The Space Environment

Growing debris threats to spacecraft, but annual rate of new debris production decreasing

The number of objects in Earth orbit has increased steadily and there are an estimated 35 million pieces of space debris in orbit today. Approximately 13,000 orbiting objects large enough to seriously damage or destroy a spacecraft – over 90 percent of which are space debris – are being tracked. However, the annual growth rate of tracked orbital debris has been decreasing since the early 1990s, due in large part to national space agency debris mitigation efforts.

In 2005, the space debris population grew by 2.1 percent, a modest rate increase compared with those of recent years. The new space debris was partially attributable to five incidents of satellite fragmentation and two accidental collisions in orbit over the past year. New research in 2005 indicated that global warming, and the consequent contraction in the thermosphere, could cause space debris to be more persistent and space collisions more common.

Increasing awareness of space debris threats and continuing efforts to develop international guidelines for debris mitigation

There is widespread recognition, in light of tracking efforts and recorded on-orbit collisions, that space debris is a growing threat. Since the mid-1990s, many space-faring states, including China, Japan, Russia, and the US, and the European Space Agency have developed national debris mitigation standards. In 2001, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) mandated the Inter-Agency Debris Coordination Committee (IADC) to develop a set of voluntary international debris mitigation guidelines.

In 2005, the Space Debris Working Group of the Scientific and Technical Subcommittee of COPUOS reached agreement that the intentional destruction of any orbiting object that could generate "long-lived" orbital debris should be avoided. In the US, the Federal Communications Commission (FCC) enacted rules which require orbital debris mitigation plans to be submitted by any entity requesting FCC space station authorization.

Growing demand for radio frequencies

Expanding satellite applications are driving growing demand for radio frequencies. The number of satellites operating in the 7-8 gigahertz band commonly used by GEO satellites has been increasing. Satellite operators now spend about five percent of their time addressing frequency interference issues, including the US and European Union (EU) disagreement over frequency allocation for the proposed EU Galileo navigational system. The growth in military consumption of bandwidth has also been dramatic: the US military used some 700 megabytes per second of bandwidth during Operation Enduring Freedom in 2003, compared to just 99 megabytes per second during Operation Desert Storm in 1991.

Demand for radio frequencies continued to increase in 2005. To respond to these challenges, regional organizations such as the Association of Southeast Asian Nations (ASEAN) and the EU worked on common regional radio frequency allocation policies. The US conducted a review of its policies to enhance efficient and effective management and use of the radio frequency spectrum. Radio frequency interference and piracy are of growing concern to commercial space actors. One thousand, three hundred and seventy-four incidents of satellite radio frequency interference were reported in 2005, although only one percent of these incidents were intentional.

Growing demand for orbital slot allocations

There are more than 620 operational satellites in orbit today: about 46 percent in LEO, 6 percent in MEO, and slightly more than 47 percent in GEO. Increased competition for orbital slot assignments, with greatest demand for GEO orbital slots where most communications satellites operate, has caused occasional disputes between satellite operators. The International Telecommunications Union (ITU) has been pursuing internal reforms designed to address slot allocation backlogs and related financial challenges.

Demand on orbital slots continued to increase in 2005, leading certain COPUOS delegates to express the view that GEO orbital slot positions should be shared equitably among states. Iran became the 45th state to acquire indirect access to space, launching a satellite using Russian launch services. In 2005, cooperation and competition over scarce orbital slots in GEO continued to mark relations among commercial space operators.

Space surveillance capabilities to support collision avoidance slowly improving

The US Space Surveillance Network uses 31 sensors worldwide to monitor over 9,000 space objects in all orbits, supporting collision avoidance and debris re-entry. Since 2004, the US has moderated public access to the two-line elements to registered users out of concern for national security. Russia maintains its Space Surveillance System with 14 sensors, and monitors some 5,000 objects (mostly in LEO), but does not widely disseminate data. The EU, Canada, China, France, Germany, and Japan are all developing new space surveillance capabilities.

In 2005, the US expanded its space surveillance and space situational awareness capabilities by modernizing its Michigan Orbital Debris Survey Telescope and Ground-Based Electro-Optical Deep Space Surveillance system, continuing to pursue a Space-Based Surveillance System, and announcing plans for a space situational awareness nanosatellite in GEO. China established its first Target and Debris Observation and Research Center, while actors in Europe explored the possibility of setting up a space surveillance network by pooling existing ground-based radars and optical telescopes with new capabilities.

