Space Systems Negation

Indicator Description

This chapter assesses trends and developments related to the research, development, testing and deployment of capabilities designed to *negate the capabilities of space systems*. It also assesses the development of s*pace situational awareness capabilities* as a key enabler of negation techniques. Space negation relates closely to space protection capabilities (see chapter Space Systems Protection).

Key Trends

TREND 7.1: 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.

TREND 7.2: 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.

TREND 7.3: 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. Both states successfully ground and air-based missile ASATs on their own satellites. 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. Most states have directed energy capabilities able to laser dazzle sensitive optical satellite sensors. Over 30 states have access to high power laser systems that form one key ingredient to blind satellite sensors or even heat to kill a satellite. 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.

TREND 7.3: Proliferation of space-based negation enabling capabilities – Space-based negation efforts require sophisticated capabilities, such as precision in-orbit maneuverability and space tracking. Many space-based negations capabilities have dual-use potential and thus may be developed for other purposes. For example, orbital servicing satellites, but more generally, many existing satellites have precision attitude control and fuel to maintain orbits, some of the key capabilities required for space based negation. The US leads in the development of most of these enabling capabilities, though none appear to be integrated into dedicated space-based negation systems.

2006 Developments

TREND 7.1: Proliferation of capabilities to attack ground stations and communication links

2006: Advances in ionosphere reconfiguration
The US Air Force is funding a project that seeks to use plasma to reconfigure a part of the ionosphere.[1] The modified ionosphere would have different radio frequency properties, selectively blocking out radio transmission in an area while the surrounding areas are unaffected. The Microwave Ionosphere Reconfiguration Ground based Emitter (MIRAGE) project would employ microwave transmitters on the ground and a small rocket to dispense chaff into the air at an altitude of 60-100 km.[2] About one litre of plasma is generated by the microwave-chaff interaction, changing the number of electrons in that portion of the ionosphere. The first phase of Mirage was recently completed by Research Support Instruments[3]. Atmosphere modification may used as a method to conduct ground based negation. As it would not directly interfere with satellite communication, this type of disruption would be difficult to detect by conventional means or to distinguish from a normal atmospheric event.

2006: Israel considers disruption of commercial satellite broadcasts
Israel is believed to be seeking technological solutions to selectively disrupt Al-Manar TV transmissions broadcasting from commercial satellites.[4] During the 2006 Israel-Lebanon war the television station remained on the air despite continued Israeli disruption efforts. Terrestrial transmitters were targeted and the local Al-Manar channels were jammed and replaced with Israeli programming, while satellite TV signals were not disrupted[5].

In the event of future conflicts with the Hezbolla, Israel is seeking the capability to jam-on-demand the Al-Manar satellite transmissions without disrupting services to other legitimate users of the satellite[6]. It is unclear how Israel intends to accomplish this goal. Experts in the country acknowledged that Israel currently has the capability to interfere with satellite broadcasts but not in a selective way.[7] They also acknowledge that causing collateral damage to other legitimate users of the satellite service is against international law and is not in Israel's interest. Currently the Al-Manar satellite channel is transmitted by Arab Satellite

Communications Organization (ARABSAT) of Riyadh, Saudi Arabia, and reaches 200 million viewers through satellite packages[8].

2006: US government commission warns of Chinese cyberwarfare
The US-China Economic and Security Review Commission released a report in November 2006 stating that China is improving its cyberwarfare capabilities[9]. According to the report, China is developing offensive network warfare capabilities, such as disrupting the information flow of an adversary's network and planting computer viruses to damage equipment.[10] Network intrusion is also used as a means of obtaining foreign military and military related technology.[11] As evidenced by the "Titan Rain" incidents in 2003 and the recent network intrusion at the US Commerce Department's Bureau of Industry and Security and NASA, US government and defense contractors are vulnerable to attacks against their networks.[12]

Net Assessment
Ongoing efforts to develop ground-based space negation capabilities could detract from space security by threatening the security of countries' space assets and creating a spiral of negation capabilities. The willingness of some countries to target commercial satellites is a demonstration of the increasingly blurred distinction between legitimate military, commercial and civilian targets, which may threaten the secure and sustainable use of space for all actors. This does not seem to be balanced by an equivalent trend in protection of grounds stations.

