (discipline finding inspiration in biological systems to define new engineering solutions);
- and many more...

The benefits of a space program to society

We know that we explore and develop space because there are real rewards to be reaped - political, economic and social. Space exploration advances new technologies, foster international cooperation and spur economic growth. Terrestrial applications of technologies developed for space

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[†] NASA spin-offs. http://www.thespaceplace.com/nasa/spinoffs.html.

have saved many lives, made possible medical breakthroughs, created countless jobs, and yielded diverse other tangible benefits for society.

Space exploration offers the nations the chance to leave the history of warfare behind and work together towards a new, peaceful age. Our changing world political situation can benefit from international cooperation in space. The cold-war was symbolized by the race to the Moon. The new world order could well be symbolized by cooperating in the space arena.

There is also new knowledge to be gained - about new technologies, about medical advances, about climate control and environmental protection - that can enhance our quality of life.

Technology developed for space program has often subsequently provided practical benefits to society. In the Benchmark I we have considered a lot of examples of technology transfers.

For example, NASA spin-offs [1] help us in such areas, as Health and Medicine, Transportation and Public Safety, Communications (much of cell phone technology has been derived from space program spin-offs), Environmental and Resource Management (remote sensing technology developed for analysis of planetary images has improved agricultural production; similar technology can be used for natural resource management and disaster analysis), Scientific Knowledge (the extreme greenhouse effect identified on Venus in the 1960's led to more research into global warming on Earth).

The possibilities of solar power satellites for unlimited clean energy, extraterrestrial materials for manufacturing, and pharmaceutical development for medical research could greatly enhance the future of human society. Solar energy could be harvested 24 hours a day, 7 days a week and beamed safely down to collectors on Earth. Using weightless space manufacturing techniques, unique materials could be created.

Communications satellites have literally opened up the world for exchange of information, ideas and currency. Earth monitoring satellites are allowing us to better understand our global environment. Weather satellites have dramatically improved weather forecasts and severe weather predictions.

The space program is also a part of the solution to unemployment. Increased space funding would directly create hundreds of thousands of new jobs.

The space program can enrich society by directly enhancing the quality of education. Tens of thousands of students bettered their education after being inspired by the successful space programs. Many of these young people dreamed of becoming astronauts or workers on space development.

Future advancements in space transportation will make it possible for average citizens to tour the solar system. The prospect of space travel seems attractive to the public, and particularly to children. Yet in order to understand space flight children need to understand a wide range of subjects in engineering, physics, chemistry, biology and other scientific fields. Thus it can be anticipated that the development of a space program could help to make modern technological education an interesting and natural process, rather than one that is seen as unnecessary and boring.

India

In 1962 the Indian government established the Indian National Committee for Space Research (INCOSPAR) to conduct sounding rocket research. As the program grew in the late 1960s INCOSPAR became the Indian Space Research Organization (ISRO), and by 1975 ISRO launched its first satellite, Aryabhata, on a Soviet rocket. In 1980[‡], under the coordination of ISRO, India became the first developing nation to design and launch its own satellite, after the Rohini-1 was launched on a Satellite Launch Vehicle (SLV). Shar Space Launch Center on the Sriharikota Island on India's east coast state of Andhra Pradesh is used by ISRO to launch space satellites on PSLV (Polar SLV) and GSLV (Geostationary SLV) rockets as well as atmospheric sounding Rohini rockets. The Indian space program aimed at the self-reliant development of space technology and its applications for the rapid economic improvement of the country. This has meant a focus on communications satellites to provide critical services, including telemedicine and distance learning; meteorology payloads to improve weather forecasting; remote sensing satellites to identify and map the nation's natural resources. Although the military has no dedicated satellites exclusively for military operations, certain satellites, such as the Technology Experiment Satellite (TES) launched in 2001 and Cartosat-1 launched in 2005, are dual-use and therefore can be used for both civilian and military applications. Recently ISRO announced plans to develop its own regional satellite navigation system, building the satellites, ground stations, and receivers all within India. ISRO also developed its first planetary science mission, the Chandrayaan-1 lunar orbiter, launched in early 2008. Other science missions are in the early planning stages. Those missions include Chandrayaan-2, a second lunar mission, around 2011; a mission to an asteroid or comet in 2015; and a Mars mission in 2019.

The beginnings

India's space program took off in 1962 when the Indian National Committee for Space Research was set up to test

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[‡] K. Kasturirangan. India's Space Enterprise – A Case Study in Strategic Thinking and Planning. http://rspas.anu.edu.au/papers/narayanan/2006oration.pdf.

rockets. Unlike every other space-faring countries (with the exception of Japan and Europe), India's space capabilities were not born out of an existing military ballistic missile programs, but instead out of the practical goal of eventually having satellite launch capabilities. The Indian space program began establishing itself with the launch of foreign sounding rockets (American, French, British and Russian). The space program development can be categorized under three separate phases - the first phase linked to proof of concept demonstration, the second dealt with the realization of end-to-end systems at an experimental level that led to the third and current operational phase[§].

The first (proof of concept) phase of the Indian space program was characterized by the use of foreign space systems - US satellites ATS-6 in the Satellite Instructional Television Experiment (SITE), Franco-German satellite Symphonie in the Satellite Telecommunication Experimental Project (STEP), and US system Landsat in the earth observation experiment. The second phase was identified with a goal to derive an end-to-end experience in the realization of space systems where the potential of its use at the national level had already been clearly demonstrated in the "proof of concept" phase. In this phase two missions, Bhaskara (earth observation satellites) and Apple (satellite communications, including building of a body stabilized geosynchronous satellite), was developed. Also the successful realization of India's first launch vehicle SLV-3, with a modest payload capability of 40 kg and initiation of the augmented capability version ASLV with 150 kg payload capability took place in this phase[**].

As opposed to India, the potential military utility of space was the central reason for China embarking on its national space program since 1956. The program was aimed at developing China's aviation, guided missiles, rockets and missile defenses. In 1956, the Twelve-Year-Plan for Chinese aerospace, also known as Project 581, was established. It was the first Chinese satellite project, with the objective of placing a satellite in orbit by 1959. During the cordial Sino-Soviet relations of the 1950s, the USSR engaged in a cooperative technology transfer program with the PRC under which they trained Chinese students and provided the fledgling program with a sample rocket. However this support was withdrawn after the 1960 Sino-Soviet split[††].