Laws, Policies, and Doctrines

Progressive development of legal framework for outer space activities

Since the signing of the Outer Space Treaty (OST) in 1967, the international legal framework related to space has grown to include the Astronaut Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1979), and the Moon Agreement (1979), as well as a range of other international and bilateral agreements and relevant customary international law. This legal framework establishes the principle, primarily through the OST, that space should be used for 'peaceful purposes' and is not subject to claims of national sovereignty. The OST prohibits the stationing of nuclear weapons or any other weapons of mass destruction anywhere in space. The abrogation of the Anti-Ballistic Missile Treaty in 2002 eliminated a longstanding US/USSR-Russia prohibition on space-based conventional weapons, stimulating renewed concerns about the potential for space weaponization.

In 1981, the UN General Assembly (UNGA) adopted a resolution that states refrain from actions contrary to the peaceful use of outer space, calling for negotiations within the Conference on Disarmament (CD) on a multilateral agreement on the Prevention of an Arms

Race in Outer Space (PAROS). Voting patterns have demonstrated nearly unanimous support for the PAROS resolution, suggesting a consistent and widespread desire on the part of states to expand international law to include prohibitions on weapons in space.

In 2005 there was a noteworthy shift in the PAROS debate, when Israel and the US voted against the PAROS resolution – the first opposition votes in the resolution's history. Also, Russia tabled a new resolution, inviting states to provide input on measures to promote transparency and confidence building in outer space. Continuing efforts to stimulate discussion on PAROS, China and Russia submitted a non-paper to the CD on Definition Issues Regarding Legal Instruments on the Prevention of Weaponization of Outer Space.

COPUOS remains active, but the CD deadlocked since 1998

A range of international institutions, such as UNGA, COPUOS, ITU, and CD, have been mandated to address space security issues. However, the CD has been deadlocked since 1998 and unable to address the PAROS mandate to develop an instrument relating to space security and the weaponization of space.

The CD deadlock persisted in 2005, without any formal work on PAROS. However, two informal sessions on PAROS were organized for CD delegates, as well as a number of international conferences on space security. At COPUOS debate emerged on the possible introduction of topics pertaining to the militarization of space. An aborted effort was also made to create four open-ended ad hoc committees under UNGA First Committee auspices to address PAROS and other priority issues.

Space-faring states' national space policies consistently emphasize international cooperation and the peaceful uses of outer space

All space-faring states emphasize the importance of cooperation and the peaceful uses of space, including the promotion of national commercial, scientific, and technological progress. The US has recently announced plans for peaceful space exploration of the Moon and Mars, while there is growing interest in manned space programs. Brazil and India tend to focus on the utility of space cooperation for social and economic development.

New space policies were adopted in China, Europe, Japan, Kazakhstan, Russia, and the US in 2005. The European Commission (EC) unveiled a plan to spend more than $5-billion on "Security and Space" programs for 2006-2013 and to double its budget for space-related research programs. Russia approved a new Federal Space Program with the stated objective of retaining status as a leading space power. Japan's 20-year space plan outlined manned flights to the moon by 2025 as a first step to explore the solar system. Stated objectives of China's new space plan include launching four space flights, the first of which will feature China's first spacewalk in 2007. Finally, China released a White Paper in 2005, which reiterated its position that effective preventative measures, including international legal instruments, are needed to prohibit the deployment of weapons in outer space and the threat or use of force against objects in outer space, and ensure that outer space is used purely for peaceful purposes.

Growing focus within national military doctrine on the security uses of outer space

A growing number of states, led by China, Russia, the US, and key European states, increasingly emphasize the use of space systems to support national security. Dependence on these systems has led several states to view space assets as critical national security infrastructure. US military space doctrine has also begun to focus on the need for "counterspace operations" to prevent adversaries from accessing space.

Building on existing trends, in 2005 actors that included the EU, India, Israel, and Japan placed more emphasis on the national security applications of space. Israel and Japan introduced plans to boost surveillance capabilities from space. India's Air Force urged the government to set up a Strategic Aerospace Command to better develop military space capabilities. A European Panel of Experts on Space and Security urged the development of a security-related space strategy as well as a balance between the civil and military uses of space. The US was expected to release a new military space directive that, according to certain media reports, would depart from current policy by explicitly calling for development of certain space systems negation capabilities to ensure that space systems or services cannot be used for purposes hostile to US national interests.