TREND 7.2: The US leads in development of space situation awareness capabilities to support space negation

2006: US and Chinese advances in space situational awareness
The US Air Force is planning to upgrade the Air Force Space Surveillance System (Space Fence) at a cost of $275-million over five years.[13] The Space Fence is the radar portion of the US Space Surveillance Network (SSN) which also includes the Ground-Based Electro-Optical Deep Space Surveillance (GEODSS). It is a multistatic radar system operating in Super High Frequency with three transmitters and six receivers located within the continental US.[14] The upgrade will convert the radar systems to S-band, allowing for greater search capability and faster revisits of space objects. The resolution of the radars will also be increased allowing for detection of objects as small as five centimetres in size. The US government plans to move two systems overseas to broaden the detection area of the system and allow a larger section of space to be monitored at the same time.[15] It is not yet decided which countries will receive the two systems. The US Air Force is expected to release a contract notice to perform the upgrades and relocate the transmitters in early 2007, with fielding scheduled to begin in 2008 followed by initial operations in 2013-2014.[16] The upgraded Space Fence will improve the United States' space situational awareness, allowing it to better track and target small spacecraft including microsatellites. In 2005 restrictions on public access to information from the US SSN were put into effect. Other advances in US space situational awareness include the SBIRS missile early warning program and the Space Tracking and Surveillance System (STSS), which allows for tracking and targeting of ballistic missiles (see Space-Based Strike Weapons).

Upgrades in China's space-monitoring network and satellite orbit determination error will provide China with a greater ability to track foreign spacecraft (see Space Systems

Protection). Europe continued work in 2006 to develop independent space surveillance capabilities (see Space Environment).

Net Assessment
Ongoing efforts to develop independent space surveillance systems may have a positive effect on space security by increasing the capability and redundancy of capabilities, but it could also support space systems negation.

TREND 7.3: Ongoing proliferation of ground-based capabilities to attack satellites

2006: Chinese laser illuminates US satellites
China reportedly used a ground based laser to illuminate American spy satellites flying over Chinese territory. The previously unreported incidents were acknowledged by the director of the National Reconnaissance Office, Donald Kerr, in October 2006. Details were not provided regarding which satellites were involved or the number of incidents[17]. Public disclosure of the tests was the subject of much internal debate within the US administration as it involves US foreign policy in the Asia-Pacific regions.[18]

As few details are available about the physical effects of the laser incident, it is difficult to verify the power of the laser used or the intent behind it.[19] Laser illumination at very low powers is used for satellite laser ranging as part of routine space surveillance. However, it may be presumed from the US reaction that the laser was higher in power than this, and that the power that was deemed threatening. Some reports claim that the illumination used a high power laser to test Chinese abilities to blind spacecraft.[20] The incidents were detected after satellite operators noticed occasional and sudden decline in the performance of the satellites as they pass over China.[21] Investigation by the sensors at the Reagan Test Range on the Kwajalein atoll in the South Pacific detected streams of photons projected at the spacecraft. High power lasers could conceivably blind the sensitive optics in imagery satellites such as the US reconnaissance satellites.[22] The top US military officer in charge of space operations, Gen. James Cartwright, denied that there is clear evidence of Chinese intentions to interfere with US space assets.[23] Nonetheless, the ability to illuminate satellites in orbit with a laser beam demonstrates Chinese advances in laser, satellite tracking, and optics technology. A case could be made that the laser system is only intended to protect Chinese assets from being imaged. No official Chinese statements have been released.

2006: North Korea Attempts Ballistic Missile Launch and Nuclear Test
North Korea attempted a test launch of its Taepodong-2 ICBM in July 2006. The missile failed 34 seconds into its flight and crashed into the Sea of Japan.[24] The test was followed by five short-range missile tests, and one medium-range one.[25] The Taepodong-2 missile is thought to be able to reach the continental United States with a small payload. In October 2006 North Korea attempted to detonate a plutonium implosion nuclear device.[26] The test appears to have failed, with the yield estimated to be less than one kiloton.[27] Air sample testing confirmed the explosion to be nuclear and not simulated with conventional explosives as some initially believed.[28] While both the missile and the nuclear test were failures, North Korea is steadily developing all prerequisite capabilities for a HAND capability.

