Russian and Chinese Responses to U.S. Military Plans in Space

Pavel Podvig and Hui Zhang

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Preface

In recent years, Russia and China have urged the negotiation of an international treaty to prevent an arms race in outer space. The United States has responded by insisting that existing treaties and rules governing the use of space are sufficient. The standoff has produced a six-year deadlock in Geneva at the United Nations Conference on Disarmament, but the parties have not been inactive. Russia and China have much to lose if the United States were to pursue the programs laid out in its planning documents. This makes probable the eventual formulation of responses that are adverse to a broad range of U.S. interests in space. The Chinese anti-satellite test in January 2007 was prelude to an unfolding drama in which the main act is still subject to revision. If the United States continues to pursue the weaponization of space, how will China and Russia respond, and what will the broader implications for international security be?

The American Academy called upon two scholars to further elucidate answers to these questions and to discuss the consequences of U.S. military plans for space. Pavel Podvig, a research associate at the Center for International Security and Cooperation at Stanford University and former researcher at the Moscow Institute of Physics and Technology, discusses possible Russian responses, given their current capabilities and strategic outlook. Hui Zhang, a research associate at the John F. Kennedy School of Government at Harvard University, considers Chinese responses.

Each scholar suggests that introducing weapons into space will have negative consequences for nuclear proliferation and international security. As Podvig points out, Russia's main concern is likely to be maintaining strategic parity with the United States. This parity will be destroyed by the deployment of weapons in space, making a response from Russia likely. Podvig writes, "Russia does not have many options for the development of its own weapon systems in space or for its reaction to the development of this capability by other countries. . . . However, this does not mean that there will be no reaction." He suggests that Russia will be more likely to undertake other countermeasures such as extending the life of its ballistic missiles, measures that are "the most significant and dangerous global effects of new military developments, whether missile defense or space-based weapons."

Zhang arrives at similar conclusions. He describes how U.S. plans will negatively affect peaceful uses of outer space, disrupting current civilian and commercial initiatives, but focuses on a much greater concern among Chinese officials—that actions by the United States in space will result in a loss of strategic nuclear parity. China's options for response, as detailed by Zhang, include building more ICBMs, adopting countermeasures against missile defense, developing ASAT weapons, and reconsidering China's commitments on arms control. Thus introducing weapons into space would destabilize the already vulnerable international non-proliferation regime. Zhang concludes, "U.S. space weaponization plans would have potentially disastrous effects on international security and the peaceful use of outer space. This would not benefit any country's security interests."

These papers are part of the American Academy's "Reconsidering the Rules of Space" project. The project examines the implications of U.S. policy in space from a variety of perspectives, and considers the international rules and principles needed for protecting a long-term balance of commercial, military, and scientific activities in space. The project is producing a series of papers, intended to inform public discussion of legitimate uses of space, and induce a further examination of U.S. official plans and policies in space. Other papers consider the physical laws governing the pursuit of security in space (spring 2005), challenges posed to the United States space program by current policies (spring 2005), and the possible elements of a more comprehensive space security system (forthcoming).

In May 2002, the American Academy convened a workshop on Chinese Perceptions of U.S. Space Plans to support Hui Zhang's work on his essay. Pavel Podvig's essay was reviewed at a workshop at the University of Maryland in January 2005. We join the authors in thanking the participants in these workshops for their participation and insights.

We also thank five anonymous reviewers for their comments on the papers. We acknowledge the excellent work of Helen Curry, Phyllis Bendell, and Anne Read in producing this report. We are, most of all, grateful to the authors for applying their knowledge and experience to these important issues.

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Acronyms

ABM	Anti-Ballistic Missile (Treaty)
ASAT	anti-satellite (weapons)
BMD	ballistic missile defense
CD	UN Conference on Disarmament
CTBT	Comprehensive Test Ban Treaty
DEW	directed energy weapon
FEL	free-electron lasers
FMCT	Fissile Material Cutoff Treaty
GEO	geosynchronous orbit
GMD	ground-based midcourse defense
GPS	Global Positioning System
GUKOS	Main Space Systems Directorate
HEL	high-energy laser
HEO	highly elliptical orbit
HPM	high-powered microwave
ICBM	intercontinental ballistic missile
KEW	kinetic energy weapon
LEO	low Earth orbit
MDA	Missile Defense Agency
MEO	medium Earth orbit
MRV	multiple reentry vehicle
MIRV	multiple independently targeted reentry vehicle
NIE	National Intelligence Estimate
NFIRE	Near Field Infrared Experiment (satellite)
NPR	Nuclear Posture Review
OKIK	stationary control and measurement complex
OST	Outer Space Treaty
PAROS	prevention of an arms race in outer space
PRC	People's Republic of China
SBI	space-based interceptor
SDI	Strategic Defense Initiative
SBIRS	space-based infrared system
SBL	space-based laser
SLBM	submarine-launched ballistic missile
THAAD	Theater High Altitude Area Defense
UNKS	United Space Systems Directorate

CHAPTER 1

Russia and Military Uses of Space

PAVEL PODVIG

Russia is one of the few countries to carry out a full range of activities in space. The Russian government supports a number of space programs, from manned flights to civilian and military communication, navigation, and satellite-imagery systems. Russia has at its disposal launchers and launch facilities that can deliver a range of payloads to almost any orbit. These capabilities make Russia an important actor in all developments related to military uses of space, especially those related to the weaponization of space.

