Assessing China's ASAT program

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Contents

Introduction

Desmond Ball of the Australian National University discusses China's anti-satellite (ASAT) test of 11 January this year, and outlines the history of US and Russian anti-satellite testing. Ball provides detailed account of the current Chinese programme, and the vulnerabilities of different satellite constellations to kinetic energy, laser, and radio frequency weapons. The Chinese test, writes Ball,

> "involved a fairly primitive system. It is the sort of capability available to any country with a store of MRBMs/IRBMs (medium range/inter-continental ballistic missiles) or satellite launch vehicles, and a long-range radar system, such as Japan, India, Pakistan, Iran and even North Korea. American satellites are lucrative targets in the Chinese strategy of asymmetric warfare."

Ball concludes by noting that

> "China has been a prominent advocate of the 'prevention of an arms race in outer space' (PAROS). In one move, albeit fairly primitive, it has provided a major stimulus to such a race."

Essay - Assessing China's ASAT program

On 11 January 2007, the PRC successfully tested a direct-ascent, kinetic-kill anti-satellite (ASAT) vehicle, destroying an inactive Chinese *Feng Yun 1C (FY-1C) weather satellite (launched in 1999). The satellite was in a polar orbit, at an altitude of 865 km (537 miles), and was attacked when it passed over the Xichang Space Centre in Sichuan province. The satellite broke into more than 900 pieces, generating more debris than any previous space event and threatening many operational spacecraft. [1]*

The launch vehicle was probably a mobile, solid-fuel KT-1 missile, a version of the DF-21 MRBM, with a range of 1,700 km to 2,500 km, although according to some accounts it was a KT-2, also mobile and solid-fuel, based on DF-31 IRBM/ICBM technology, with a range of more than 6,000 km. The launch vehicle and warhead were guided to the target by ground-based radars. [2]

This was the fourth test, the previous three being failures. [3] Neither the DF-21 nor the DF-31 technology has proven very reliable. It would require a stockpile of at least 20 of these launch vehicles to guarantee the destruction of 6-7 satellites.

Satellite systems and vulnerabilities

Direct-ascent weapons only threaten satellites in low earth orbit (LEO) that come within their range and the range of their associated ground-based radar tracking stations. Weapons launched from China are also restricted to high-inclination polar-orbiting satellites, being unable to reach those in low-inclination equatorial orbits. The most important polar-orbiting LEO satellites are photographic intelligence (PHOTINT) or imaging satellites (such as the US KH-11s) and electronic intelligence (ELINT) satellites (such as the US Navy's White Cloud system).

Geostationary satellites, stationed at 36,000 km above the earth, include most communications satellites, missile launch detection and early warning satellites (DSP and SBIRS), large SIGINT satellites (calledMentor, Magnum and Orion), and some navigation satellites. These satellites are most vulnerable to radio frequency (RF) and laser weapons systems.

Highly elliptical satellites, with perigees of a few hundred kilometers and apogees of as high as 40,000 km (such as Soviet/Russian Molniya communications satellites and US Jumpseat/Trumpet SIGINT satellites), are only vulnerable to direct-ascent weapons launched from China if their perigees are over northeast Asia, where they mostly have their apogees, and even then their relatively high speed at perigee would defy interception by either direct-ascent or co-orbital weapons.

The systems most vulnerable to RF weapons are UHF communications satellites (in geostationary orbits), used by the US Navy and Allied navies, and GPS navigation and positioning satellites (which orbit at 19,300 km). Iraq purchased at least six high-powered GPS jammers from a Russian company; they were all quickly destroyed by US forces through the first two nights of Operation Iraqi Freedom in March 2003. [4]

High-power lasers can be used for both destruction of unprotected satellites, or of their softer elements (such as their solar panels), and 'dazzling' or 'blinding' satellites equipped with optical sensors. The satellites most vulnerable to 'dazzling' or 'blinding' include imaging reconnaissance satellites and infra-red DSP/SBIRS spacecraft.

Kinetic-energy weapons, such as direct-ascent and co-orbital systems, can only be used once, with kill probabilities of less than 100 percent. Lasers and RF weapons can be continuously applied *against a target satellite until it is destroyed or effectively disabled, and then be directed against a procession of subsequent satellites.*

Other PRC ASAT programs

The PRC is the third largest user of space for military purposes, though it is often difficult to distinguish its military from its civilian/scientific space programs. It has developed several sorts of PHOTINT/imagery satellites, including a high-resolution electro-optical imaging system first launched in 2000, a robust ELINT satellite program, and communications and navigation satellites primarily for military purposes. It has a world-wide network of ground stations for tracking and monitoring satellites, with eight domestic stations and one in Namibia, and four Yuan Wang tracking ships.

The PRC has a broad ASAT research and development program, investigating a variety of ASAT techniques. These include the development of radio frequency (RF) weapons for jamming satellite signals, ground-based lasers for effectively blinding satellite sensors, and, perhaps, a 'parasitic micro-satellite' or 'piggy-back' satellite program.