The PRC continued the program independently and launched their first rocket, based on the Soviet R-2, in late 1960. In 1964 the first indigenous Dongfeng missile was launched. The same technology, adapted into the Long March rocket, was used to launch the PRC's first satellite Dong Fang Hong I (The East Is Red I), in 1970, allowing the PRC to join the space-faring club. Further development of the Long March rocket series allowed the PRC to initiate a commercial launch program in 1985, which has since launched over 30 foreign satellites.

PRC's manned space program started as early as 1968, when it was founded by Tsien Hsue-Shen of the Space Flight Medical Research Centre. Project 714 aimed to put two taikonauts into space by 1973 with the Shuguang-1 spacecraft. The program was officially cancelled on May 13, 1972 for economic reasons.

Present state

"The Indian space program today is a large integrated program, which is self-reliant and applications driven, maintaining vital links to the user community and committed to excellence in scientific endeavors..." By the early nineties, all four major components of the space program - Satellite Communications, Meteorology, Earth Observations and Launch Vehicles - had entered the operational stage. India has established two operational space systems. The Indian National Satellite (INSAT) system, currently made up of nine satellites in orbit is one of the largest domestic satellite communication systems in the world. The four INSAT satellites of the first generation have been bought abroad, but the subsequent three generations of satellites, many of which are currently in service, were all designed and built indigenously. The Indian Remote Sensing satellite (IRS) system, with a constellation of seven satellites, comprises some of the best satellites in the world for generating information on natural resources. Space launch vehicles developed by India are aimed towards providing autonomous launch capability to orbit these classes of satellites. India's Polar Satellite Launch Vehicle (PSLV) is well proven through successful flights and it provides the capability to orbit remote sensing satellites of the 1.4 tone class in polar sun synchronous orbits. The Geo synchronous Satellite Launch Vehicle (GSLV), capable of launching 2 to 2.5 tone class of INSAT satellites, has been

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[§] Transparency and Confidence-building Measures in Outer Space Activities and the Prevention of Placement of Weapons in Outer Space.
http://www.geneva.mid.ru/disarm/d-01.html.

[**] Defense Meteorological Satellite Program (DMSP). http://www.ngdc.noaa.gov/dmsp/dmsp.html.

[††] United Nations treaties and principles on outer space and other related General Assembly resolutions. Addendum. Status of international agreements relating to activities in outer space as at 1 January 2006.
http://www.unoosa.org/pdf/publications/ST_SPACE_11_Rev1_Add1E.pdf

operationalised with three successful flights in a row, making India one of the six countries in the world to demonstrate capabilities for geo-stationary satellite launch[‡‡].

ISRO has also entered the lucrative market of launching payloads of other nations upon its rockets from Indian soil. For example, the CARTOSAT-II, launched on the July 2006, carries a small Indonesian payload.

The future plans

India is developing a new heavy launch vehicle, GSLV Mark III, which will incorporate larger versions of proven technology, and will be indigenously built. Based around the proven format of liquid main stages and two solid strap-on boosters, it will resemble the Ariane-5 and several other modern launchers. The first flight is scheduled for 2008[§§].

India also has embarked on an ambitious planetary exploration program, the flagship mission of which is Chandrayaan-1. This mission aims to place a satellite around the Moon at an altitude of about 100 km from the lunar surface for physical and chemical mapping of the lunar surface. The upgraded version of PSLV viz., PSLV-XL which has a liftoff weight of 316 tones, will be used for launching the spacecraft.

Another more long-term project, that has been underway, is the effort to develop a reusable launch vehicle (RLV) for the launch of satellites. A scaled-down technology demonstrator is scheduled to fly around 2008. ISRO is continuing research related to using scramjets in RLVs after 2010.

And finally, ISRO recently announced its intent to send a manned mission to space by 2014. A successful space-capsule recovery experiment has confirmed gravity of its intentions.

Launch of INSAT-4CR by Geosynchronous Satellite Launch Vehicle, GSLV-F04

Background

ISRO's Geosynchronous Satellite Launch Vehicle, GSLV-F04, has launched India's communication satellite, INSAT-4CR, from Satish Dhawan Space Centre SHAR, Sriharikota in Andhra Pradesh on September 02, 2007.

The 49 metre tall, 414 tonne, GSLV is a three stage vehicle. The first stage, GS1, comprises a core motor with 138 tonne of solid propellant and four strap-on motors each with 42 tonne of hypergolic liquid propellants (UH25 and N204). The second stage has 39 tonne of the same hypergolic liquid propellants. The third stage (GS3) is a cryogenic stage with 12.6 tonne of Liquid Oxygen (LOX) and Liquid Hydrogen (LH2). The Aluminum alloy GSLV payload fairing is 3.4 m in diameter and is 7.8 m long.

The three-axis attitude (orientation) stabilisation of GSLV is achieved by autonomous control systems provided in each stage. Single plane Engine Gimbal Control (EGC) of the four strap-ons of the first stage are used for pitch, yaw and roll control. The second stage has Engine Gimbal Control (EGC) for pitch and yaw and hot gas Reaction Control System (RCS) for roll control. Two swivellable vernier engines using LH2 and LOX provide pitch, yaw and roll control for the third stage during thrust phase and cold gas system during coast phase. The Inertial Guidance System (IGS) in the Equipment Bay (EB) housed above the third stage guides the vehicle till spacecraft injection. The closed loop guidance scheme resident in the on-board computer ensures the required accuracy in the injection conditions. GSLV employs S-band telemetry and C-band transponders for the vehicle performance monitoring, tracking, range safety/flight safety and Preliminary Orbit Determination (POD)[***].

GSLV employs various separation systems such as Flexible Linear Shaped Charge (FLSC) for the first stage, pyro-actuated collet release mechanism for second stage and Merman band bolt cutter separation mechanism for the third stage. Spacecraft separation is by spring thrusters mounted at the separation interface.

Satish Dhawan Space Centre (SDSC) SHAR, located on the east coast of India is the launch station for all satellite launch vehicles of India. Sriharikota was selected as the launch site to take advantage of the earth's rotation and other factors affecting the flight of a launch vehicle.