Civil Space Programs and Global Utilities

Growth in the number of actors gaining access to space

By 2004, 10 actors had demonstrated an independent orbital launch capacity. Forty-four states have accessed space independently or with the launch services of others. In the 1990s, the rate of increase doubled from just less than one new actor to just less than two per year, mostly for civil space programs. In the last 12 years Surrey Satellite Technology Ltd. of the UK has enabled seven countries to build their first civil satellites. Iran and South Korea have announced plans for civil space programs. China recently joined Russia and the US as the only space powers with demonstrated manned spaceflight capabilities.

In 2005 China, Russia, and the US launched 24 civil spacecraft, of which nine were manned. Europe and Japan fielded new launch vehicles and Iran became the 45th state to launch a satellite. There were also a number of qualitative advances in space propulsion with the testing of "double layer thrusters" by the European Space Agency (ESA) and continued work on nuclear electric power and propulsion technologies by NASA.

Changing priorities and funding levels within civil space programs

The general trend in recent years has seen civil space expenditures increase in India and China and decrease in the EU, Japan, Russia, and the US. The budget of the Indian Space Research Organisation (ISRO) grew over 60 percent in real terms between 1990 and 2000, while the US NASA and European ESA budgets dropped by 25 percent and nine percent respectively between 1992 and 2001. The annual number of civil space missions has generally held steady for the past decade, with a decreasing number of manned missions, and an increasing number of missions involving small satellites and microsatellites. Civil space programs increasingly include security and development applications. India has designed 19 telecommunications and remote sensing satellites for development applications; and Algeria, Brazil, Chile, Egypt, Malaysia, Nigeria, South Africa, and Thailand are all placing a priority on satellites to support social and economic development.

In 2005 most space-faring states, except Japan, experienced modest increases in civil space budgets. With a budget of $16.5-billion, NASA continues to be the world's dominant civil space investor. China, Japan, Russia, and the US announced plans to develop manned spacecraft in the coming decades. The asteroid interception missions completed by civil space agencies in Japan and the US represent a significant achievement in engineering, although the results of the Japanese mission remain uncertain and the technologies could have dual-use functions.

Steady growth in international cooperation in civil space programs

International civil space cooperation efforts over the past decades have included the US-USSR Apollo-Soyuz docking of manned modules, Soviet flights to the MIR space station with foreign representatives, the Hubble Space Telescope, and joint NASA-ESA projects such as Skylab. The most prominent current example of international cooperation is the International Space Station (ISS), involving 16 partner states, 44 launches, and an estimated cost of over $100-billion. International civil space cooperation has played a key role in the proliferation of technical capabilities for states to access space.

Continuing the trend of international civil space cooperation, Russia reached agreements with Brazil, Canada, China, Egypt, ESA, India, Indonesia, Iran, Kazakhstan, and South Korea in 2005. The US established agreements with India, Japan, Russia, and Sweden. ESA, a regional space agency that embodies the benefits of international cooperation, signed agreements with China, India, Morocco, Russia, and Ukraine. Eight regional partners – Bangladesh, China, Indonesia, Iran, Mongolia, Pakistan, Peru, and Thailand – signed an agreement to form the Asia Pacific Space Cooperation Organization.

Dramatic growth in global utilities as states acknowledge strategic importance of satellite-based navigation systems

The use of space-based global utilities, including navigation, weather, and search-and-rescue systems, has grown substantially over the last decade. For example, GPS unit consumption grew by approximately 25 percent per year between 1996 and 1999, generating sales revenue of $6.2-billion in 1999. These systems have spawned space applications that are almost indispensable to the civil, commercial, and military sectors, as well as most modern economies. The number of actors developing satellite-based navigation capabilities has grown, from two (Russia and the US) in 1990, to five in 2004 with the addition of China, the EU, and Japan. Currently, there are 88 navigation satellites in orbit, of which between 60 and 80 are operational. The strategic value of satellite navigation was underscored by the conflict over frequencies for Galileo and GPS, which was resolved in 2004.