Russia also has an important role in the future development of space because it remains a nuclear state with sizable offensive strategic nuclear forces. Although the relationship between Russia and the United States—as well as the other nuclear states—no longer has the adversarial nature that characterized it during the cold war, an expansion of U.S. military capabilities in space might affect Russia's security calculations and force its government to take measures that would protect Russia's strategic status vis-à-vis the United States.

Russia is capable of carrying out its own military space program. Despite the setbacks of the last decade, during which all Russian military programs suffered due to lack of adequate funding, recent steps of the Russian leadership indicate their intention to expand the military space program. Although it is not clear whether Russia could maintain its military presence in space so as to successfully compete with the United States, an expansion of the military space program would be an important benchmark and would certainly affect U.S. military policies.

All of these factors would certainly come into play if the United States decided to proceed with development and operational deployment of space-based weapon systems. There is little doubt that Russia would be compelled to respond. The exact nature of the response, however, is much less clear. On one hand, the factors described above give some reason to believe that Russia has the capability to mount a strong and potentially destabilizing response to U.S. space-weapon programs. On the other hand, recent history suggests that Russia's reaction might be quite restrained, as it was when the United States withdrew from the Anti-Ballistic Missile (ABM) Treaty.

Several factors will determine Russia's response: the overall context of the U.S.-Russian relationship, which will guide Russia's evaluation of the threat that U.S. programs pose to its security; its calculation of the kind of response warranted; and the ability of the Russian military and military industry to undertake the measures required for such a response.

WEAPONIZATION OF SPACE IN RUSSIA'S MILITARY THINKING

Russian military leaders and civilian experts have closely analyzed discussions within the United States about military uses of space, as well as the doctrinal documents of the U.S. military. These analyses have heightened concern in Russia about the effects that the development of space-based military systems might have on the U.S.-Russian military balance. Russians see the development of military space systems by the United States as evidence of a growing gap between military capabilities of the two countries. This gap challenges the condition of strategic parity that Russia still believes to be the underlying principle of its relationship with the United States.[1]

Before considering specific issues that have drawn the attention of the Russian military, I should note that, at this moment, the issues in question are primarily U.S. research projects on the military use of space and not development or deployment programs. Although some U.S. research projects are very ambitious, there are no specific plans for the United States to deploy weapon systems in space. This uncertainty about the actual plans of the U.S. military gives observers in Russia (as well as elsewhere) room for a wide range of expectations and encourages the consideration of worst-case scenarios.

Russia's reaction to the potential weaponization of space should also be considered in the context of the current U.S.-Russian strategic relationship. From the Russian perspective, the current situation is one of strategic parity, where the United States is unlikely to be able to gain unilateral military advantage that would undermine the retaliatory potential of the Russian strategic forces. It is usually assumed that various technological developments would have the potential to jeopardize the existing strategic balance. Until recently, missile defense dominated the discussion in Russia on technological developments of this kind. Now the emphasis has shifted, and although missile defense still figures prominently, it is usually considered just one of many potentially destabilizing U.S. programs. As with missile defense, it is widely believed that deployment of weapons in space will open a way for the balance currently secured by the offensive strategic forces to be undermined.[2]

Specific conflict scenarios, considered in the context of space weaponization, can be categorized according to the goals of a conflict and the role that space-based systems could play. Given the very important status that Russia assigns to its strategic nuclear forces, the developments it considers most threatening usually involve an attack intended to undermine Russia's retaliatory potential. This includes direct attacks on launchers, command and control centers, communication links, and other components of the strategic

1. Aleksandr Gorshkov, "V vooruzhennykh silakh SShA proiskhodit ne prosto reforma, a revolyutsiya," *NVO NG*, April 1, 2005.

2. Aleksandr Gorshkov, "V vooruzhennykh silakh SShA proiskhodit ne prosto reforma, a revolyutsiya."

infrastructure.[3] However, because it is recognized that the probability of a targeted attack on nuclear forces is essentially zero, analyses of potential threats often consider other possibilities that are believed to be more likely. One scenario of this kind would include a standoff strike with conventional weapons. The strike would attack civilian and military infrastructure, not targeting strategic nuclear forces directly but nevertheless making nuclear retaliatory strike impossible.[4]

Most Russian writings on this subject accept that military systems deployed in space would play a key role in any future conflict, regardless of the specific scenario. The most alarmist view, expressed by some Russian analysts, is that space will be used for the deployment of "strike weapons" able to attack targets on the ground. According to this view, space would give a decisive advantage to an attacker, allowing an adversary to launch a highly coordinated attack on Russia's strategic forces.[5] It should be noted that in this context, missile-defense systems are usually considered an important component of the "space strike" force even though they may not have space-based components. It is assumed that missile-defense systems would operate in coordination with the strike force to further weaken Russia's retaliatory potential.