GSLV was declared operational after both its two developmental test flights conducted in April 2001 and May 2003 were successful. In its first operational flight, GSLV successfully launched the 1,950 kg EDUSAT into the predetermined GTO. However, the second operational flight, GSLV-F02, with INSAT-4C on board, conducted on July 10, 2006, did not succeed. The Failure Analysis Committee (FAC) chaired by Mr K Narayana, former Director of SDSC SHAR, with the participation of experts from academic and research institutions besides ISRO, concluded that the performance of all vehicle subsystems,

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[‡‡] *Rescue Agreement* (Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space). http://www.eisenhowerinstitute.org/programs/globalpartnerships/fos/newfrontier/rescueE.pdf

[§§] *Registration Convention* (Convention on the Registration of Objects Launched into Outer Space).

[***] David Grahame. A Question of Intent: Missile Defense and the Weaponization of Space. http://www.basicint.org/pubs/Notes/2002NMDspace.htm.

except one strap-on stage was normal until 56.4 sec. The primary cause for the failure was the sudden loss of thrust in one out of the four liquid propellant strap-on stages (S4) immediately after lift-off at 0.2 sec. With only three strap-on stages working, there was significant reduction in the control capability. However the vehicle attitude could be controlled till about 50 sec. At the same time the vehicle reached the transonic regime of flight and the vehicle attitude errors built up to large values, resulting in aerodynamic loads exceeding the design limits thus leading to break up of the vehicle. It was concluded that the propellant regulator in the failed engine had much higher discharge coefficient in its closed condition. The reason for this could be an inadvertent error in manufacturing, which escaped the subsequent inspection, and acceptance test procedures. This regulator has functioned satisfactorily in all the previous 50 engines manufactured and tested so far.

FAC concluded that the design of GSLV is robust and recommended implementation of strict control on fabrication, inspection and acceptance procedures. Among others, FAC has recommended fabrication processes to be critically reviewed and updated. It has recommended for independent inspection of all critical dimensions of components and subassemblies by in-house agencies. Further, long duration hot test on one out of every 20 engines fabricated has been recommended to ensure that production process is under control. In addition, FAC has recommended strengthening the process of clearance of launch during Automatic Launch Sequence (ALS) phase.

FAC conclusions and recommendations have been accepted and necessary action taken to implement all of them.

Treaties and agreements that govern uses of space

There are treaties and regulatory arrangements that have a bearing on some aspects of space use. The *UN Charter* is the foundation upon which most multilateral treaties governing the use of space have been based[†††]: "All members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any manner inconsistent with the purposes of the UN". The Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space, adopted in 1963, set forth the basis of international space law.

- 1963 Limited Test Ban Treaty (Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water).
- No nuclear explosions are allowed in space, whether as a test or part of an anti-satellite (ASAT) weapons system or as a component of an anti-ballistic (ABM) missile system. It was the first legally binding document containing a specific prohibition of the military use of outer space.
- 1967 Outer Space Treaty (Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies):
    - Originated in the Committee on the Peaceful Uses of Outer Space (COPUOS).
    - Provides that outer space is not subject to national appropriation by claim of sovereignty or other means.
    - Forbids states from any activity that could harmfully interfere the peaceful space activities of other countries.
    - Prohibits the deployment of weapons of mass destruction in orbit, on celestial bodies, or in any other manner in space.
    - Prohibits the establishment of military bases, installations and fortifications on celestial bodies.
    - Prohibits the testing of any type of weapons and the conducting of military maneuvers on celestial bodies.
    - Provides that a state is internationally liable for damage caused by its space objects. The principle of cooperation and mutual assistance shall be followed in space exploration. Harmful contamination of the moon and other celestial bodies shall be avoided. All stations, installations, equipment, and space vehicles on the moon and other celestial bodies shall be open for inspection to representatives of other states on a reciprocal basis.
    - As of 1 January 2006 the treaty has been ratified by 98 States and signed by 27 others.
- 1968 Rescue Agreement (Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space).
    - "States shall, upon request, provide assistance to launching states in recovering objects that return to Earth outside the territory of the launching state."
    - As of 1 January 2006, the agreement has been ratified by 88 States and signed by 25 others.
- 1972 Liability Convention (Convention on International Liability for Damage Caused by Space Objects).
    - Elaborates on Article 7 of the Outer Space Treaty. Provides that a launching State shall be

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[†††] ABM Treaty (Treaty between the United States of America and the Union of Soviet Socialist Republics on the limitation of anti-ballistic missile systems). http://www.eisenhowerinstitute.org/programs/globalpartnerships/fos/newfrontier/ABM.htm

  liable to pay compensation for damage caused by its space objects on earth, in air or in space. Provides procedures for settling claims for damages.
  - As of 1 January 2006 has been ratified by 83 States and signed by 25 others.
- 1972 ABM Treaty (Treaty between the United States of America and the Union of Soviet Socialist Republics on the limitation of anti-ballistic missile systems).
  - US-Russian bilateral treaty which forbade the deployment and testing of ABM systems or components in space. Also forbade parties from interfering with each others' national technical means of verification.
  - Demised in 2002.
- 1976 Registration Convention (Convention on the Registration of Objects Launched into Outer Space).
  - Provides that states should maintain a national launch registry and transmit information from that registry to a registry that is maintained by the UN.
  - As of 1 January 2006, has been ratified by 46 States and signed by 4 others.
- 1979 Moon Agreement[‡‡‡] (Agreement Governing the Activities of States on the Moon and Other Celestial Bodies).
  - Describes the moon and its natural resources as the common heritage of mankind and it reserves the moon for exclusively peaceful purposes.
  - It bars the emplacement of nuclear or other weapons of mass destruction on the moon and also prohibits the placing in orbit, or in any other trajectory to or around the moon, of objects carrying such weapons and the establishment of military bases, the testing of any type of weapons, and the conduct of military activities on the moon.
  - As of 1 January 2006 has been ratified by 12 States and signed by 4 others.
- The UN General Assembly has adopted three more sets of principles based on the work of the Committee on the Peaceful Uses of Outer Space:
- The Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting, adopted in 1982 considers political, social, economic and cultural implications of broadcasting services.
- The Principle Relating to Remote Sensing of the Earth from Space adopted in 1986 provide for international cooperation and participation in remote sensing; they specify that such activities will be permitted without the consent of the states being sensed but that the latter will have the right to receive data and information concerning their resources.
- The Principles Relevant to the Use of Nuclear Power Sources in Outer Space, adopted in 1992, requires design of such systems to minimize radiation exposure in case of accident. They provide guidelines and criteria for safe use of nuclear power sources in outer space, including the requirement that a safety review be made prior to launching of any nuclear power source and that results of such review be made public through the Secretary-General of the United Nations, who should also be notified of any re-entry of radioactive materials to the earth.

