APPENDIX F

CAPABILITIES OF POTENTIAL ADVERSARIES

1. China's ASAT capabilities
As a potential response to US missile defense and "space control" plans

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China is concerned about U.S. missile defense and "space control" plans, which would lead to weaponization of outer space and stimulate a costly and destabilizing arms race. China is further concerned that the US missile defense program, as currently advertised, would neutralize China's strategic nuclear deterrent.

Many Chinese firmly believe that China should take every possible means to maintain the effectiveness of its nuclear deterrence to negate the threats from missile defense and space weaponization plans. Many Chinese officials have made it clear that they would respond to space weaponization by building up its nuclear arsenals and reconsidering its participation in multilateral nuclear arms control agreements.

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In this paper, I will explore the possibility that China could take ASAT measures to counter a space-based U.S. missile defense system. I will examine Chinese technology and military capabilities that could be used as ASAT weapons. However, it should be clear that this is a discussion of potential capabilities, not that China has already developed or deployed these weapons.

These platforms of space weapons and sensor satellites would themselves become prime high value targets and the most vulnerable elements for defense suppression attacks.[3] Thus, for those missile defense systems relying on weapons or crucial sensors based in space, as Prof. Ashton Carter (of Harvard University) stated "ASAT attack on these components is probably the cheapest and most effective offensive countermeasure." In practice, destroying a satellite is far simpler than destroying a warhead carried on a reentry vehicle for several reasons, as Prof. Dick Garwin explained. "The satellite is far more fragile than is a nuclear warhead equipped with reentry vehicle; the satellite follows a highly predictable trajectory; the satellite is considerably larger than a warhead; the intercept time can be chosen, for the most part, at the convenience of the attacker, and the attack can take place within a short range of ground-based radars or laser systems to aid the attack."[5]

CHINA COULD DEVELOP ASAT WEAPONS AS AN ASYMMETRIC METHOD TO COUNTER AGAINST US SPACE WEAPON SYSTEMS

It is believed that an effective ballistic missile defense (BMD) system must start intercepting ICBM as early as the boost phase, for which space weapons could be used, such as the Space Based Laser (SBL) and Brilliant Pebbles (BP) missile defense concepts. A layered missile defense system would include space based sensors, such as early warning satellites (DSP/SBIRS-high) and a space-based missile tracking system (SBIRS-low). The SBIRS-high as planned would consist of 5 or 6 new early warning satellites located in high orbit and designed to detect the hot plume of the missile during its boost phase using infrared sensors. The SBIRS-low system would have approximately 24 satellites located in low Earth orbit. These satellites would be equipped with both wide field-of-view infrared sensors designed to detect targets during boost phase and narrow field-of-view infrared and visible light sensors designed to track targets during midcourse. SBIRS-low is designed to help with target discrimination by adding different types of sensors to the National Missile Defense system.

Therefore, it is reasonable to believe that China could resort to asymmetric methods to counter these critical and vulnerable space-based components in low earth orbit such as the space-based tracking satellites (e.g., SBIR-low) and the weapon carrier vehicle satellites. The asymmetric approach "countering an adversary's strengths by focusing on its weaknesses," could be a feasible military strategy in a conflict with the United States in the future. In fact, since the Gulf War, some military experts in China have written articles to advocate that China should respond "asymmetrically" to American superiority by damaging U.S. satellites in a future war, given the huge advantage U.S. enjoys in conventional and nuclear weapons, and its reliance on satellites for military operations and pursuit of space dominance.[6] Recently, some Americans have claimed that

China is developing or deploying ASATs that would threaten U.S. space assets. However, Chinese officials explain that these Chinese publications do not indicate that the government is pursuing ASATs. Some analysts argue that China's pursuit of ASAT would politically damage its position on a ban of ASATs. Indeed, China has been advocating a ban on space weaponization since 1980s when SDI developed.[7] From the Chinese perspective, any anti-ballistic missile (ABM) weapons are also ASAT weapons, thus China hopes a ban on space weaponization (including ASATs) would ban any ABM weapons and halt the U.S. missile defense program. If the United States deploys a multi-layer missile defense system with a space weapons component, it is believed that it would be politically acceptable for China to pursue ASATs as an effective countermeasure.