Although "space strike" weapons have a prominent place in the ongoing discussion in Russia about the military use of space, attention is also paid to the systems that support military operations on the ground. The most important of these are the systems that provide the reconnaissance, targeting, and navigation information that allow an attack to be conducted from a distance and to use flexible and accurate targeting. The Global Positioning System (GPS) navigation system and optical and electronic reconnaissance and communication satellites are among the currently deployed systems of this kind. It is correctly assumed that the number of these systems will grow with improvements in their technical characteristics and with their increased ability to operate as part of an extensive and well-coordinated network. A capability of this kind would introduce new uses of military force, and it is not yet understood how these would affect Russia's reliance on the strategic nuclear force that exists today. The resulting uncertainty is one of the reasons the Russian military is wary of the continued militarization of space, as it is unclear if Russia would be able to deal with the new situation.

Assessment of the threats that space-based military systems might pose is only one part of the discussion of this subject within the Russian military. The discussion also addresses the question of how to respond to these threats and how the Russian military should adapt to the growing role of space systems in military operations.

3. Sergey Brezkun, "Natsionalnaya prerogativa," *VPK*, no. 8 (75), March 2–15, 2005; Radmir Smirnov, "Zvezdnyye voiny: novaya versiya," *NVO NG*, October 15, 2004.

4. The model on which scenarios of this kind are based is the NATO bombing campaign in Serbia in 1999.

5. This kind of thinking directly echoes the one that dominated in the early stages of the Strategic Defense Initiative (SDI) debate—the Soviet Union considered "space strike weapons" to be the most threatening aspect of the program at that time.

Because the threat is seen largely as a threat to strategic assets—strategic forces, command and control systems, and key objects of the civilian and military infrastructure—responses are inevitably discussed through the frame of strategic-defense options. This approach draws heavily on the Soviet tradition of considering strategic defense as a distinct mission; until a reform in 1997, this mission was assigned to Air Defense Forces, a separate service within the Soviet and later the Russian military.

A series of reforms in recent years subordinated the air-defense component of the service to the Air Forces and transferred space-related branches—early-warning systems, space surveillance, and missile defense—to the Space Forces. This transformation remains a contentious point in Russia, and many analysts argue that defense in airspace and in outer space should be considered together and advocate an organizational reform that would facilitate integration between various defense systems.[6] Defense officials express the point of view that although integration is indeed essential, it does not necessarily require further organizational changes.[7]

The degree to which defending airspace and defending outer space are considered to be part of a single mission varies, but most experts agree that defenses are, at the very least, united by the strategic nature of any threat that they would have to counter. As a result, some strong parallels between air and space defense are drawn, and it is in this context that experts most often mention the need to counter space-based assets of the attacker.[8] In discussions of this possibility, little distinction is made between "strike weapons" in space and support systems like navigation or communication. This is understandable, as all these systems are assumed to be highly integrated.[9]

Overall, although its leaders rarely spell out the belief explicitly, the Russian military seems to accept the view that anti-satellite systems may have a legitimate role in future conflicts. Characteristically, while advancing a diplomatic initiative to ban space-based weapon systems, Russia also underscores that anti-satellite systems not based in space should be excluded from this ban.[10] However, Russia has no specific plans for anti-satellites systems.

To summarize, discussion in Russia of the weaponization of space and related issues recognizes the increasing role of space-based systems in military operations. This development is usually considered a threat, mainly because it has the potential to undermine the existing strategic balance and weaken Russia's status as a major power. However, because this threat has not yet

6. Vyacheslav Baskakov, "Kosmicheskiye sily kak garantiya oborony strany," *NVO NG*, October 7, 2004.

7. Aleksandr Rukshin (Chief, Operational Directorate of the General Staff), "Air and Space Defense," *VPK*, no. 15, December 17–23, 2003.

8. G. P. Kupriyanov, "Osnovnyye tendentsii razvitiya form vooruzhennoy borby v vozdushno-kosmicheskoy sfere," *Voyennaya mysl*, no. 1 (2005).

9. Vladimir Slipchenko, "Reforma bez kotoroy ne oboitis," *VPK*, no. 48 (65), December 15–21, 2004.

10. Geoff Fein, "Russian Federation Seeks Ban On Space-Based Weapons," *Defense Daily*, February 9, 2005.

materialized, Russia's response is discussed only in very general terms. On the balance, the prevailing view in Russia is that there is more to lose than gain from the weaponization of space, and so the official Russian position opposes the development and deployment of space-based weapons.

This does not mean that Russia opposes any military use of space. On the contrary, military and political leaders emphasize the importance of developing systems that would support military operations from space—navigation, communication, and reconnaissance.[11] Deployment of these systems would eventually require a means of protecting them, which could in theory bring Russia to reconsider its current opposition to space weapons.[12]

To understand whether Russia could indeed change its position on the weaponization of space, we need to go beyond official statements and discussion among Russian military experts. The course of the military space program in Russia will be determined primarily by the availability of the resources required to support the program and by the ability of the industry and the military to manage development projects for the military use of space.

EXISTING MILITARY SPACE PROGRAMS

Virtually all active Russian military space programs were initiated in the Soviet Union. Even in cases where the first launch was conducted after the breakup of the Soviet Union, research and development had been largely completed before that time. During the 1990s, the primary challenges that Russia faced were to preserve the military programs that it had inherited and to prevent deterioration of the infrastructure that supported space operations. To a certain degree, Russia has been successful in meeting these challenges, managing to keep most of its military space systems in operation. However, as discussed below, in most cases the systems in question have operated at a level that does not provide full operational capability and have relied on equipment manufactured before the breakup of the Soviet Union.