With respect to lasers, the Pentagon reported to Congress in 1998 that 'China already may possess the capability to damage, under specific conditions, optical sensors on satellites that are very vulnerable to damage by lasers', and that 'given China's current interest in laser technology, it is reasonable to assume that Beijing would develop a weapon that could destroy satellites in the future'. [5]

In August-September 2006, US reconnaissance satellites were 'painted' or 'illuminated' by 'high-power' ground-based lasers on several occasions as they passed over China. Several reports stated that these were ASAT tests, although some analyses suggest that they may have been 'low-power' illuminations from Chinese satellite laser ranging (SLR) stations intended to precisely determine satellite orbits. [6]

In its annual reports to Congress in 2003 and 2004, the Pentagon asserted that China has 'developed and tested an ASAT system described [in a Hong Kong newspaper article in January 2001] as a parasitic micro-satellite', i.e., a small satellite that attaches itself to a target satellite to disrupt or destroy that satellite on command. However, strong doubts have been cast on the credibility of this claim. [7]

US and Soviet/Russian ASAT programs

The Soviet Union developed a wide range of ASAT capabilities, including direct-ascent launchers armed with both nuclear and conventional warheads, co-orbital anti-satellite systems, and laser and RF systems. The current status of these systems is uncertain. Many of them involved facilities in the Central Asian States (especially Kazakhstan and Tajikistan). Some of them have definitely not been properly maintained for many years.

The crudest system involved the long-range Galosh anti-missile missile, first deployed around Moscow in the late 1960s and up-graded through the 1970s and 1980s as the exo-atmospheric intercept component of the anti-ballistic missile (ABM) system built to protect the national command authority. It carried a 3.5 megaton nuclear warhead, which would have indiscriminately destroyed all LEO satellites passing over the Moscow region.

The deployment of Gorgon (SH-11 or ABM-4) exo-atmospheric missiles began in 1983-84 to replace theGalosh system. Thirty-six of them remain operational around Moscow, carrying 1 Mt warheads.

With a range of 350 km, they are capable of intercepting very low altitude satellites passing over the Moscow region. Other Gorgon interceptor missiles may be operational at the Sary Shagan ABM test range in Kazakhstan. [8]

The first operational non-nuclear ASAT system was developed in the late 1960s and early 1970s. It involved a co-orbital ASAT system, using an SL-11 launch vehicle carrying a radar sensor and a pellet-type warhead; the missile was launched when the target satellite passed over the launch site and within one or two orbits (90-200 minutes) was manoeuvred to within a kilometer of the target satellite and the warhead detonated. It was able to reach satellites at altitudes between about 230 km to 1,000 km. It was tested about 20 times from 1963 to 1972, including seven interceptions with target satellites and five detonations. [9]

Testing of a new co-orbital system began in 1976. It used optical and infrared sensor systems instead of an on-board radar, and had a target envelope extended to 160 km to 1,600 km, enabling the interceptor to usually manoeuvre to its target in a single orbit. It was tested about once a year from 1978 to 1982. [10]

The system was declared operational in 1979. The launch site was at the Tyuratam (Baikonur) space complex in Kazakhstan, which had two launch pads and storage space for many interceptors; several interceptors could have been launched each day from each of the pads. The system was reportedly modernised in 1991, but there have been no flight tests since 1982, and the system is probably no longer functional.

High-power laser systems became operational at Sary Shagan, near Lake Balkhash, in the mid-1970s. On five occasions in October-November 1975, a DSP-East missile launch detection/early warning satellite (controlled from Nurrungar in South Australia) was blinded by intense illumination from within the Soviet Union, though this could have been caused by fires in natural gas pipelines rather than a laser beam. [11]The DSP-E satellites were 'painted' again on several occasions in 1983-84, probably deliberately. [12] In 1976, a new KH-11 imaging satellite was 'painted' and 'permanently damaged' by a Soviet laser. [13] The Sary Shagan facility illuminated the Challenger Shuttle on 10 October 1984, causing malfunction of on-board equipment and discomfort and temporary blindness of the crew. [14] Two high-power lasers systems (using a ruby laser and a pulsed carbon-dioxide laser) were operational at Sary Shagan in 1987. By the time the Soviet Union collapsed, eight laser facilities had been constructed or were under construction for ASAT purposes, including a free-electron laser (FEL) prototype ASAT facility at Storozhevaya in the North Caucasus and the Sary Shagan complex. Three of them were situated in Tajikistan - at Nurek, Dushanbe and an unidentified site between these two places. [15]

The Soviet Union also experimented with a space-based laser for ASAT use. In 1987, it launched a Skif-DM satellite 'intended for perfecting the design and on-board systems of a future military space complex with laser weaponing', but the satellite failed to reach orbit, and no further launches were attempted. [16]