The expansion of global utilities, particularly in the area of satellite navigation, continued in 2005. The EU launched the first of its constellation of Galileo navigation satellites, while India, Israel, Morocco, Saudi Arabia, and Ukraine announced their participation in the project. In a significant reversal of policy, Russia required the fitting of GLONASS satellite navigation systems on a wide range of Russian space, air, land, and sea vehicles. It also made plans to cooperate with China and India on GLONASS. India also started development of its own separate civilian satellite navigation system called GAGAN.

Commercial Space

Continued overall growth in the global commercial space industry

The commercial space sector, including manufacturing, launch services, space products, and operating insurance, accounted for an estimated $2.1-billion in revenues in 1980 and exceeded $100-billion by 2004. This growth is being driven by the satellite services industry, including telecommunications, which accounted for 60 percent of 2003 commercial space revenues in spite of some decline within the manufacturing and launch sectors. Major commercial satellite telecommunications companies today include PanAmSat, Loral, SES Americom, Intelsat, and News Corporation.

In 2005 there were 17 commercial launches, an increase over 2004. Commercial space revenues for the year were expected to reach $115-billion. Twenty new commercial satellites were launched. Providers of commercial space services had a watershed year; some satellite radio companies doubled subscriptions. The general trend to privatize government-owned telecommunications agencies continued in 2005 with the first initial public stock offerings of New Skies Satellites and Inmarsat. There was ongoing consolidation in the commercial space industry with Intelsat purchasing PanAmSat, SES Global purchasing New Skies, the European Aeronautics Defence and Space Company (EADS) acquiring Dutch Space BV, Alcatel Alenia merging with Telespazio, and SpaceDev merging with Starsys Research Corporation.

Declining commercial launch costs support increased commercial access to space

Commercial space launches now account for about one-third of the 60 to 70 annual space launches. The costs to launch a satellite into GEO have declined from an average of about $40,000/kilogram in 1990 to $26,000/kilogram in 2000, with prices still falling. In 2000, payloads could be placed into LEO for as little as $5,000/kilogram. The European and Russian space agencies are the most active space launch providers. Today's top commercial launch providers include Lockheed Martin and Boeing Launch Services in the US, Arianespace in Europe, Energia in Russia, and two international consortia – Sea Launch and International Launch Service. With the launch of Mojave Aerospace Ventures' SpaceShipOne in 2004, the private sector entered the suborbital manned spaceflight sector. Cheaper space access has also been key to the growth of high-resolution commercial satellite imagery.

Demand for commercial launchers stayed flat in 2005 and the US continued to lose market share to Europe and Russia. European and multinational commercial space launchers saw strong growth in 2005, with the European Ariane 5G vehicles experiencing a record year. Japan successfully tested a new launcher in 2005 and China announced its imminent return to commercial space launch. The embryonic space tourism sector advanced in 2005. More than 20 companies are developing a suborbital, reusable launch vehicle for space tourism. Scaled Composites and Virgin Galactic announced a joint venture, The Spaceship Company, which plans to build a fleet of commercial suborbital spacecraft and equipment to be deployed in commercial space flights by the end of 2008. Despite these promising developments, the space tourism industry continued to face the twin challenges of supply constraint and uncertain liability regulation in 2005.

Government subsidies and national security concerns continue to play an important role in the commercial space sector

The 1998 US Space Launch Cost Reduction Act and the 2003 European Guaranteed Access to Space program provide for significant government subsidization of the space launch and manufacturing markets, including insurance costs. The US and European space industries also receive important space contracts from government funds. The 1987 Missile Technology Control Regime (MTCR), designed to restrict the proliferation of missile technology, has encouraged actors outside the regime to develop space systems using components that are restricted by the regime itself. In 1999, the US placed satellite export licensing on the State Department's US Munitions List, bringing satellite product export licensing under the International Traffic in Arms Regulations (ITAR) regime and significantly complicating the way US companies participate in international collaborative satellite launch and manufacturing ventures.

Government continued to play a central role in commercial space in 2005. The US Department of Defense remained the single largest commercial space client. At the same time, commercial space actors such as the International Space Business Council cited ITAR as the "industry's most serious issue." High insurance premiums also continued to represent a barrier to growth in the industry. As a result, a number of commercial space actors have stopped insuring their in-orbit assets and/or purchased spare satellites.

Space Support for Terrestrial Military Operations

The US and Russia lead in developing military space systems

By the end of the Cold War, the US and USSR had developed extensive military space systems to provide military attack warning, communications, reconnaissance, surveillance, intelligence, navigation and weapons guidance. By the end of 2003, the US and USSR/Russia had together launched more than 4,800 military satellites, while the rest of the world had launched only 70 to 80.