As part of its extensive space program, the Soviet Union developed and deployed military space-based systems in virtually all categories—from missile early warning to reconnaissance, from communication to satellite navigation. The extent to which these systems are supported today indicates in part the priorities of the Russian armed forces, although one must take into account that, in reality, support depends on a number of factors, including the real operational needs of the armed forces, the ability to manufacture spacecraft and launchers in Russia, and the interests of the space industry. These factors make determining the priorities of the armed forces more difficult, but still allow conclusions to be drawn about the direction of development in the Russian military space program.

As of 2007, Russia maintained active military space programs in five areas—early warning, optical reconnaissance, communication, navigation, and signal intelligence.

11. Anatoly Perminov, "Voyennyy kosmos Rossii," *Voyennaya mysl*, no. 1 (2004).

12. Vladimir Slipchenko, "Reforma bez kotoroy ne oboitis."

Early-Warning Satellites

Sensors deployed in space are traditionally considered a vital component of an early-warning system if the system is to provide timely warning of a missile attack. Because sensors in space can be made capable of detecting ballistic missiles almost immediately after launch, these sensors can provide the maximum possible warning time—up to 30 minutes in the case of land-based intercontinental ballistic missiles (ICBMs). The Soviet Union began development of its space-based early-warning system in 1971 and was able to deploy it by 1982.[13] Early-warning satellites complement a network of radar stations deployed along the periphery of the Soviet territory.

In its full configuration, the space-based early-warning system, known as Oko or US-KS, consists of up to nine satellites on highly elliptical orbits (HEO) and one satellite on a geostationary orbit (GEO). This configuration allows continuous coverage of ICBM bases on U.S. territory. Submarine patrol areas in the ocean are not covered by this system, so it cannot detect launches of sea-based ballistic missiles.

To maintain continuous coverage of U.S. ICBM bases, the system needs at least four satellites on HEO. Filling all nine HEO slots in the constellation and adding a GEO satellite increases the reliability of launch detection, but does not extend coverage in a substantial way.[14] Until the mid-1990s, Russia managed to maintain the Oko system in almost full capacity and had the capability to reliably detect launches of U.S. land-based missiles. This required about three launches per year to replenish the constellation. Russia was able to conduct these launches despite the serious financial difficulties of that period. The capabilities of the system began deteriorating between 1997 and 1998, after a

Table 1: Recent Launches of Early-Warning Satellites

	NORAD number	Launch date	Inclination (degrees)	Perigee (km)	Apogee (km)	End of operation	Comment
US-KS/Oko							
Cosmos-2345	24894	08/14/97	3.6	35118	36466	02/1999	GEO
Cosmos-2351	25327	05/07/98	64.6	3210	37200	05/2001	HEO
Cosmos-2368	26042	12/27/99	63.1	2394	37977	12/2002	HEO
Cosmos-2388	27409	04/02/02	64.3	490	39842	11/2006	HEO
Cosmos-2393	27613	12/24/02	63.0	879	39454	02/2007	HEO
Cosmos-2422	29260	07/21/06	62.9	860	39000	Active	HEO
Cosmos-2430	32268	10/23/07	63.0	560	39200	Active	HEO
US-KMO							
Cosmos-2350	25315	04/29/98	2.1	35758	35808	06/1998	GEO
Cosmos-2379	26892	08/24/01	0.6	35770	35804	Active	GEO, 12E
Cosmos-2397	27775	04/24/03	2.0	35545	35908	05/2003	GEO

13. Pavel Podvig, "History and the Current Status of the Russian Early-Warning System," *Science and Global Security*, vol. 10, no. 1 (2002): 21–60.

14. Ibid.

series of malfunctions caused premature termination of the operations of some deployed satellites. By the end of 1999, the system had been reduced to the minimum level of four satellites on HEOs.

The system suffered a further setback in May 2001, when a fire destroyed its command and control center at Serpukhov-15 near Moscow. As a result of the fire, Russia lost control over all four deployed satellites and for about four months did not have the ability to detect missile launches from space.[15] All four satellites were eventually lost and have been replaced by two HEO satellites, Cosmos-2388 and Cosmos-2393, and one GEO satellite, Cosmos-2379. Since the end of 2002 until 2006, the system has operated in this configuration, which theoretically allows continuous coverage of U.S. ICBM fields, albeit with reduced reliability. In 2006 and 2007, two new satellites, Cosmos-2422 and Cosmos-2430, joined the constellation, and two others—Cosmos-2388 and Cosmos-2393—ended their operations.

Because the capabilities of the Oko/US-KS do not allow it to detect launches from areas other than continental United States, the Soviet Union began development of a new generation of early-warning satellites in the 1980s. The new satellites were to be capable of detecting missiles against a background of Earth's cloud cover and were to be deployed both on highly elliptical and geostationary orbits. This system was designated US-KMO.