Beyond this, there are some relevant international agreements and declarations:

- 1971 Agreement Relating to the International Telecommunications Satellite Organization "Intelsat".
- 1985 Convention on the International Maritime Satellite Organization (INMARSAT) with Annex and Operating Agreement (1976); as amended 1985; with Protocol (1981).
- In 1994, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) adopted the Beijing declaration on space technology applications for environmentally sound and sustainable development in Asia and the Pacific. This declaration proposed a cooperative program of space activities including satellite meteorology, remote sensing, communications and education. A review of the ESCAP efforts occurs in 1999.
- Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries was adopted in 1996.
- 1998 Commercial Space Act promotes commercial space opportunities and established the construction of the ISS as a priority goal of

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[‡‡‡] *Moon Agreement* (Agreement Governing the Activities of States on the Moon and Other Celestial Bodies). http://www.eisenhowerinstitute.org/programs/globalpartnerships/fos/newfrontier/Moon.pdf

national policy in the economic development of Earth orbital space.

The space legislation is necessary for improving

Although the current international legal instruments concerning outer space, to some extent, do prohibit and restrict the deployment of weapons, use of force as well as military activities in certain parts of space, the related provisions contained in them are seen by some states to be limited in scope and therefore inadequate for preventing weaponization of outer space.

There is little progress towards treaties in this area. One obstacle is a lack of US support. The new US space policy says the US will "oppose the development of new legal regimes ... that seek to prohibit or limit US access to or use of space." There is also uncertainty over what such a treaty should cover: for example whether it should prohibit space-based weapons, or any use of force against space-based objects (even from the ground). How to verify compliance with such a treaty is also unclear.

However, the progress of science and technology could make it necessary to strengthen the existing international legal system. There have been several suggestions on how to move forward. The Weapons of Mass Destruction Commission (WMDC) recommended a review conference of the Outer Space Treaty which could extend its scope and strengthen the Treaty. Another suggested step could be the establishment of rules of the road (general practice and procedures) in outer space or confidence building measures.

Moon Agreement

The Moon Agreement has not been ratified by the space powers (except France). One key reason is that the treaty outlaws military bases on the moon, and also outlaws any nation, corporation, or individual from making land "claims" on the planetary body.

The Moon Treaty placed limitations on national sovereignty: "The moon is not subject to national appropriation" and "the placement of personnel, space vehicles, equipment, facilities, stations and installation on or below the surface of the Moon... shall not create a right of ownership." Article 11 of the Moon Treaty directs the establishment of an international regime, whose purposes are:

- The orderly and safe development of the natural resources of the moon
- The rational management of those resources
- The expansion of opportunities in the use of those resources
- An equitable sharing by all States-Parties in the benefits derived from those resources.

The "common heritage of mankind" would thus require an international consortium to monitor and hold accountable actions with potential consequence towards any other State.

Obviously, it is the criteria for exploitation of natural resources found on the moon, Mars and other celestial bodies that is of the greatest practical interest. In the foreseeable future, Mars and perhaps its two satellites will be the only sources of usable resources for space researchers or colonists, until we are able to reach the nearest earth-asteroid for mining. By not signing the Moon Treaty, the USA and Russia/USSR tried to set a precedent for the possible future commercialization of space that most likely will occur in the 21st Century.

Most scientists also do not want to recognize the Moon Treaty for fear that it would inadvertently prevent our expansion into space if no economic benefits can be derived. The Moon Treaty, however, does not place a moratorium on exploitation of natural resources, but insists upon the establishment of an international regime to monitor and control such exploitation. In fact, mining could be begun on an experimental basis even while clearer rules are established and eventually made law. But what is at question here, if taken literally, is the "common heritage of mankind" clause which indicates that if exploitation does commence, all nations should have a share in the proceeds.

Monitoring and verification of compliance with space treaties

Appropriate, feasible and effective verification could play an important role in ensuring faithful observance and implementation of a treaty[§§§]. It could also help boost the confidence of each and every State Party to a treaty. But verification of a space treaty is difficult according to many states. China stated in the Conference on Disarmament (CD) about "the complex nature of verification of outer space activities, which bears on the security interest of all countries, as well as to technical and financial constraints of verification". Russia concurred, "Transparency and Confidence Building Measures could, for a certain period of time, compensate for the lack of verification measures..." Transparency and Confidence Building Measures are a good step towards enhancing trust and international cooperation amongst states. They facilitate management of situations which could otherwise lead to international tension. Most states acknowledge that Confidence Building Measures do not replace verification but may function as a start to a step-by-step approach on preventing the *weaponization* of outer space. A working paper was presented by Russia and China to the CD, suggesting different types of Confidence Building Measures including: exchanges of information,

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[§§§] Space Based Infrared System. http://www.fas.org/spp/military/program/warning/sbir.htm demonstrations, notifications, consultations and thematic workshops.

Verification measures envisaged by various sides uptil now can be divided roughly into two categories:

Remote-sensing survey:

- Outer space to outer space survey, which means using satellites to monitor the activities of outer space objects;
- Outer space to the earth survey, which refers to, for example, using satellites to monitor the activities of space vehicles on the Earth and in the Earth's atmosphere;
- The Earth to outer space survey, which means, for example, using ground-based facilities to monitor the activities of outer space targets.

On-site inspections:

- Inspections of relevant space research laboratories on the ground to find out whether or not research on weapons intended to be deployed in outer space or weapons targeting outer space objects intended to be deployed is going on[****];
- Verification of objects intended to be launched at space rockets launching sites to see whether they are weapons or whether there are weapons on board.
- More specifically, the following ideas have been proposed:
  - Establishing an international satellite monitoring agency to verify the observance of certain bilateral agreements and to monitor crisis situations (proposed by France)
  - Seeking satisfactory verification measures for the prevention of an arms race in outer space and conducting direct international verifications, including on-site verifications under any possible circumstances (proposed by Sweden in 1985)
  - Setting up a PAXSAT (Pax Satellite) system to conduct verifications through space based remote-sensing survey (proposed by Canada in 1984)
  - Establishing an international space monitoring agency (proposed by the former Soviet Union)
  - Forming an international observer team to ensure the absence of deployment of weapons in outer space. The team will dispatch permanent observers to each space-launching site worldwide to ensure that no weapons will be deployed in outer space. To this end, prior to each launch, the following information should be submitted in due course to members of the observer team: the venue and timing of the launch, the type of the launching vehicle, and general information concerning launching objects (proposed by the Soviet Union in 1983);
  - Verifying laboratories which conduct outer space research (proposed by the Soviet Union in 1986. In 1986, the United States tabled a similar proposal at the Conference on Disarmament).