The US has dominated the military space arena since the end of the Cold War. It currently spends roughly 95 percent of all the money spent on global military space expenditures and has approximately 135 operational, military-related satellites – over half of all the military satellites in orbit. Russia is believed to have some 85 dedicated military and 18 multi-purpose satellites in orbit. The US is, by all major indicators, the actor most dependent on its space capabilities. The 2001 Report of the Commission to Assess United States National Security Space Management and Organization warned that US dependence on space systems made it uniquely vulnerable to a "space Pearl Harbor" and recommended that the US develop enhanced space control (protection and negation) capabilities.

Nineteen dedicated military space satellites were launched in 2005. The US launched seven military satellites: two signals intelligence satellites, two reconnaissance satellites, two technology satellites, and one navigation satellite. However, 2005 also saw significant cutbacks to a number of US military space programs. The Future Imagery Architecture, the SBIRS-High program, the TSAT system, and the Space Radar were all plagued by delays and cost overruns and saw funding cutbacks.

With a budget currently 30 times less than that of the US, Russia continued to face setbacks in its military space programs. In 2005, Russia launched six military satellites: four navigation satellites, one communication satellite, and one reconnaissance satellite. However, it also saw three failed launches and the loss of two military satellites. Russia announced future funding and growth for a military space program that includes the launch of six military satellites in 2006 and the future orbiting of an entire constellation of high-resolution space radars.

More states developing military space capabilities

Declining costs for space access and the proliferation of space technology are enabling more states to develop and deploy their own military satellites using the launch capabilities and manufacturing services of others, including the commercial sector.

China provides military communications through its DFH series satellite, and has deployed a pair of Beidou navigation satellites to ensure its navigational capability. China also maintains three ZY series satellites in LEO for tactical reconnaissance and surveillance functions, has deployed three military reconnaissance satellites, and is believed to be purchasing additional commercial satellite imagery from Russia to meet its intelligence needs.

EU states have developed a range of military space systems. France, Germany, Italy, and Spain jointly fund the Helios 1 military observation satellite system in LEO, which provides images with a one-meter resolution. France, Germany, and Italy are planning to launch six low-orbit imagery intelligence systems to replace the Helios series by 2008. The UK maintains a constellation of three dual-use Skynet 4 communications satellites in GEO. France operates four signal intelligence satellites. The EU Galileo satellite navigation program, initiated in 1999, is intended to operate for civil and commercial purposes, but will have an inherent dual-use capability.

Israel operates a dual-use Eros-A imagery system as well as the military reconnaissance and surveillance Ofeq-5 system. India maintains its Technology Experimental Satellite and a naval satellite, both of which provide military reconnaissance capabilities. Japan operates the commercial Superbird satellite, which also provides military communications and has two reconnaissance satellites – one optical and one radar. In cooperation with a French company, Thailand will soon produce its first intelligence and defense satellite.

International military space programs were active in 2005. Ongoing regional tensions drove military space development in Asia. China launched the Beijing-1 (Tsingshua-1) Earth observation microsatellite amid speculation that China's continued participation in the Galileo navigation system might eventually be used to improve the accuracy of its missiles. Taiwan announced plans to launch a $300-million Follow-On RSS reconnaissance satellite. In an effort to improve satellite images of North Korea's nuclear and missile facilities, Japan began research in 2005 on scaling down the size of reconnaissance satellites to enhance their maneuverability. Pakistan began construction of a remote sensing satellite.

In 2005, France continued development of the most advanced and diversified independent military space capabilities in Europe with the launch of the Syracuse 3A military communications satellite and ongoing work on the Spirale early-warning and Melchior military communications satellites. Spain launched the XTAR-EUR communications satellite, and the UK launched a dual-use imagery microsatellite called TopSat.

The Middle East saw a proliferation of military space capabilities with the launch of Iran's Sina-1 satellite, which, although officially civil, has been claimed to have dual-use remote sensing functions. Israel, for its part, announced its intention to launch the Ofeq-7 and TechSAR surveillance and reconnaissance satellites. In North Amrica, Canada announced its intention to launch a radar surveillance satellite called RADARSAT-2 as part of Project Polar Epsilon.