The first early-warning satellite of the new generation was launched in 1991. By 2006, there had been six US-KMO satellite launches; the last was Cosmos-2397, launched in April 2003.[16] Only one of these satellites—Cosmos-2379—is operational today. The program has been plagued by satellite malfunctioning, which significiantly shortened satellites' lifetimes. For example, all but one of the US-KMO system launched since 1994 ended their operations prematurely.[17]

Russia is currently working on a new space-based early-warning system, known as EKS. Flight tests of satellites of the new system are expected to begin in 2009.[18]

Optical Reconnaissance

Russia operates at least six different types of optical reconnaissance satellites, which vary in their capabilities and missions from wide-area cartography to detailed photography of specific areas of interest. As it is the case with other systems, photoreconnaissance programs can be divided into legacy programs that continue from the Soviet era and newer programs activated after 1992.

15. Ibid.

16. I. Safronov, "Moskva ustanovila nad mirom protivoraketnyy control," *Kommersant*, April 28, 2003.

17. K. Lantratov and E. Fedorov, "Otstavka kosmicheskogo naznacheniya," *Kommersant*, August 25, 2003.

18. "Ispytaniya novoy kosmicheskoi sistemy SPRN nachnutsya v 2009 godu," *Gazeta.ru*, August 20, 2007.

The older programs, which still constitute the core of Russia's imaging capability, are systems of the Yantar family. Three types of satellites are known as Yantar: Yantar-4KS2 Kobalt, Yantar-4KS1 Neman, and Yantar-1KFT Kometa. Although the spacecraft are quite different in their missions and capabilities, they share design features as they were built around a common platform.

Yantar-4KS2 Kobalt is a photoreconnaissance satellite that produces detailed imaging. It carries a camera and two capsules that allow it to return exposed film to the earth during the mission. At the end of a flight, the spacecraft itself is returned to the ground, acting as a third reentry capsule. The flight time of a spacecraft of this type is typically about 60 days, so the film is returned at about 20-day intervals. Kobalt satellites have been deployed in low-earth orbit, with an inclination of about 67 degrees and perigee and apogee of about 170 km and 350 km respectively.

During the 1980s, when the Yantar-4KS2 Kobalt was the primary Soviet reconnaissance satellite, the Soviet Union launched up to nine satellites of this type annually to provide timely imaging data. As a rule, there was at least one spacecraft of this type in orbit at any given time. By the end of 1990s, the launch rate had dropped to one satellite every one or two years, and Russia could no longer constantly keep an operational satellite in orbit, even though duration of the mission was almost doubled to reach about four months.

As part of the Kobalt program, in 2004 the Space Forces launched the Cosmos-2410 satellite, which was described as a reconnaissance satellite of a new generation, Kobalt-M. The mission was not entirely successful—the spacecraft completed its mission prematurely and was not recovered after reentry. Nevertheless, the problems with the satellite appear to have been relatively minor and the Space Forces announced plans to begin regular launches of Kobalt-M satellites after 2006.[19] The second launch took place in May 2006, and the third in June 2007.

One of the most serious drawbacks of film-based reconnaissance satellites is their inability to provide immediate data and their limited life span, which is determined by the amount of film a satellite can carry on board. Photoelectronic reconnaissance satellites have a clear advantage in these areas. Soviet satellites of this type, which are known as Yantar-4KS1 Neman, transmit imaging information electronically, using geostationary relay satellites when necessary.

Regular launches of Neman satellites began in 1984. A mission would usually last from six to eight months, after which the satellite would reenter the atmosphere. In the 1980s, the Soviet Union launched one or two Neman satellites each year, to have at least one operational spacecraft in orbit. The situation changed in the late 1990s; after 1995, there were only two launches of Neman satellites—one in 1998 and one in 2000.

The third system of the Yantar family includes the Yantar-1KFT Kometa topographic imaging satellites. These film-based satellites provide wide-area

19. I. Safronov, "Rossiiskiy voyennyi kosmos ischerpal sovetski zapas," *Kommersant*, November 12, 2005.

Table 2: Recent Launches of Optical Reconnaissance Satellites

	NORAD number	Launch date	Inclination (degrees)	Perigee (km)	Apogee (km)	End of operation
Yantar-4KS2 Kobalt						
Cosmos-2348	25095	12/15/97	67.1	176	370	04/14/98
Cosmos-2358	25373	06/24/98	67.1	167	334	10/22/98
Cosmos-2365	25889	08/18/99	67.1	166	342	12/15/99
Cosmos-2377	26775	05/29/01	67.1	176	382	10/10/01
Cosmos-2387	27382	02/25/02	67.1	176	369	06/27/02
Cosmos-2410	28396	09/24/04	67.1	175	368	01/09/05
Cosmos-2420	29111	05/03/06	67.1	180	360	07/19/06
Cosmos-2427	31595	06/07/07	67.1	180	360	08/23/07
Yantar-4KS1 Neman						
Cosmos-2359	25376	06/25/98	64.9	240	302	07/12/99
Cosmos-2370	26354	05/03/00	64.8	240	300	05/04/01
Yantar-1KFT Kometa						
Cosmos-2349	25167	02/17/98	70.4	228	286	04/02/98
Cosmos-2373	26552	09/29/00	70.4	265	285	11/13/00
Cosmos-2415	28841	09/02/05	64.8	207	307	10/16/05
Orlets-1 Don						
Cosmos-2399	27856	08/12/03	64.9	205	326	11/24/03
Cosmos-2423	29402	09/14/06	64.9	175	340	11/14/06
Orlets-2 Yenisey						
Cosmos-2372	26538	09/25/00	64.8	201	313	04/20/01
Arkon						
Cosmos-2344	24827	06/06/97	63.4	1509	2748	10/1997
Cosmos-2392	27470	07/25/02	63.5	1507	1834	07/2003

imaging data for military as well as civilian purposes. These satellites began operations in the early 1980s and were launched at a rate of about one satellite annually, with nominal mission duration of about 45 days.