CHINA'S ASAT CAPABILITIES

In fact, many types of ASAT weapons have been proposed.[8] The U.S. and Soviet Union tested several types of ASAT weapons. Between 1960 and 1983, the Soviet Union developed and tested some ASAT. In 1976, the United States began ASAT studies and in 1984 began testing a homing vehicle. ASAT weapons include a wide variety of ground-, sea-, air, and space-based weapons using the kinetic-energy weapon (KEW) and Directed-energy weapons (DEW).

An ASAT system would have either non destructive ASAT devices such as jammers or other electronic or electro-optical countermeasures, or ASAT weapons capable of damaging satellites (in which case it would be an ASAT weapon system),or both. In the following, I will examine what kind of ASATs could be suitable to China.

Nuclear-armed ASAT

Ordinary nuclear weapons such as ICBMs and SLBMs, when detonated in space, will kill nearby satellites through prompt radiation and the electro-magnetic pulse (EMP). It is believed that any nuclear powers (including China) with nuclear-armed long or intermediate range ballistic missiles have capabilities to attack satellites in LEO with nuclear weapons. With some modifications, these weapons might be used to attack satellites at higher altitudes.

Beyond this direct-ascent nuclear ASAT, nuclear weapons could be concealed aboard satellites as nuclear space mines. These mines would be detonated on command within lethal range of a quarry of satellites and destroy them almost instantly. These nuclear ASATs could be as small and inexpensive as many existing satellites. Such weapons could be developed and tested covertly. Moreover, such ASATs do not need advanced satellite surveillance systems. Thus, China could have such ASAT capabilities without pursuing complicated technologies. These ASATs would be feasible to neutralize the space-based components located at LEO for a missile defense system.[9] However, the use of such nuclear ASAT would be inhibited by the Outer Space Treaty (1967). The use of such weapons would damage not only adversary's satellites but also Chinese. Use of a nuclear ASAT seems unlikely except as a last resort in a nuclear conflict.

Kinetic-Energy Weapons

A number of kinetic-energy weapons, either ground- or space-based, would probably be used to attack satellites. All these kinetic-energy ASATs would be cheaper and technically easier than those for BMD systems.

The optimum ASAT system for China could be ground-launched small kinetic-kill vehicles that can be used to destroy their target by colliding with it at extremely high velocities. These vehicles can reach satellites in LEO, and if mated with a larger booster, they might attack satellites in higher orbits. More recently, the United States developed such miniature homing vehicle technology for a weapon that could be launched from an aircraft. Scientists believe that such ground-based ASATs are far easier and cheaper to destroy satellites at LEO than other methods. Any country able to launch a satellite or build a sounding rocket could develop these types of ASATs. Another possible KE ASAT concept China could deploy are co-orbital interceptors which approach its quarry at a low closing velocity before destroying it. Such a kind of ASAT could be smaller and cheaper than most satellites as presently designed. The Soviet Union tested such interceptors between 1968 and 1983. Also a space mine with conventional charges might be used as space-based ASATs. Some experts suggested "space shrapnel", swarms of small pellets produced around an adversary's satellite orbits, that might, in the case of a space-based laser system, cause a defect on the surface of the reflecting mirror and render a space-based laser ineffective. All of these could be within Chinese technological capability.

High-Energy Laser Weapons

High-energy laser (HEL) weapons are devices capable of producing intense, damaging beams of electromagnetic radiation that could damage a satellite permanently or jam optical communication and sensor systems at lower power levels. HEL weapons could be ground- space-, air-,or sea-based. Since the 1980s, mainly encouraged by the Strategic Defense Initiative, many possible types of HEL weapons for BMD or ASATs have been proposed, such as DF chemical lasers and free-electron (FEL) lasers for ground based ASAT; HF chemical lasers, FELs and nuclear-pumped X-ray lasers for space based.

Since the 1980s China has made great progress in R&D of high energy lasers, which could be partly promoted by US program of directed energy weapons and partly funded under the national 863 program for high technology development. However, not all these high energy lasers would have ASAT capabilities, such as the solid and gas lasers.