Space Systems Protection

The US and Russia lead in general capabilities to detect rocket launches, while the US leads in the development of advanced technologies to detect direct attacks on satellites

US Defense Support Program satellites provide early warning of conventional or nuclear ballistic missile-based attacks. The US is also developing capabilities to detect in-orbit attacks on satellites through its Rapid Attack Identification, Detection, and Reporting System (RAIDRS) program. Russia began rebuilding its aging missile launch warning system in 2001 by replacing its Oko series satellites with three early-warning satellites. France is due to launch two missile-launch early-warning satellites, Spirale-1 and 2, in 2008. Most actors have a basic capability to detect a ground-based electronic attack, such as jamming, by sensing an interference signal or by noticing a loss of communications. Directed energy attacks move at the speed of light, making advance warning very difficult to obtain.

The US maintained its lead in space situational awareness capabilities in 2005 with developments in a number of new programs. The Autonomous Nanosatellite Guardian for Evaluating Local Space (ANGELS) program is intended to provide the continuous monitoring of areas in the immediate proximity to assets in GEO. The Space Surveillance Telescope (SST) is designed to complement existing space surveillance systems with advanced ground-based optical searching and tracking of objects in GEO. The Deep View radar is supposed to provide high-resolution images for objects in deep space as well as critical monitoring of activities in GEO. And the Large Millimeter Telescope is expected to be the world's largest and most sensitive single-aperture telescope when it is completed in 2008.

Protection of satellite ground stations is a concern, while protection of satellite communications links is poor but improving

Many space systems lack protection from attacks on ground stations and communications links. Typically with only one operations center and one ground station each, most commercial space systems are vulnerable to negation efforts. While many actors employ passive electronic protection capabilities, such as shielding and directional antennas, more advanced measures, such as burst transmissions, are generally exclusive to the military systems of more technically advanced states. China and the US have been aggressively pursuing a variety of jamming protection capabilities.

In 2005, the US successfully tested the GPX airborne pseudo-satellite, employing an unmanned aerial vehicle to boost power of GPS satellite signals and overcome jammers. In addition, researchers at the University of Surrey in the UK, the Turkish research the Tubitak-Bilten institute in Turkey, Pennsylvania State University, and the US Naval Research Laboratory have each been conducting research on more robust encryption of satellite communications.

Protection of satellites against some direct threats is improving, largely through radiation hardening, system redundancy, and greater use of higher orbits

Both the range of actors employing satellite protection capabilities and the depth of these capabilities are increasing. China and Japan are developing navigation satellites that will increase the global redundancy of such critical systems. The EU and the US have agreed to make their navigation systems interoperable. Increasingly, states are placing military satellites into higher orbits, where they are less vulnerable to attacks than in LEO, due to greater warning times and difficulty of access. Most key US, European, and Russian military satellites are already hardened against the effects of a high-altitude nuclear detonation. The US is reportedly developing a stealth satellite with the ability to evade detection by the terrestrial space surveillance systems of other actors. Reflecting concerns about the protection of commercial satellites, in 2002, the US General Accounting Office recommended that "commercial satellites be identified as critical infrastructure."

To reduce the vulnerability of satellites to natural and manmade threats in orbit, the US improved radiation hardening in 2005. The US Defense Threat Reduction Agency, the Air Force Research Laboratory, and Honeywell have been working to mainstream radiation-hardened semiconductors that will improve resistance to various types of radiation. To facilitate the use of MEO, the Air Force Research Laboratory, the Defense Advanced Research Projects Agency (DARPA), and NASA were developing a Demonstration and Science Experiments satellite to characterize the radiation environment in MEO.

Russia and the US lead in capabilities to rapidly rebuild space systems following a direct attack on satellites

Russia and the US are able to responsively re-constitute satellite systems. The US is supporting two responsive initiatives: the Force Application and Launch from CONUS (CONtinental US) or FALCON program seeks to develop a rocket capable of placing 100-1,000 kilograms into LEO within 24 hours; and the RASCAL program seeks to deliver 50-130 kilograms into LEO on short notice. The US is also supporting the High Frequency Active Auroral Research Program that looks at measures to mitigate the environmental impact of a nuclear attack in space, and could help facilitate recovery.

