

CHAPTER 2

THREATS TO THE SECURITY OF OUTER SPACE: EMERGING TECHNOLOGIES

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INTRODUCTORY REMARKS

The most advanced space weapon systems are technically very difficult to develop. Some technologies have, indeed, been trying to “emerge” for the past 40 years and are still not operational today. Only the most conventional ground-to-ground anti-satellite weapon (ASAT) systems are operational at this point. So, by “emerging technologies” we really mean the technologies that are the most likely to emerge, that is, those that receive distinct attention from defence planners and get the most research and development efforts in 2006–2007.

This presentation is of the descriptive kind and focuses mostly on US systems. With a requested military space budget of US\$ 22.5 billion in 2006, the United States is where the bulk of the military space research is being done currently. Although a large part of US military space programmes remains classified, the United States is also where the open press has the most access to information.¹

The definition of space weaponry is a difficult issue that the conference participants had to tackle. In this presentation, we chose to define as “threats to the security of outer space” all ASAT weapons, including systems meant for missile defence when they can have a secondary use as an ASAT.² This is a broad definition. A more limited one may prove politically more adequate when it comes to writing an arms control proposal.

A definition of ASATs is based on three sets of parameters:

1. The target of the ASAT can be the satellite itself, but also the control station on the ground or even the electronic communication link

between the ground station and the satellite. If the satellite is the element being targeted, a technically important distinction appears between target satellites in low-Earth orbit (LEO), which is relatively easy to reach, and target satellites in geosynchronous orbit (GEO). Orbiting 36,000km from the Earth, the latter are much harder to get to.

2. The ASAT weapon itself can be launched from the ground or from a plane to either of these targets. It can also be stationed in space, waiting to attack elements of a satellite system in space or elsewhere.³
3. The issue of what type of damage one aims to produce, which is more of a policy decision than a technical one. In 2002, the US Joint Space Command came up with a list of possible tactical actions.⁴ Although not offering very clear definitions, it distinguishes between different degrees of damage:
 - Disruption: a temporary impairment of the satellite system, for example, delaying transmission of data by jamming a telecommunication satellite or dazzling an observation satellite;
 - Denial: a temporary elimination of the satellite system, for example, the interruption of electrical power to the ground station so it cannot process the data it receives;
 - Degradation: a permanent partial or total impairment of utility, for example, an attack on the ground segment, or the blinding of an observation satellite; and
 - Destruction: a permanent elimination of the utility of the space system.

These three sets of possibilities combine to make many types of weapon systems possible.

EXISTING TECHNOLOGIES

The easiest and most inexpensive ASATs to deploy at the time of writing are the following:

- Electronic warfare such as jamming or spoofing telecommunication systems. One of the rare ASATs currently

deployed, the Counter Communication System, is an electronic warfare device that was deployed in 2004 in the US 76th Space Control Squadron. It consists of three ground-based portable jamming packages, bought off-the-shelf from commercial companies, and produces reversible damage to the communication links of satellites, even in GEO if they are unprotected types such as commercial satellites;

- Cyberwarfare, which means hacking the space system's computer system; and
- Conventional attacks on ground stations are another easy military action. It would be surprising not to find a target list of foreign countries' satellite control facilities ready in many countries' military command, but attacks on a ground station are not always an efficient option since satellites operate in a network so that they can relay data to other ground stations.

EMERGING TECHNOLOGIES?

Weapon projects that target the satellites themselves are those that render technological innovation necessary. The development of these technologies encounters many technical difficulties. Indeed, the first systems developed to reach and harm satellites did not give satisfactory results at all.

NUCLEAR DIRECT-ASCENT WEAPONS

The US military services launched no less than four different nuclear ASAT programmes in the early 1960s. The US Air Force launched the "Bold Orion" air-launched missile programme in 1959 as well as another project based on the Thor rocket. The Navy had its own air-launched programme called Hi-Ho. The US Army developed Project Mudflap, which was responsible for the first successful satellite intercept test in May 1963 and based on the Nike and Zeus rockets.

But different problems made these systems unsustainable. In the early 1960s, the guidance systems remained too poor (probably in the order of a few miles) to allow conventional warheads to be considered for an efficient ASAT: only a nuclear warhead could destroy the target satellite. But the explosion of a nuclear device in LEO generates electrons that get trapped in

the Earth's magnetic field and destroy all non-hardened satellites. After a test in 1962, seven US satellites were impaired during the following months.

It also became more difficult to conduct such tests after the Partial Test-Ban Treaty was signed in 1963. Work on nuclear ASAT systems was, therefore, eventually stopped and all US programmes were dismantled.

In the former Soviet Union, work focused on improving guidance systems so that an ASAT that would detonate a conventional bomb close to the targeted satellite became feasible. The "co-orbital ASAT" system was developed and tested between the 1960s and the 1980s.

KINETIC ENERGY ASATs (KEASATs)

After the nuclear ASATs disappointment, the attention in the United States turned to kinetic energy ASATs. Kinetic weapons rely on their speed to smash into and destroy the target. They are often also called "hit-to-kill" programmes.

Again, there have been numerous attempts at developing a successful programme. Among many projects, two have received particular attention in the past. The Air Launched Miniature Vehicle was a US Air Force project consisting of a rocket launched from an F-15 plane and equipped with a heat-seeking "Miniature Homing Vehicle". It was cancelled in 1988. The KEASAT programme was an Army-operated ground-based system targeting LEO satellites. It was apparently cancelled by the Clinton Administration in 1997. For a few years, Congress reinstated the budget line for KEASAT in spite of the Pentagon's disinterest.

The problem with kinetic energy weapons, apart from their questionable feasibility (and particularly the infrared homing technology), is the creation of debris that, just like nuclear weapons, can harm friendly satellites as well as the intended target. Indeed, the KEASAT project included the development of a sheet of Mylar plastic to hinder the scattering of the debris. This apparently proved too difficult to make.