Among those Chinese HEL researches, the most relevant laser technologies with potential ASAT capabilities are FEL and Chemical Oxygen-Iodine Laser (COIL). Also given the US advantage in space, it could be expected that if China pursues ASATs, it could likely develop ground based HEL weapons instead of space based lasers.

Free Electron Laser (FEL). China began to investigate FEL in 1985, funded under the 863 program.[10] In May 1993, China activated its first FEL, the Shuguang-1 (in English "Dawn light"). In July 1994 Shuquang-1 achieved a power of 140 MW, with a theoretical maximum output of 10GW.[11] As reported, the size of FEL systems currently limits deployment options. And China is working to reduce the size of FEL systems through the miniaturization of electronic devices.[12] The Shuguang-1 was developed by Chinese Academy of Engineering Physics. A second FEL facility located in Beijing was developed by the China Academy of Sciences Institute of High Energy Physics.[13] China's FEL systems, including Raman, Compton, electromagnetic wave pumped, and Cherenkov lasers, have been modeled and simulated by the Beijing Institute of Applied Physics and Computational Mathematics.

The FELs have a number of advantages: they can operate at short wavelengths that can pass through atmosphere windows and have a higher quality beam for long distance propagation. Free-electron lasers can probably be made more efficient than other short-wavelength lasers and could be ground- or space-based.

Chemical Oxygen-Iodine Laser. China also has investigated Chemical Oxygen-Iodine Laser (COIL). Its wavelength is 1.315um, just within the atmospheric window. With such short wavelength, COIL is suitable for a long distance propagations that has the potential to be an effective DEW. It is reported Dalian Institute of Chemistry and Physics (DICP) is responsible for China's COIL development program, began in the early 1980s and taken as a national 863 project in April 1991. In May 1995, China conducted one of its first tests of a COIL against a target at140 meters, achieving a power of 10 kilowatts with an output energy of 40-50 kilojoules for 3-4 seconds.[14]

These HEL researches and developments could provide the technology base for China's ground based HEL weapons that could dazzle or permanently blind optical sensors of those space -based MD component. At higher power level, they could damage those satellites. In practice, these ground-based high-energy lasers would be much simpler and effective to destroy satellites than those proposed as space-based weapons against ICBM in the boost phase. The target is larger, the target number is smaller and the laser can be focused for a longer period of time on its target. Moreover, ground-based lasers are less restricted by parameters such as on mass, size, energy consumption, and efficiency than their space-based counterparts.

Although the beams of space-based laser weapons would not have to pass through the atmosphere and could damage unhardened satellites at great range, space-based laser weapons would be subject to attack by adversary's ASAT weapons. Moreover, although ground-based lasers would have infrequent opportunities to attack satellites, they could shoot inexpensively and repeatedly. To have a wide field attack, a ground-based HEL system could need space-based reflectors to relay laser beams from ground-based lasers to their targets. HEL weapons would not operate through cloud cover. Finally, the effects of atmospheric turbulence would pose a serious problem for ground-based lasers. For a weapon system, optics must compensate for atmospheric turbulence through the use of adaptive mirrors which use numerous electronic devices to shape and achieve the optimal beam pattern. It has been reported that China has placed high priority on development of adaptive optics and deformable mirrors.

China's concentration on the field of adaptive optics began in 1980. Some have already been made.[15]

High Powered Microwave (HPM) Weapons

HPM weapons are devices capable of producing intense, damaging beams of radio frequency radiation. They could be used to overload and damage satellite electronic equipment at high power levels or, at lower power levels, merely to temporarily overload satellite electronic systems (i.e., for jamming). HPW weapons could be ground-, or space-based. Unlike ground-based laser weapons, HPM weapons could operate through cloud cover. However, the maximum pulse energy per unit area which can be beamed through the atmosphere is limited. at lower power, HPM weapons could be used as a jammer.

The lethality of HPW weapons could be less than that of HELs. However, even Jamming, when applied against the space-based component of BMD, could drastically reduce the efficiency of the surveillance, acquisition tracking system, or even put it out of action completely.