The US and Russia conducted research on responsive lift technologies in 2005. SpaceX Corporation continued research on several low-cost launch vehicles of small, medium, and high capacity while Lockheed Martin completed a successful test-firing of a hybrid motor as part of the Small Lift Vehicle program. Russia continued research on air launch capacbilities with a potential Ishim rocket system to be launched from a MiG-31 fighter jet and the Polyot vehicle to be launched from an Antonov carrier.

Space Systems Negation

Proliferation of capabilities to attack ground stations and communications links

Ground segments and communications links remain the most vulnerable components of space systems, susceptible to attack by conventional military means, computer hacking, and electronic jamming. A number of intentional jamming incidents targeting communications satellites have been reported in recent years and Iraq's acquisition of GPS-jamming equipment for use against US GPS-guided munitions during Operation Iraqi Freedom in 2003 suggests that jamming capabilities are proliferating. The US leads in developing doctrines and advanced technologies to temporarily negate space systems by disrupting or denying access to satellite communications, and has deployed a mobile system to disrupt satellite communications without inflicting permanent damage to the satellite.

In 2005 Libya and Iran carried out state-sponsored jamming of satellite communications. China continued to be a major target of satellite jamming. Significantly, the APSTAR VI communications satellite, designated "jam-proof" by China, was jammed in 2005, allegedly by the Falun Gong.

The US leads in the development of space situational awareness capabilities that could support space negation

Several space actors are increasing investments in space surveillance capabilities for debris monitoring, satellite tracking, and near-Earth object detection. The US and Russia maintain the most extensive space surveillance capabilities. China and India also have satellite tracking, telemetry, and control assets essential to their civil space programs. Canada, France, Germany, and Japan are all actively expanding their ground-based space surveillance capabilities. While this technology enhances transparency and enables space collision avoidance, it can also provide capabilities for targeting satellites and space negation. For example, the US has explicitly linked its development of enhanced space surveillance systems to efforts to enable offensive counterspace operations.

The US increased its lead in space situational awareness technologies in 2005 with research and development into ANGELS and the Deep View radar. These dual-use systems could facilitate targeting for space systems negation. Some actors in Europe have begun discussions on the option of pooling existing space surveillance capabilities as well as developing additional independent capabilities of their own, to be less reliant on US data.

Ongoing proliferation of ground-based capabilities to attack satellites

A variety of US and USSR/Russian programs during the Cold War and into the 1990s sought to develop ground-based ASAT weapons employing conventional, nuclear, and directed energy capabilities. The capability to launch a payload into space to coincide with the passage of a satellite in orbit is a basic requirement for conventional satellite negation systems. Twenty-eight states have demonstrated suborbital launch capability; of those, 10 have orbital launch capability. As many as 30 states may already have the capability to use low-power lasers to degrade unhardened satellite sensors. The US leads in the development of more advanced ground-based kinetic-kill systems with the capability to directly attack satellites. It has deployed components for a ground-based ballistic missile defense system and is developing an airborne laser system, both of which have inherent LEO satellite negation capabilities.

In 2005, the US and China continued to work on directed energy technologies. The US is pursuing lighter, smaller, and more durable solid state laser designs, which have not yet been able to generate the same level of continuous power as other types. The existing American Starfire laser range was fitted with a sodium-beacon laser with possible ASAT applications. Northrop Grumman and Raytheon continued development of the advanced high-power chemical oxygen-iodine laser for the MDA Airborne Laser project. Research in China continued on laser frequencies and adaptive optics, which can help to maintain laser beam quality over long distances. Though not a dedicated program, this basic research could eventually support ground-based and airborne ASATs.

In 2005, more advanced work on ground-based kinetic kill weapons was conducted in China, Russia, the UK, and the US. The US conventional kinetic-energy ASAT program was awarded a contract to develop three advanced kill vehicles. The US continued to research and develop its Ground-based Midcourse Defense system and Russia upgraded the A-135 anti-ballistic missile system. China, EADS, and the UK conducted basic research into kinetic kill vehicles for missile defense. Such kinetic kill interceptors could serve as ASATs.

Proliferation of space-based negation enabling capabilities

Space-based negation efforts require sophisticated capabilities, such as precision in-orbit maneuverability and space tracking. Many of these capabilities have dual-use potential. For example, microsatellites, which provide an inexpensive option for many space applications, could be modified to serve as kinetic-kill vehicles. The US leads in the development of most of these enabling capabilities, though none appear to be integrated into dedicated space-based negation systems.