In addition to the Yantar systems described above, Russia is developing at least three other photoreconnaissance satellite systems. Two of them use film-based satellites—Orlets-1 Don and Orlets-2 Yenisey—and the other is based on an electronic reconnaissance satellite, Arkon.

The distinguishing feature of Orlets-1 and Orlets-2 is the increased number of film capsules that can be returned to the ground during the satellite's mission. Orlets-1 has eight capsules and Orlets-2 is reported to have 22. In addition, it is likely that the satellites' optics systems allow them to take images at a higher resolution than that achieved by the satellites of previous generations. Because the satellites rely on film for recording images, their lifespan is relatively short—from 40 to 60 days.

Orlets-1 is an older program; satellites of this type have been in operation since 1989. From 1989 to 1993, these satellites were launched annually, but after that there were only three launches, in 1997, 2003, and 2006. Cosmos-2423 was the last satellite of this type.

Although the Orlets-2 program began in the late 1980s, the first launch of a satellite of this type was conducted in 1994. That first flight, of Cosmos-2290, lasted for more than seven months and appeared to be of an experimental nature. The next launch was conducted in 2000. As of 2007, it remains the most recent launch of a satellite of this type. It appears that the Orlets-2 is still largely an experimental program. Don and Yenisey satellites will be replaced by satellites of a new type, known as Persona. Its first launch is expected in 2008.

Another optical reconnaissance program under development is known as Arkon. Development of this system began in the mid-1980s, but it was not before June 1996 that a satellite was ready for launch. The new satellite, Cosmos-2344, was deployed in a relatively high orbit, with perigee of about 1500 km and apogee of about 2700 km. This is unusual for imaging satellites, which tend to be deployed in lower orbits to get better spatial resolution. The Cosmos-2344 transmitted imaging information to the ground control center electronically, using geostationary relay satellites when necessary.

It is likely that one reason for the unusual choice of orbit was to facilitate an extension of the satellite's lifetime, which at high altitudes would be unaffected by atmospheric drag. However, the actual lifetime of the satellites proved to be fairly short. The first satellite ceased operations only four months after launch because of a malfunction. The second—and so far the last—launch of Arkon was conducted in July 2002. That satellite functioned for over one year, after which it stopped operations, probably short of its intended operational lifespan.[20]

As this brief overview of the Russian optical reconnaissance programs suggests, Russia does not have the capability to maintain continuous coverage of the Earth with its satellites. Moreover, even if all its satellites were operational, Russia would have rather limited capability to obtain high-resolution imaging data in a timely manner. New systems intended to provide that capability still seem to be in experimental stages.

Naval Reconnaissance and Signal Intelligence

The Soviet Union invested considerable resources into development of a system that would provide the capability to detect ships at sea and direct missiles at them. The first version of this system began operating in the early 1970s. It included satellites of two types: passive signal intelligence satellites, known as US-P or EORSAT; and active radar surveillance satellites, US-A or RORSAT. While the system has been in operation, the satellites and their mission profiles have undergone a number of modifications. Operations of the active system, US-A, were discontinued in 1988, primarily due to concerns about the nuclear reactors used to power the satellite systems. A modified version of the US-P system, known as US-PU, is currently in operation.

20. K. Lantratov and E. Fedorov, "Otstavka kosmicheskogo naznacheniya."

The US-PU/EORSAT system includes satellites that can track surface ships by detecting their radio communications, radar emissions, etc. A full constellation of these satellites includes three or four spacecraft deployed on circular orbits with altitudes of about 400 km. A US-PU satellite usually stays in orbit for about two years, after which it reenters the atmosphere. Until 1997, Russia launched one or two satellites of this type every year to keep the system operational. After 1997, however, the interval between launches increased to almost two years; as a result, there has been no more than one working satellite in orbit at any given time.

Table 3: Recent Launches of Signal Intelligence Satellites

	NORAD number	Launch date	Inclination (degrees)	Perigee (km)	Apogee (km)	End of operation
US-PU/EORSAT						
Cosmos-2347	25088	12/09/97	65	410	410	11/19/99
Cosmos-2367	26040	12/26/99	65	404	418	07/19/02
Cosmos-2383	27053	12/21/01	65	410	410	03/20/04
Cosmos-2405	28350	05/28/04	65	412	427	04/20/06
Cosmos-2421	29247	06/25/06	65	409	430	Active
Tselina-2						
Cosmos-2333	24297	09/04/96	71	848	852	
Cosmos-2360	25406	07/28/98	71	848	852	
Cosmos-2369	26069	02/03/00	71	848	854	
Cosmos-2406	28352	06/10/04	71	850	890	
Cosmos-2428	31792	06/29/07	71	850	880	

It was reported that the US-PU system would be discontinued, and Comos-2383, which orbited from December 2001 to March 2004, was thought to be the last satellite of this type. However, the Space Forces launched two more satellites of the US-PU type after that. Still, the system is expected to be withdrawn from service and replaced by a new-generation Liana system.