Operational monitoring of compliance with space treaties would include the full array of open literature searches, technical and intelligence monitoring and information sharing worldwide, and notification of violation.

Certainly monitoring is impossible without use of corresponding technical means and information systems. Space surveillance systems which can track launches of vehicles and their moving in space are necessary. Such systems already for a long time are used by militaries.

The US Space Surveillance Network (SSN) is operated by US Army, Navy, and Air Force personnel and comprised of radars and optical sensors at 25 sites worldwide, as well as one dedicated on-orbit satellite. The SSN can track objects in LEO with a radar cross-section of 5 centimeters in diameter or greater. The system makes up to 80,000 observations daily. In order to be able to keep track of everything once it's detected, the 1st Command and Control Squadron (1st CACS) maintains a catalog (SATCAT) of all space objects orbiting the earth (and some beyond) which are ten centimeters or larger in size. Over the years, they have catalogued almost 25,000 objects.

Russia also has a Space Surveillance System (SSS), which functions using Russia's early warning radars in space and more than 20 optical and electro-optical facilities at 14 locations on Earth. The main optical observation system, Okno, allows detection of objects up to 40,000 kilometers, although its capacity to detect smaller objects is unclear. The network as a whole carries out some 50,000 observations daily, contributing to a catalogue of approximately 5,000 objects, mostly in LEO. Furthermore, while information from the system is not classified, Russia

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[****] Inter-Agency Space Debris Coordination Committee. http://www.iadc-online.org/

does not have a formal system in place for widely disseminating information about observations.

Non-Treaty approaches to Space Security

Space-based defenses

In Benchmark I we have defined the "space-based defense" as military defense using some space systems. Now we shall examine some kinds of modern and perspective systems used in space-based defenses.

I. SBIRS

The US Space Based Infrared System (SBIRS) is a global satellite system designed to meet the United States' infrared space surveillance requirements over the next 20 to 30 years. The system addresses critical war fighter requirements in the areas of missile warning, missile defense, technical intelligence, and battle space characterization. The SBIRS program consists of high altitude (SBIRS High) and low altitude (SBIRS Low) components. SBIR High includes satellites in Geosynchronous Earth Orbits (GEO) and Infrared (IR) sensors on satellites in Highly Elliptical Earth Orbits (HEO). SBIRS Low includes sensors on satellites in Low Earth Orbits (LEO). SBIRS will be controlled from the ground through a number of ground assets. Its ground assets include:

- A CONUS-based Mission Control Station (MCS)
- A backup MCS; a survivable MCS possibly located with the Mobile Consolidated Command Center (MCCC)
- Overseas Relay Ground Stations
- Re-locatable Terminals; and other associated communications links.

SBIRS Low could augment the space surveillance mission area by using its sensors for detecting and tracking space objects above the horizon. The number of sensors in the constellation would permit routine stereoscopic viewing and offer almost comprehensive instantaneous field of regard, 24 hours a day. The LEO satellites compliment the SBIR High element by providing a unique precision mid-course tracking and discrimination capability critical for effective ballistic missile defense. In addition, the LEO element provides an enhanced capability for missile warning, technical intelligence, and battlespace characterization.

II. DMSP

The DMSP[††††] (Defense Meteorological Satellite Program) is a US DoD program run by the Air Force Space and Missile Systems Center (SMC). The DMSP designs, builds, launches, and maintains satellites monitoring the meteorological, oceanographic, and solar-terrestrial physics environments. Each DMSP satellite has a sun-synchronous near-polar orbit at an altitude of 830km above the surface of the earth. The data from the DMSP satellites are received and used at operational centers continuously. The data are sent to the National Geophysical Data Center's Solar Terrestrial Physics Division Earth Observation Group (NGDC/STP/EOG) by the Air Force Weather Agency (AFWA) for creation of an archive. Currently, data from 4 satellites (3 day/night, 1 dawn/dusk) are added to the archive each day.

III. MSX

The Midcourse Space Experiment (MSX) is a US Ballistic Missile Defense Organization project which offers major benefits for both the defense and civilian sectors[‡‡‡‡]:

1) MSX experiments are providing critical, first-time observations of missile target signatures against Earth-limb, auroral-, and celestial-cluttered backgrounds
2) MSX will aid future spacecraft design by monitoring on-orbit contamination of optical instruments
3) MSX investigation of the composition of Earth's atmosphere is increasing our understanding of our environment.

Loaded with innovative sensors and related technologies, MSX was the first space demonstration of technology to identify and track ballistic missile signatures during the midcourse phase of flight – the time between booster burnout and missile reentry. Designers of future operational space and ground-based surveillance and tracking systems require simultaneous, wideband optical data on midcourse missile flight[§§§§]. Since successfully completing that yearlong assignment in 1997, the spacecraft has been transitioned to the Air Force, for which it continues to track objects in geosynchronous orbits.

IV. NFIRE

The Near-Field Infrared Experiment (NFIRE) satellite is designed to gather information on missiles during the first few minutes of their flight. "That will allow it to get a close-up view of a burning ICBM at conditions that are truly real world," according to a Missile Defense Agency (MDA) official.

MDA initially planned to launch two ballistic missiles toward the NFIRE satellite, allowing it to view and collect infrared data about the missile in flight. The first ballistic missile would pass within 20 kilometers of the satellite, the second within 4 kilometers. The NFIRE payload was to

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[††††] Defense Meteorological Satellite Program (DMSP). http://www.ngdc.noaa.gov/dmsp/dmsp.html.

[‡‡‡‡] MSX: Midcourse Space Experiment. http://www.jhuapl.edu/cedac.