In the case of the United States, the first operational anti-satellite system also involved a direct-ascent vehicle with a nuclear warhead. It consisted of a single Nike Zeus ABM missile, with a 400 kiloton warhead, code-named Mudflap, based on Kwajalein Atoll in the western Pacific, which was operational from 1962 to 1966. It was replaced by a small number of Thor missiles based on Johnston Island, two of which were maintained on 24-hour alert, from 1966 to 1972. [17]

In July 1982, President Ronald Reagan announced a 'National Space Policy', a 'key element' of which was to develop 'an anti-satellite (ASAT) capability, with operational deployment as soon as possible'. [18] The lead program involved the ASM-135 ASAT missile, a 3-stage Air-Launched

Miniature Vehicle (ALMV). It was successfully tested on 13 September 1985 against an old US scientific satellite (P78-1 SolWind), using a modified F-15 Eagle as the launch platform. In December 1985, however, Congress imposed a ban on further testing of the ALMV in space. [19]

During the Reagan Administration, the US also used lasers based in Maui and Oahu in Hawaii and San Juan Capistrano in California to blind Soviet reconnaissance satellites orbiting over US ABM test facilities. The facility in California, later moved to Cloud Croft in New Mexico, reportedly 'possessed a full anti-satellite capability'. [20]

The US Army's megawatt-class MIRACL (Mid-Infrared Advanced Chemical Laser) facility at the White Sands Missile range in New Mexico was tested in an ASAT capacity in October 1997. The laser was directed at a satellite orbiting 420 km above the Earth, and although only low power (30 watts) was used, the satellite was temporarily blinded. [21]

During the 1990s the US Army also developed a ground-based kinetic-energy kill vehicle. Three vehicles were produced, and officials said in December 2002 that, with two test flights, the system could be deployed operationally within three years. However, no tests were funded, and two of the three kill vehicles that had been built have been dismantled for use in other projects. [22]

The US has begun working on several programs which could be 'foundational' for a space-based ASAT system, including the Experimental Spacecraft System (XSS-11), the Near-Field Infrared Experiment (NFIRE), and the Space-based Interceptor (SBI) programs. President Bush's budget request for FY 2008 includes $10 million for initial studies of the SBI. [23]

The militarisation of space

China's ASAT test of 11 January involved a fairly primitive system, limited to high-inclination LEO satellites. It is the sort of capability available to any country with a store of MRBMs/IRBMs or satellite launch vehicles, and a long-range radar system, such as Japan, India, Pakistan, Iran and even North Korea. However, its LEO coverage does include some extremely valuable satellites, including imaging and ELINT satellites, and the test is likely to generate reactions in several countries.

Many countries now use space satellites for military and intelligence purposes. In addition to the US and Russia, for example, several European countries, Israel, India and Japan also maintain reconnaissance satellites in LEOs vulnerable to China's KT-1 and KT-2 direct-ascent ASAT missiles.

China's ASAT test has been widely viewed as a direct challenge to US space superiority. The US maintains by far the largest fleet of military and intelligence satellite systems in the world, and the mission of the US Space Command is to maintain control of space. The transformation of the US military for Network-centric Warfare and Information Operations is increasing its reliance on space-based assets. American satellites are lucrative targets in the Chinese strategy of asymmetric warfare. As one Chinese defence analyst has noted: 'For countries that can never win a war with the United States by using the method of tanks and planes, attacking the US space system may be an irresistible and most tempting choice'. [24] Even a limited ASAT capability would be extremely useful to the PLA in contingencies involving the Taiwan Strait. China's test will strengthen the arguments in the US for an enlivened ASAT program, as well as prompt the further development of counter-measures.

China's ASAT test is also likely to prompt India to develop ASAT capabilities. Both the Defence Research and Development Organisation (DRDO) and the Indian Air Force have proposed various ASAT systems, but these have so far been resisted by the Indian government. Israel has also raised concerns about transfers of ASAT technology from China to countries in the Middle East, and especially Iran.

China has been a prominent advocate of the 'prevention of an arms race in outer space' (PAROS). In one move, albeit fairly primitive, it has provided a major stimulus to such a race. The PLA can only have calculated that the inevitable reactions were worth risking for a demonstrable capability to threaten a relatively few valuable LEO imaging and ELINT satellites in some critical contingency.

Figure 1: Schematic of China's ASAT test, 11 January 2007

Source: Post by pacman on Chinese Military Forum, 2007-04-22

Figure 2: KT-1 launch vehicle

Source: 'KT-1' at Encyclopedia Astronautica, © Mark Wade, 1997 - 2007

Figure 3: Feng Yun 1C debris 5 minutes after impact

Source: Detail from 'Chinese ASAT Test', T. S. Kelso, 10 February 2007

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Also by Desmond Ball: Whither the Japan-Australia security relationship? Desmond Ball, Austral Policy Forum 06-32A, 21 September 2006.

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