In addition to the US-P system, which was dedicated to the observation of electronic signatures of surface ships, the Soviet Union deployed a number of general-purpose signal intelligence and electronic reconnaissance systems, all of the Tselina family. The first two generations of signal intelligence satellites, Tselina-O and Tselina-D, were in operation until 1984 and 1994 respectively. The system currently in operation is known as Tselina-2. Its development began in the mid-1970s and the first spacecraft of this type was launched in 1984.

Tselina-2 satellites are deployed in relatively high circular orbits (altitude about 850 km). A full Tselina-2 constellation consists of four satellites in four orbital planes. Until the mid-1990s, Russia managed to maintain an almost full constellation, but by early 2004 only one operational satellite remained in orbit. In June 2004, the Space Forces launched a new satellite of the Tselina-2 type, and one more satellite was launched in 2007. 2007 was reported to be

Table 4: Recent Launches of Navigation Satellites

	NORAD number	Launch date	Inclination (degrees)	Perigee (km)	Apogee (km)	End of operation	Comment
Parus							
Cosmos-2361	25590	12/24/98	82.9	969	1013		
Cosmos-2366	25892	08/26/99	82.9	963	1013		
Cosmos-2378	26818	06/08/01	82.9	963	1010		
Cosmos-2389	27436	05/28/02	82.9	950	1017		
Cosmos-2398	27818	06/04/03	82.9	950	1017		
Cosmos-2407	28380	07/22/04	82.9	948	1004		
Cosmos-2414	28523	01/20/05	82.9	917	960		
Cosmos-2429	32052	09/11/07	83.0	970	1010		
Glonass							
Cosmos-2374	26566	10/13/00	64.8	19119	19128		Glonass 783
Cosmos-2375	26564	10/13/00	64.8	19119	19128		Glonass 787
Cosmos-2376	26565	10/13/00	64.8	19119	19128		Glonass 788
Cosmos-2380	26989	12/01/01	64.8	19119	19128		Glonass 790
Cosmos-2381	26988	12/01/01	64.8	19119	19128	Active	Glonass 789
Cosmos-2382	26987	12/01/01	64.8	19119	19128		Glonass 711
Cosmos-2394	27617	12/25/02	64.8	19119	19128		Glonass 791
Cosmos-2395	27619	12/25/02	64.8	19119	19128	Active	Glonass 792
Cosmos-2396	27618	12/25/02	64.8	19119	19128		Glonass 793
Cosmos-2402	28113	12/10/03	64.8	19137	19137		Glonass 794
Cosmos-2403	28114	12/10/03	64.8	19137	19137	Active	Glonass 795
Cosmos-2404	28112	12/10/03	64.8	19137	19137	Active	Glonass 701
Cosmos-2411	28509	12/26/04	64.8	19137	19137	Active	Glonass 712
Cosmos-2412	28510	12/26/04	64.8	19137	19137	Active	Glonass 797
Cosmos-2413	28508	12/26/04	64.8	19137	19137	Active	Glonass 796
Cosmos-2417	28917	12/25/05	64.8	19137	19137	Active	Glonass 798
Cosmos-2418	28916	12/25/05	64.8	19137	19137	Active	Glonass 713
Cosmos-2419	28915	12/25/05	64.8	19137	19137	Active	Glonass 714
Cosmos-2424	29672	12/25/06	64.8	19137	19137	Active	Glonass 715
Cosmos-2425	29670	12/25/06	64.8	19137	19137	Active	Glonass 716
Cosmos-2426	29671	12/25/06	64.8	19137	19137	Active	Glonass 717
Cosmos-2431	32277	10/26/07	64.8	19137	19137	Active	Glonass-718
Cosmos-2432	32276	10/26/07	64.8	19137	19137	Active	Glonass-719
Cosmos-2433	32275	10/26/07	64.8	19137	19137	Active	Glonass-720
Cosmos-24??	32393	12/25/07	64.8	19137	19137	Active	Glonass-72?
Cosmos-24??	32394	12/25/07	64.8	19137	19137	Active	Glonass-72?
Cosmos-24??	32395	12/25/07	64.8	19137	19137	Active	Glonass-72?

the last launch of a satellite of this type—like US-PU, Tselina-2 satellites are expected to be replaced by the new Liana system. The first satellite of the new type is expected to be launched in 2008.

Navigation Satellites

Two major military navigation systems are currently in use in Russia. The first, known as Tsiklon or Parus, includes satellites in circular orbits with altitudes of about 1000 km. The system provides accuracy of about 100 m. Initially developed as a military system, the system was later widely used for navigation by Soviet (and now Russian) civilian ships. In recent years, Russia has launched about one satellite per year, which is probably enough to keep the system operational.

Another navigation system, known as Glonass, is the Soviet (now Russian) equivalent of the U.S. Navstar/GPS system. Like its U.S. counterpart, it includes satellites deployed in semi-synchronous circular orbits with altitudes of 20,000 km. There are differences in configuration—the Russian system includes 24 satellites deployed in three orbital planes, as opposed to four orbital planes for GPS. The accuracy provided by the Glonass system, assuming that the full constellation is deployed, is comparable to that of GPS.