2006: Progress continues in the US on laser application and mirror relays

Hardware and software development of the Air-Borne Laser (ABL) system continued in 2006 in preparation for a live test against a ballistic missile in 2008.[29] The ABL aircraft is a modified Boeing 747-400F designed to shoot down short range ballistic missiles in the boost phase using a megawatt-class laser. In addition to the Chemical Oxygen Iodine Laser (COIL) main laser, the ABL aircraft also has two kilowatt-class solid state illuminator lasers used by the beam control/fire control system for target tracking and atmosphere measurement. The COIL laser and two solid state lasers underwent successful ground testing in late 2005 and early 2006 and the two illuminator lasers were integrated into the ABL aircraft.[30] In-flight firing of the illuminator lasers is planned for 2007. The entire program has cost $3.5 billion to date.[31] While the intended purpose of the ABL is ballistic missile defense, the components of the program have the potential for ASAT applications. If the laser were directed into space, the thinning atmosphere would simplify beam control problem and the lasers would be able to deliver more energy at greater ranges. It would be a potent ASAT since it can move to the region of a satellite overpass whereas a ground based equivalent has to wait for an overpass of the site. It is unknown at the moment whether the lasers aboard the ABL are able to track a satellite in orbit.

In 2006 Boeing completed a $20-million contract with the US Air Force to develop the Aerospace Relay Mirror System (ARMS) –suitable for air, sea or land basing, which is a half scale prototype of a strategic mirror relay system.[32] Mirror relays can extend the range of lasers beyond line-of-sight. In the summer of 2006 a crane mounted ARMS successfully relayed a sub-kilowatt beam from a ground laser to a target located two miles away.[33] The Air Force plans to use the hardware as a permanent test bed for laser relay technology development.

The US Air Force is seeking $5.7 million US in FY 2007 to test fire a laser from the StarFire Optical Range against a satellite in low earth orbit.[34] The funding is requested under a weapons technology development heading.[35] The stated goal of the test is to perform atmospheric compensation and beam control experiments for applications including ASAT, relay mirror systems, satellite tests and diagnostics, and high resolution satellite imaging. Air Force officials denied plans to develop ground based laser ASAT systems, stating that the focus of the laser test is on imaging, despite including ASAT as a potential application in the budget request. Laser tests are controversial: in April 2006 a Congressional subcommittee voted not to fund any development of laser space technologies with ASAT purposes[36].

2006: Progress on High Energy Lasers in the US and basic research in China

Northrop Grumman and Textron System were chosen by the US Army Space and Missile Defense Command to develop high powered solid state laser system under the Joint High Power Solid State Laser (JHPSSL) program.[37] The contract calls for the development and lab demonstration of a 100 kilowatt laser by 2009. The Northrop Grumman contract is worth $56.68-million and the Textron Systems contract is valued at $30-million.

Northrop Grumman also successfully demonstrated the Strategic Illuminator in 2006.[38] The continuously pulsed solid state laser achieved multi-kilowatt class performance with good beam quality for five minutes during tests. Northrop Grumman is also working on a brassboard version of the laser, designed to withstand temperature ranging from -50 degrees Celsius to +50 Celsius.[39] The Missile Defense Agency is funding the project.

Research in China continued in 2006 on atmospheric effects on laser propagation and laser Doppler radar for detecting space targets.[40] Laser communication in space and the damage effects of high energy laser weapon on ballistic missiles were also studied.[41]

Net Assessment
The ongoing progress in the development of ground-based space negation technologies, particularly the more advanced laser ASAT capabilities being developed and potentially tested in the US, and Chinese laser research and demonstrations, have a negative impact on space security. Although intentions behind the Chinese laser illumination incident are not clear, it could be indicative of competition with US laser programs in an attempt to develop countermeasures. The advancement of capabilities for a HAND by North Korea is also threatening. On the other hand, it must be noted that none of these ASAT capabilities were used in 2006 to permanently damage other states' space assets. Moreover, the reluctance of US legislators to approve funding for laser ASAT tests is a positive development.

TREND 7.4: Increasing access to space-based negation enabling capabilities

2006: MiTEx satellites launched into GEO orbit
On 21 June 2006, a Delta II rocket launched a pair of Microsatellite Technology Experiments (MiTEx) satellites with an attached NRL upper stage transfer motor into a geostationary transfer orbit.[42] The MiTEx satellites are technology demonstrators for the Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) sponsored by DARPA, the US Air Force and the US Navy.[43] A major goal of the MiTEx demonstrations includes assessing the potential of small satellites in GEO for defense applications.[44]