[§§§§] Michael Krepon. Weapons in the Heavens: A Radical and Reckless Option. http://www.armscontrol.org/act/2004_11/Krepon.asp.

include a Generation-2 kill vehicle that the satellite would fire at the ballistic missile when it closes within 4 kilometers.

V. Space-Based Test Bed

The space-based interceptor test bed is a US military program to develop and test miniaturized missile defense interceptors based in space. The Space Test Bed would consist of several satellites and would be used for experiments including attempts to destroy medium- and intercontinental-range target missiles by ramming them. MDA will decide in 2008 whether to build and launch satellites for a series of space-based test intercepts, with the first experiments expected in 2010-2011. The defense budget contains $10.6 million to begin this effort. By 2012, MDA expects the test bed to comprise a thin constellation of three to six spacecraft in orbit to test the functionality of a space based BMDS (Ballistic Missile Defense System).

VI. Spirale

Spirale (French acronym for "Preparatory System for IR Early Warning") is the French national program for the design and production of a space based optical early warning system demonstrator[*****]. The demonstrator covers the supply and operation of a complete system able to collect and analyze infrared imagery against a land background, in order to detect ballistic missiles during their boost phase, just after launch. The space segment consists of two 120 kg class micro-satellites operating in an elliptical orbit, due to be launched by Ariane 5 in 2008. The first of its kind in Europe, this demonstrator program will pave the way for a future operational, early warning optical space program. It will form a strategic link in an anti-ballistic missile defense system and will also contribute to other operational missions, such as proliferation monitoring.

VII. Space Based Laser

The Space Based Laser (SBL) is being designed to operate in Low Earth Orbit and destroy hostile ballistic missiles during their boost phase of flight. An SBL platform would achieve missile interception by focusing and maintaining a high powered laser on a target until it achieves catastrophic destruction. Energy for the sustained laser burst is generated by the chemical reaction of the hydrogen fluoride (HF) molecule. The HF molecules are created in an excited state from which the subsequent optical energy is drawn by an optical resonator surrounding the gain generator. The technology for this weapon is still in the very early stages of development and the program has been beset by delays and difficulties. Although MDA closed its SBL program office and canceled a test of the system scheduled for 2012, SBL related work may be continuing as a classified program of MDA.

VIII. Kinetic kill vehicle (KKV)

Several types of space-based kinetic missile defenses have been considered in the past 15 years. The GPALS (Global Protection Against Limited Strikes) missile defense system was intended to include a constellation of 1,000 Brilliant Pebble kill vehicles. These small satellites were intended to intercept missile warheads during the midcourse phase of their flight. The system currently under development is intended to attack a missile during its boost phase.

As part of this system, satellite kill vehicles would be placed in orbit where they would remain until a missile launch was detected. A kill vehicle near the missile launch site would then use its on-board propulsion and sensors to accelerate out of its orbit and home on the missile, attempting to destroy it by direct impact.

Space-based defense timeline[†††††]

- 1963: The USA has put into orbit the first satellite, capable to find out a point of nuclear explosion[‡‡‡‡‡].
- 1967: The USSR puts into orbit satellite Kosmos-139, capable to destroy enemy space vehicles.
- 1971: The USA begin the program of creation of systems of a military satellite communication.
- Mar 1983: US President Reagan announces that the US will start an expanded research and development program of missile defense system. His idea becomes the "Strategic Defense Initiative," or SDI. Opponents call it "Star Wars."
- Jan 1984: US President's directive established the SDI to explore the possibility of developing missile defenses as an alternative means of deterring nuclear war. The emphasis in the program was to be on non-nuclear developments, although research work on defensive nuclear devices was to continue "as a hedge against a Soviet ABM breakout."
- Jun 1984: The US Army demonstrated hit-to-kill capability in the Homing Overlay Experiment (HOE).
- Sep 1986: Completed the Delta 180 experiment. During this experiment, SDIO completed what was

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[*****] SPIRALE program. http://www.astrium.eads.net/families/a-safer-world/futuredefnce/spirale.

[†††††] Jeremy Singer, Space News. MDA Plans Competition for Space Test Bed Beginning 2008. http://www.space4peace.org/bmd/mda_sbi_testbed.htm

[‡‡‡‡‡] Research on the International Space Station. NASA. http://www.latech.edu/ideaplace/nerc/lithographs/research_on_the_international_space_station.pdf.

the first equivalent of a boost phase intercept of a target.

- Nov 1986: The formation of the concept for Brilliant Pebbles, a space-based interceptor design.
- Jul 1987: SDIO developed a national missile defense concept called the Strategic Defense System Phase I Architecture. This concept consisted of ground and space based sensors and weapons, as well as a central battle management system.
- 1988: Successful hover testing was completed and demonstrated successful integration of the sensor and propulsion systems in the prototype Space-Based Interceptor (SBI).
- Mar 1989: Delta 183 launch vehicle lifts off, carrying a satellite known as Delta Star to test several sensor related technologies. The satellite observed several ballistic missile launches including some releasing liquid propellant as a countermeasure to detection.
- Feb 1990: The Relay mirror experiment (RME) demonstrated critical technologies for space-based relay mirrors to be used with an SDI Directed-energy weapon system.
- Jan 1991: President Bush shifted the focus of SDI from defense of North America against large scale strikes to a system focusing on theater missile defense called Global Protection Against Limited Strikes (GPALS).
- May 1993: The Strategic Defense Initiative Organization was being redesigned to the Ballistic Missile Defense Organization (BMDO).
- 1994: The Brilliant Pebbles program was canceled by the BMDO.
- Jun 1997: First fly-by test of the Boeing/TRW exo-atmospheric kill vehicle.
- Feb 1999: The US Air Force canceled its contracts with TRW Inc. and Boeing Co. to design and develop the prototype satellites for SBIRS-low.

Defense or Offense?

Some of the space-based systems being developed for defense purposes have ASAT capabilities and can be used as weapons.