For these reasons, the hit-to-kill method has now lost favour. A new solution appears to be the ejection of the target satellite out of orbit by a micro- or nano-satellite,⁵ rather than smashing it. Kinetic ASAT programmes are, therefore, looking into "ejection" or "de-orbiting" capacities. Several

such systems are currently researched, as shown by the US military budget request for 2007:

- The Space-Based Interceptor Test Bed is a Missile Defense Agency (MDA) programme, which aims to build and test a satellite that could manoeuvre in orbit and intercept a target. The programme probably has links to the MDA Micro-sats programme and it may really be a continuation of the old KEASAT programme under a new name and new management;
- The Near Field Infrared Experiment (NFIRE) is an MDA programme for a manoeuvring satellite. It was intended to have a kill-vehicle on-board, but it was cancelled;
- The XSS is an Air Force micro-satellite programme that does proximity operations in LEO and takes pictures. The XSS-11 is currently deployed as a test; and
- Angels is an Air Force defensive nano-sat programme.

The Spacecraft for the Unmanned Modification of Orbits (SUMO) was a Defense Advanced Research Projects Agency (DARPA) programme that attempted to build satellites that would approach, seize and push satellites away from their orbit. SUMO was mentioned in the press in 2004 and 2005. There is no trace of a budget request for SUMO in 2007.

Kinetic or “de-orbiting” ASAT technologies that are being actively researched include:

- Developing nano-sat and micro-sat buses, which may also offer applications in the field of space mines;
- Acquiring precise LEO and GEO manoeuvring capacities, including research and development on propulsion and power issues; and
- Improving high-resolution hardware and lightweight optics to equip these satellites.

DIRECTED ENERGY WEAPONS

Directed energy weapons are based on the use of laser or microwave beams. Laser ASATs can temporarily or permanently affect the sensors of an observation satellite (respectively dazzling or blinding them); microwave ASATs can jam a telecommunication satellite. If using high levels of energy,

both types of ASATs can permanently destroy most satellites electronic systems.

There is evidence of Soviet research on chemical source laser and other types of directed energy weapons in the 1970s: research facilities were located in Dushanbe (Tajikistan) and Sary Shagan (Kazakhstan). Both territories are now outside Russian control and it is likely that all laser-related work has been stopped. On the other hand, a US Department of Defense report of July 2005 claims that China is conducting research to develop a ground-based laser ASAT weapon.⁶

Although the technology meets many challenges, continuing research seems to indicate that the Pentagon thinks such ASATs remain a credible option today. The budget request for 2007 shows that a number of research programmes on laser (including the excimer and free-electron types) and microwave weapons is under way in the United States.

The Mid-Infrared Advanced Chemical Laser (MIRACL) programme has been mentioned since the 1980s. It is a ground-based laser system fuelled by a chemical reaction and is managed by the US Army. The 2007 budget request for the Army shows US\$ 16.6 million for the laser programme that includes MIRACL. The US Air Force has a global request of US\$ 162.3 million for programmes related to high energy and directed energy.

A space-based laser programme that was launched by the MDA seems to have disappeared from the 2007 budget request. Here too, technical difficulties are present. In the case of a ground-based laser, the beam has to be very powerful and focused to get through the atmosphere. If the laser system is airborne, the issue becomes the size and weight of the instruments. Positioning a space-based laser in orbit so that it can harm its target is equally very challenging.

Another issue is the type and level of damage that such weapons could cause to their target. The "defensive" MIRACL test of October 1997 produced initial information on laser damages to satellites, but further tests are deemed necessary.

Currently researched technologies include:

- More powerful and better focused laser beam technologies to go through the atmosphere and on to LEO, where most observation satellites are deployed;
- Miniaturization and lightening of the instruments;
- Assessment and analysis of damages made to the target, which makes the conduct of tests necessary; dazzling and blinding tests could be commissioned by the US Air Force in 2006 or 2007; and
- Microwave technology is less mature than laser technology, and microwave-related programmes deal more with basic or advanced research than with weapon systems development per se.

ASAT technology developments are meeting technical challenges every day, so “emerging” should be understood as a process, not a result. Also, given that half the US military space budget is classified, we must admit that there may be some technological developments that we do not know about.

Notes

- ¹ Most of the sources used for this paper come from Laura Grego, Union of Concerned Scientists; Jeffrey Lewis at <armscontrolwonk.com>; and a recent paper by Michael Katz-Hyman, Henry L. Stimson Center, and Theresa Hitchens, Center for Defense Information.
- ² However, arms control debates on missile defence per se such as the debate held at the beginning of the 1980s in relation with the Reagan Administration “star wars” programme is a controversy steeped in the nuclear mindset of the Cold War and is irrelevant to today’s ASAT issue.
- ³ According to this definition, a weapon deployed in space and targeted at ground targets that are part of the satellite architecture such as a control station, would be an ASAT. On the other hand, a system such as the very exotic “Rods from the Gods” project, where tungsten rods would be deployed in LEO to strike deep-buried ground targets, would certainly be a space weapon but not an ASAT, because the target would not be part of a space system. Mentioned in 2005, “Rods from the Gods” does not seem to be researched anymore.

- ⁴ United States Joint Space Command, 2002, *JSCUS DoD Joint Doctrine for Space Operations*, 9 August, Washington, DC, pp. IV-7–IV-8.
- ⁵ Micro-sats weigh between 10kg and 100kg, nano-sats weigh between 1kg and 10kg.
- ⁶ United States Office of the Secretary of Defense, 2005, *The Military Power of the People's Republic of China*, Annual Report to Congress, July, Washington, DC.