The MiDSTEP program, as described in the DARPA FY 2007 budget estimate integrates a variety of advanced technologies into microsatellites that can operate as high as geostationary orbits. These technologies include lightweight optical space situation awareness sensors, lightweight power, chemical and electrical propulsion systems, and active radio frequency sensor technologies. The budget for MiSTEP is modest at $7-million dollars in FY 2006 and a request for $8-million in FY 2007.[45]

The technologies being developed by the MiDSTEP program have potential ASAT applications.[46] The small size of the MiTEx satellites makes them advantageous for space-based ASAT purposes because they are difficult to track in GEO; only the US Space Surveillance Network can reliably detect the satellites at the present time. Moreover, the NRL upper stage motor is thought to process greater capability and to have a longer lifespan than is required to transfer microsatellites to GEO.[47] The experimental upper stage has solar panels, high performance delta-V motors, long lifetime attitude control thrusters, high performance star tracker, and large capacity fuel tanks.[48] The purpose of the upper stage is to provide enhanced maneuverability to the MiTEx satellites and enables them to perform proximity operations around other GEO satellites[49].

2006: US Funding requests for potential space-based negation capabilities
The US Missile Defense Agency and US Air Force plan to pursue several programs that could potentially yield space-based ASAT capabilities.[50] MDA requested funding in the FY

2007 budget for space programs that include the Space Based Interceptor Test Bed, the Near Field Infrared Experiment (NFIRE), and several MDA small satellite programs developing distributed sensing, propulsion, and using microsatellites as practice targets for ballistic missile interceptors.. These are all focussed on missile defense, but have ASAT potential. MDA also announced a 2007 test its Multiple Kill Vehicle. The US Air Force has requested funding for a further Experimental Small Satellite (XSS) mission.

Space Based Ballistic Missile Interceptor

The Missile Defense Agency has requested $45 million for FY 2008 to explore space based interceptors to attack ballistic missiles in the boost phase (see Space-Based Strike Weapons).

NFIRE

The FY 2007 budget request included $10.8-million for NFIRE, which includes a follow-on mission that would reinstate the originally planned 'kill vehicle' (see Space-Based Strike Weapons).

MDA Microsatellite Programs

The US Missile Defense Agency is working on several maneuverable microsatellite programs.[51] The MDA FY 2007 budget request included descriptions of a distributed sensing experiment, a propulsion experiment, and the Target Risk Reduction Experiment.[52] The propulsion experiment will test the ability of the axial and divert propulsion system to maneuver a microsatellite to a specific point in space. Two microsatellite would be launched in the experiment, with the first satellite tested after 30 days and the second after a year in orbit to determine the survivability of the propulsion system after a dormant period. The Target Risk Reduction Experiment would use a microsatellite as a cooperative target to demonstrate the ability of an interceptor to track it. The distributed sensing experiment with three microsatellites is scheduled to be placed in orbit in early 2007.[53] Funding for the microsatellite programs is under the Ballistic Missile Defense Technology, Sensing Systems heading, which includes several other research programs for a total request of $207-million.[54]

Successful thruster test for the Multiple Kill Vehicle

In July 2006 the industrial team working on the MDA Multiple Kill Vehicle Payload system demonstrated a prototype monopropellant thrusters and attitude control thrusters for small kill vehicles (see Space-Based Strike Weapons).

XSS Follow on missions

The US Air Force is funding follow-on missions for the Experimental Satellites Series.[55] The Air Force FY 2007 budget requests $26.6-million to complete the bus and payload for the next XSS satellite, to perform environmental testing, and to begin integration with the launch vehicle.[56] The XSS-11 spacecraft demonstrated proximity operations and autonomous rendezvous technology in low earth orbit in 2006.[57] Such technology could be applied to a space interceptor. It is scheduled for de-orbit after depleting its fuel supply.

ANGELS

The US Air Force Research Laboratory ANGELS (Autonomous NanoSatellite Guardian for Evaluating Local Space) nanosatellite has ASAT potential, although it more likely to be a DSAT (see Space Systems Protection).

Net Assessment

Developments in 2006 suggest that there is considerable development and testing of technologies that could be used for a space based negation system. Some space security experts fear that these programs would create space negation 'facts in orbit.' A space negation system would detract from space security by enabling an actor to restrict the secure access to and use of space by others. Moreover, space-based technologies that use kinetic energy interceptors pose a space debris hazard that endangers space security. To date, however, the capabilities being tested are *latent* in so far as they have not been used for space negation purposes.

ENDNOTES

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