For example, let's consider two US programs – Space Based Laser (SBL) and Kinetic Kill Vehicle (KKV). There has already been much talk of the SBL's capabilities outside of missile defense. In particular, planners have commented on its potential usefulness in allowing force projection from space. Colonel William N. McCasland, system program director for the SBL, indicated that the system could enable the US military to "deny access to space", "deny information to/from satellites" and engage in "defensive/offensive counter-air operations.[§§§§§]" [33] Military planners have even suggested that SBLs could form the replacement for the B-2A Spirit bomber, using directed energy to destroy ground based targets. In a similar manner, any KKV system could easily be altered to offensively threaten the satellite and space networks of other nations. The continued development of these space systems seriously undermines the claim that the US missile defense project is purely defensive in nature. Instead, the dual use capability of both the SBL and KKV makes them inherently threatening to the space assets and national security of other countries. Furthermore, deployment of such systems would create a new arena for a costly and potentially dangerous arms race. Among the arguments against space-based defenses in particular is that they would create orbital debris that poses a threat to operational satellites, and that an effective shield would require an unaffordable constellation of thousands of interceptors. In study, performed by the American Physical Society, noted that a constellation of at least 800 to 1,600 interceptors would be needed to provide a limited measure of protection against just Iran and North Korea. The study assumed an attack scenario involving only one ICBM fired at the United States. A far larger constellation would be needed to provide even a limited defense against a salvo of missiles.

Space-based defenses and existing treaties and agreements

At the moment there are only a few treaties that govern the use of space. However, there are only three treaties that deal with space security issues: *the Outer Space Treaty*, which bans the deployment of weapons of mass destruction (WMD) in space; *the Limited Test Ban Treaty* that prohibits the testing of nuclear weapons in space; and *the Missile Technology Control Regime (MTCR)*. The MTCR, which is actually an export control protocol, is signed by leading space-faring nations in order to prevent proliferation of rocket technologies beyond a closed circle of countries already in possession of them. The Moon Agreement expands upon the provisions of the Outer Space Treaty by also prohibiting any threat or use of force, any other hostile act or threat of hostile act on the Moon (or other celestial bodies in the solar system) and any use of the Moon (or other celestial bodies in the solar system) in order to commit such acts or threats in relation to the Earth, the Moon, spacecraft, personnel of spacecraft or man-made space objects.

[§§§§§] David Grahame. A Question of Intent: Missile Defense and the Weaponization of Space. http://www.basicint.org/pubs/Notes/2002NMDspace.htm.

Since the demise of the US-Russian Anti Ballistic Missile Treaty (which focused on limiting the testing and deployment of anti-ballistic missile defenses), there are no rules for space that actually prohibit conventional *weaponization* or the use of lasers and other dual-use technologies for military ends. Even anti-satellite weapons are not legally banned.

Modern space-based defenses do not utilize nuclear weapons or weapons of mass destruction and consequently they not violate existing treaties and agreements.

Issues of Accountability

I. Organizations that monitor outer space activities

A registry of launchings has been maintained by the United Nations Secretariat since 1962, in accordance with General Assembly resolution[******]. Information contained therein is provided on a voluntary basis by Member States and also issued in United Nations documents. In addition, the Registration Convention of 1976 requires States Parties to maintain an appropriate registry of space objects they launch into outer space, and further to transmit certain information concerning each space object carried on their registries to the United Nations Secretary-General. The United Nations Secretariat maintains a second register in which this information is recorded and to which there is full and open access. Aside from the United Nations, various space agencies and organizations around the world monitor, record and track objects launched into outer space. Some registers available online in Internet:

- The official US Registry of Space Objects Launched into Outer Space is maintained by the Space and Advanced Technology (SAT) Staff, which is located within the Department of State's Bureau of Oceans and International Environmental and Scientific Affairs.
- The official UK Registry of Space Objects is maintained by the British National Space Centre (BNSC).
- World Data Center for Satellite Information (WDC SI) is hosted by NASA's National Space Science Data Center. WDC SI has responsibilities for spacecraft launch and other descriptive information capture and dissemination. WDC SI serves as a conduit for requests from the international community for data from the NSSDC data archives.

NSSDC/WDC SI is an archival center for science data from many spacecraft. The SPACEWARN Bulletin is intended to serve as an international communication mechanism for the rapid distribution of information on satellites and space probes. The material it contains is based on guidelines in "COSPAR Guide to Rocket and Satellite Information and Data Exchange" and various Committee on Space Research (COSPAR) resolutions. The SPACEWARN Bulletin is issued on the first of each month and provides a listing of launches and brief details of each launch from the preceding month. Back issues of the SPACEWARN Bulletin are available online at.

II. The international organizations which trace activity in space:

- United Nations Committee on the Peaceful Uses of Outer Space
- The Committee on the Peaceful Uses of Outer Space (COPUOS) was set up by the General Assembly in 1959 to review the scope of international cooperation in peaceful uses of outer space, to devise programs in this field to be undertaken under United Nations auspices, to encourage continued research and the dissemination of information on outer space matters, and to study legal problems arising from the exploration of outer space.
- Conference on Disarmament
- Between 1985 and 1994, the Conference on Disarmament (CD) created an Ad Hoc Committee on PAROS. The CD delegations studied various ways and means of addressing the security challenges posed by human activity in outer space. UN Document A/48/305, Prevention of an Arms Race in Outer Space Study on the Application of Confidence-Building Measures in Outer Space (15 October 1993) reports on various confidence-building measures considered by the international community over that period. The Conference on Disarmament has not been able to agree on the formation of an Ad Hoc Committee with a mandate for outer space since 1994. This year, the CD has held a focused and structured debate on PAROS during its second session under the Russian Presidency.
- General Assembly First Committee for Disarmament and International Security
- The First Committee on Disarmament and International Security meets every year in October for a 4-5 week session, after the General Assembly General Debate. At each meeting Disarmament

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[******] The United Nations Register of Space Objects Launched into Outer Space. http://www.unoosa.org/oosa/osoindex.html.

Counselors and Ambassadors read statements on General or Thematic issues, propose draft resolutions, and vote on the resolutions. All 191 member states of the UN can attend. There is generally an annual PAROS resolution up for vote; some years addition resolutions related to outer space are proposed and voted on.