Enabling capabilities for space-based negation continued to proliferate in 2005. In the US, the XSS-11 and DART microsatellites demonstrated dual-use rendezvous and surveillance capabilities. Indeed, the DART satellite unexpectedly collided with its target satellite, sending it several kilometers off orbit. Both Japan and the US conducted asteroid interception missions in 2005 which used key negation-enabling capabilities such as tracking, firing, and monitoring. Robotic technologies for on-orbit servicing such as the Robotic Components Verification on ISS (ROKVISS) system were demonstrated on the International Space Station. DARPA expressed interest in developing capacity for in-orbit servicing, repair, and orbit manipulation using space robotics. China, Europe, and the US conducted research, development, and testing of homing sensors which could be used for a range of space systems negation applications.

Space-Based Strike Weapons

While no space-based strike weapons (SBSW) have yet been tested or deployed in space, the US continues to develop a space-based interceptor for its missile defense system

Although the US and USSR developed and tested ground-based and airborne ASAT systems between the 1960s and 1990s, there has not yet been any deployment of space-to-Earth or space-to-missile SBSW systems. Under the Strategic Defense Initiative in the 1980s, the US invested several billion dollars in the development of a space-based interceptor (SBI) concept called Brilliant Pebbles, and tested targeting and propulsion components for such a system. The US and USSR were both developing directed energy SBSW systems in the 1980s, although today these programs have largely been halted.

US research and development efforts associated with the SBI program declined in the 1990s, but were revived in 2000. The Near-Field Infrared Experiment (NFIRE), originally due for launch in 2006, was planned to be the first fully integrated SBSW spacecraft with a sensor platform and kinetic-kill vehicle. Further MDA plans include the deployment of a test-bed of three to six integrated SBIs by 2011-2012. The annual SBI budget is estimated to be only about $100-million of the $10-billion MDA budget However, even at these funding levels, the timeline for developing the technical capabilities for SBI appears to be decreasing. While such a system would have limited strategic utility, deploying weapons in space would represent a significant departure from current practice.

In 2005, no space-based weapons were tested or deployed. In the US, the question of whether the MDA should deploy and test a "kill vehicle" for NFIRE once again came under Congressional scrutiny. Despite the recommendation made by the US Senate Appropriations Committee, the MDA has removed the kill vehicle portion of the planned test, saying it posed a risk of technical failure.

A growing number of actors are developing SBSW precursor technologies outside of SBSW programs

The majority of SBSW prerequisite technologies are dual-use. They are not related to dedicated SBSW programs, but are sought through other civil, commercial, or military space programs. While there is no evidence to suggest that states pursuing these enabling technologies intend to use them for SBSW systems, their development does bring these actors technologically closer to such a capability.

Both the number of such technologies being pursued in non-SBSW programs and the number of actors doing so are increasing. For example, China, India, and Israel are developing precision attitude control and large deployable optics for civil space telescope missions. Thirty-two states have developed or are involved in developing independent high-precision satellite navigation capabilities. In the last 12 years, nine states have deployed a first small or microsatellite – a key SBI precursor technology. China and the EU are developing re-entry technologies which are also required for the delivery of mass-to-target weapons from space to Earth.

In 2005, the US, Russia, China, and Europe maintained research and development on re-entry technologies relevant to potential orbital bombardment systems. Russia announced that its military had tested a hypersonic missile system capable of precision re-entry to evade missile defenses. The US Air Force Space Command sought to apply similar principles to make US missiles maneuvrable. The US also continued work on the Common Aerothermodynamic Vehicle. The EU has begun work on the aerothermodynamic research program called European Experimental Re-entry Testbed. Researchers in Chinese academic institutions continued research on re-entry techniques for "space-based ground attack weapons systems." However, the scope, funding, and political support for such basic research remain unclear.

Upgrades were made in 2005 to the US and Russian global missile tracking and warning systems – foundational technologies for any future space-based missile interceptor. The US Air Force is seeking Congressional approval to begin work on a new space-based missile warning satellite to capitalize on new sensor technologies. As part of the modernization of its missile attack warning system, Russia plans to test a new early-warning radar station near St. Petersburg. While lagging far behind Russia and the US on missile tracking, China conducted basic research on how to obtain greater missile-tracking precision and real-time accuracy. China, the EU, India, Russia, and the US continued research and development on global positioning systems, a precursor technology of use in certain SBSW systems.