Some Chinese Institutes are engaged in research, design, and testing of HPM devices.[16] Numerous entities within China's defense industrial complex are conducting R&D in HPM power sources, the most critical segment of an HPM weapon system. For example, the University of Electronic Science and Technology of China, supported by CAEP's Southwest Institute of Applied Electronics, has been conducting developmental work on a backward wave oscillator (BWO) as an HPM source since at least 1989 and acknowledges the BWO as a leading candidate for a mobile HPM system.[17] One of China's first experiments in HPM weapon research was the Flash-I system which utilized a vircator as a power source. CAEP began development of the Flash-I in 1975. After completion in 1983, the Flash-I operated at approximately 1 GhZ and had a microwave power of 1 GW.[18] The Northwest Institute of Nuclear Technology has developed the Flash-II (Shanguang) electron beam accelerator with a maximum power of 1 terawatt. After a feasibility study in 1982, the Flash-II project, designed to aid China's electromagnetic simulation and HPM weapons research, began in 1983 and was first tested in 1990.[19]

Other space capability

The Chinese launch complexes developed to support launches are relatively large and comprehensive. The three different facilities provide the capability to launch to low earth orbits (LEO), geosynchronous transfer orbits (GTO), and polar orbits. With these launch complexes, China has positioned itself to support any requirement for a space launch, another part of a successful commercial enterprise.

Microsatellites.

China also is developing minisatellites (weighing less than 100 kgs) for missions, which include data transmission, earth sensing and other programs.[20] A joint venture between China's Tsinghua University and Great Britain's University of Surrey is building the "Tsinghua" system, a constellation of 7 minisatellites with 50-meter (m) resolution remote sensing payloads. China's small satellite program is mainly for civilian and commercial purposes including communications and meteorological applications.

Microsatellites would potentially allow China lower-cost access to space, enhanced maneuverability, and increased ability to launch-on-demand. However, these technologies could be also used for ASATs.[25] The developments of small satellites would enable China to launch satellites swiftly and allow the launchers to be mobile -- important in a space-warfare environment. Moreover, these microsatellites could be hidden in other satellites and could covertly rendezvous with other space assets to perform satellite inspection and other missions to disrupt, degrade or destroy space assets.[26]

China's spacecraft

China's unmanned and manned spacecraft program could also make some contribution to its ASAT capabilities. Some western sources reported, the Shenzhou program has contributed significantly to improvements in China's tracking and satellite maneuverability.[27] T hese programs have an ASAT potential as a 1985 report from the Office of Technology Assessment points out: "The Space Shuttle and space plane. . . have greater inherent ASAT capabilities. Finally, any highly maneuverable space-craft capable of noncooperative rendezvous has some ASAT potential."[28]

It should be noted that effective non-nuclear ASATs would require good space surveillance capabilities. An ASAT system must be controlled by an associated command, control, communications, and intelligence system. China has a limited surveillance capability.[29] China's satellite tracking system includes a domestic network, two foreign sites, and four tracking ships. Some experts argue that for ASAT purposes, China may need not a complicated system as US and Russia has. There are many commercially available technologies which can be used to construct systems to detect, identify, and track satellites in LEO.[30] The 2001 Rumsfeld Commission on Space mentions a number of ways an adversary could track, and thus potentially target an American satellite.[31] Such as: the availability of tracking data by amateur satellite observers posting their findings on the Internet; the proliferation of air and theatre missile defense radar which can track satellites in LEO; and the increasing sophistication of sensor technology (radar, optical telescopes, passive radio frequency and even satellite signals intelligence receivers) and its wide commercial availability. However, some Chinese feel that if China pursues an effective ASAT system, it will require establishing a reliable space surveillance system.

CONCLUSIONS

In response to a U.S. space-based missile defense system, China would consider ASAT measures as a counter. Furthermore, if China is to pursue ASAT weapons, China is far more likely to develop ground-based ASAT weapons, such as ground-based kinetic energy weapons, ground-based free electron lasers, and ground-based microwave weapons. Compared with space-base weapons, these ground-based ASATs would be easier to control, cheaper to deploy and most importantly they would be less vulnerable to US counters.