- General Assembly Fourth Committee on Special Political and Decolonization
- The Committee has played a crucial role in advancing space cooperation[††††††] and provides a unique opportunity for the exchange of information among governments on the latest developments in the use and exploration of outer space. The fourth committee could be a better forum to work on preventing the *weaponization* of space than the first committee since the framework of this committee is based on development instead of security and there are more actors using space for development purposes than for military ones. The 4th Committee meets every year for a four or five week session following the General Assembly General Debate and is comprised of all UN member states.
- International Telecommunication Union (ITU)[‡‡‡‡‡‡]
- ITU is international organization within the United Nations System where governments and the private sector coordinate global telecom networks and services. The ITU plays a vital role in the management of the radio-frequency spectrum and satellite orbits, finite natural resources which are increasingly in demand from a large number of services.
- Committee on Space Research (COSPAR)
- COSPAR is a scientific committee of the International Council of Scientific Unions (ICSU). Its objectives are to promote on an international level scientific research in space, with emphasis on the exchange of results, information and opinions, and to provide a forum, open to all scientists, for the discussion of problems that may affect scientific space research. These objectives are achieved through the organization of Scientific Assemblies, publications and other means. Space Research Today, COSPAR's information bulletin, published three times a year by Elsevier Science, provides reports on COSPAR and other meetings, scientific space mission news, articles from space organizations and Associates, book reviews, etc.

III. Competition for the orbital slots

In 1957, the first artificial satellite, Sputnik-1, was launched and it was the beginning of the space age. Today's satellites operate in three basic orbital bands: Low Earth Orbit (LEO, 100-1500 km), Medium Earth Orbit (MEO, 5000-10000 km), and Geosynchronous Orbit (about 36000 km). Highly Elliptical Orbit (HEO) is also increasingly being used for specific applications, such as early warning satellites.

For a given orbit, a satellite must travel at a specific orbital velocity to maintain its altitude. At geosynchronous orbit this velocity is such that satellites orbit the earth once in 24 hours. If the inclination - the angle between the orbital plane and the equatorial plane - of a geosynchronous orbit is zero (or near zero) then the satellite remains stationary over the same point on the Earth's surface. Such an orbit is known as a Geostationary Orbit (GEO). An advantage of the GEO is that antennas on the ground, once aimed at the satellite, need not continue to rotate. Another advantage is that a satellite in this type of orbit continuously sees about one-third of Earth.

The geostationary orbit was first popularized by science fiction author Arthur C. Clarke in 1945 as a useful orbit for communications satellites. As a result this is sometimes referred to as the Clarke orbit. Similarly, the Clarke Belt is the part of space approximately 35,786 km above mean sea level in the plane of the equator where near-geostationary orbits may be achieved.

GEO satellites must generate high-power transmissions to deliver a strong signal to Earth, due to distance concerns and the use of high bandwidth signals for television or broadband applications. In order to avoid radio frequency interference, GEO satellites are required to maintain at least two degrees of orbital separation, depending on what band they are using to transmit and receive signals, and the field of view of their ground antennas. This means that a maximum of 180 satellites could occupy the GEO.

Actors who wish to place a satellite in GEO must obtain an "orbital slot" in which to do so and secure a portion of the radio frequency spectrum to carry their satellite communications. Both radio spectrum and orbital slot assignments are coordinated through the International Telecommunication Union (ITU) and recognized by the ITU Convention as "limited natural resources" given their finite number. The ITU Convention states that radio frequencies and GEO "must be used efficiently and economically so that countries or groups of countries may have equitable access to both." In the case of the GEO orbit slots allocated by the ITU, the principle has been interpreted as meaning that such

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[††††††] Committee on Space Research. http://www.cosparhq.org/

[‡‡‡‡‡‡] International Telecommunication Union. http://www.itu.int.

positions should be made available on a first-come first-served basis.
Over the years, this increased demand has resulted in greater competition, motivating some space actors to file requests for orbital slots prematurely and/or in greater quantity than necessary. One example of the type of conflicts this can cause occurred in 1992, when the Indonesian Pacific Satellite Nusantara (PSN) company placed a satellite into a vacant GEO slot which was registered to Tonga. Indonesia refused to abide by the ITU ruling granting Tonga the slot, or to recognize Tonga's leasing arrangements. The dispute escalated in July 1993, when a US firm leased the slot from Tonga and orbited a satellite into position. In 1996, Tonga leased the same slot to a Chinese company, which prompted PSN to jam the satellite. Ultimately the 1998 Asian financial crisis forced PSN to abandon its project. Perhaps most worrisome is that Indonesia consistently refused to acknowledge the right of the ITU to grant slots, while the ITU was incapable of stopping Indonesia's actions.

There are measures which can help reduce the problem of competition for orbital slots and mitigate signal interference:

- Reduction of the slot's size. The two-degree spacing requirement only applies to satellites that wish to use the same frequency. Satellites with different frequencies can be spaced as little as one tenth of a degree away from one another.
- Using the "hot bird" slots. Some satellite operators have begun stacking satellites in the same orbital slot (often known as "hot bird" slots) to be able to provide more service. For example, the 91-92 degrees West slot in GEO houses a Brazilsat, two Galaxy satellites, and a Canadian Nimiq satellite.
- Some actors agreed to exchange or share rights to certain slots. For example, Telesat Canada agreed to allow a DirecTV satellite to move into one of its slots in exchange for Telesat Canada's use of a DirecTV satellite in another orbital slot.

The problem of allocation orbital slots directly connected with the problem of space debris. As of 1 January 2005, there were 1,124 objects with a cross-section of more than 1 m catalogued in the geostationary region and its immediate vicinity. Of these, only 346 are operational satellites. Debris can drift inside an operating satellite's orbital "box". An explosion in the vicinity of geostationary orbit can have catastrophic consequences, generating new debris and posing new collision hazards. Measures to mitigate debris in this orbit are therefore an absolute and urgent necessity. Mitigation measures, recommended by IADC (Inter-Agency Space Debris Coordination Committee), are relatively simple and can be achieved at a moderate cost. They consist in boosting end-of-life objects to about 300 km above GEO, then passivating them to avert future risks of explosion. Some operators are applying such measures already to free up slots occupied by old satellites for new ones. However, uptake of mitigation measures is still relatively slow, with only 1/3 of operators performing end-of-life reorbiting operations in full compliance with IADC rules. Another 1/3 go no further than partially reorbiting a satellite to ensure it does not interfere with others in geostationary orbit. And the remaining 1/3 does nothing at all: when their satellites run out of fuel, they simply discard them in space, with the obvious consequences.
There are strong incentives for space actors to cooperate in the allocation and use of orbital slots — namely confidence in the sustainability of their use. Cooperation in this area can also strengthen support for the application of the rule of law to broader space security issues.