Deployment of Glonass satellites began in 1982, but the system did not reach initial operational capability until 1989. After the breakup of the Soviet Union, the system suffered from mismanagement and inadequate funding. The Russian government tried several times to commercialize the system but was unsuccessful. As a result, although the system is in operation, the number of working satellites is rarely higher than ten. Consequently, the ability of the system to provide accurate navigation information is very limited. Development of the Glonass system is also held back by a lack of equipment that would allow the Russian military and civilian users to take advantage of the data supplied by the system.[21]

Despite these problems, Russia is determined to continue to operate the Glonass system and launches about three satellites per year to replenish the constellation. Russia is currently developing a new type of Glonass satellite, known as Glonass-M, which will have a longer lifespan and therefore will require fewer launches. The first Glosnass-M satellite was launched in December 2004. After the launches in 2007, 14 satellites in the constellation are of the Glonass-M type. Six more are expected to be launched in 2008. According to the current plans, Russia will complete deployment of the constellation of 24 satellites in 2008.

Communication Satellites

Three general categories of space-based communication systems are maintained by Russia—low Earth orbit relay satellites, satellites in HEO, and geostationary satellites. Although most of these systems were developed with

21. Andrey Liscovich, "Global Navigation Satellite System: Problems and Prospects," Center for Arms Control Studies Working Paper, Dolgoprudny, 2004.

Table 5: Recent Launches of Military Communication Satellites

	NORAD number	Launch date	Inclination (degrees)	Perigee (km)	Apogee (km)	End of operation	Comment
Strela-3							
Cosmos-2337	24725	02/14/97	82.6	1409	1409		
Cosmos-2338	24726	02/14/97	82.6	1409	1409		
Cosmos-2339	24727	02/14/97	82.6	1409	1409		
Cosmos-2352	25363	06/16/98	82.6	1300	1870		
Cosmos-2353	25364	06/16/98	82.6	1300	1870		
Cosmos-2354	25365	06/16/98	82.6	1300	1870		
Cosmos-2355	25366	06/16/98	82.6	1300	1870		
Cosmos-2356	25367	06/16/98	82.6	1300	1870		
Cosmos-2357	25368	06/16/98	82.6	1300	1870		
Cosmos-2384	27055	12/28/01	82.5	1415	1447		
Cosmos-2385	27056	12/28/01	82.5	1415	1447		
Cosmos-2386	27057	12/28/01	82.5	1415	1447		
Cosmos-2390	27464	07/08/02	82.5	1467	1507		
Cosmos-2391	27465	07/08/02	82.5	1467	1507		
Cosmos-2400	27868	08/19/03	82.5	1459	1502		
Cosmos-2401	27869	08/19/03	82.5	1466	1501		
Cosmos-2408	28419	09/23/04	82.5	1470	1517		
Cosmos-2409	28420	09/23/04	82.5	1475	1517		
Cosmos-2416	28909	12/21/05	82.5	1450	1470		
Molniya-1							
Molniya-1-90	24960	10/24/97	64.1	1117	39237		
Molniya-1-91	25485	09/28/98	64.0	988	39372		
Molniya-1-92	27707	04/19/03	63.3	586	39765		
Molniya-1-93	28163	02/18/04	62.9	791	39563		
Molniya-3							
Molniya-3-49	25379	07/01/98	62.8	466	40770		
Molniya-3-50	25847	07/08/99	62.5	472	40813		
Molniya-3-51	26867	07/20/01	62.7	255	40811		
Molniya-3-52	26970	10/25/01	62.9	646	40658		
Raduga							
Raduga 1-4	25642	02/28/99	3.6	35783	35787	11/2005	35E
Raduga 1-5	26477	08/28/00	1.2	35775	35792	Active	45E
Raduga 1-6	26936	10/06/01	0.4	35777	35795	03/2006	70E
Raduga 1-7	28194	03/27/04	1.2	35766	35804	Active	85E
Cosmos-2434	32373	12/09/07	1.0	35800	35800	Active	70E
Geizer							
Cosmos-2371	26394	07/05/00	1.3	35770	35806	Active	80E

military applications in mind, they or their modifications are also used for civilian purposes.

The Strela-3 communication system, which includes satellites in low earth orbits, was developed for the military intelligence. The satellites work in store-dump mode: they receive information as they pass over the sender and transmit it when they pass over the recipient. A full constellation includes 12 satellites deployed in two orbital planes at altitudes of about 1400 km.

The system became operational in the late 1980s, replacing an earlier but similar system. In addition to the military Strela-3 system, Russia began deployment of its civilian counterpart, known as Gonets-D and Gonets-D1, in 1992. Satellites of this system are currently deployed in the same orbital planes as military satellites and are also likely to be used for military applications.

Deployment of the Gonets/Strela-3 systems was interrupted from 1998 to 2001, as there were no launches of new satellites for more than three years (a launch attempt in 2000 was unsuccessful due to launcher failure). In December 2001, launches resumed, and by the end of 2005 the Space Forces had deployed fourteen new satellites, indicating Russia's intention to continue maintenance of these systems.

Two communication systems that include satellites on HEO are Molniya-1 and Molniya-3. The orbits used for deployment of these satellites, Molniya orbits, are named after the satellites. An orbit of this type has a perigee of 400–1000 km and an apogee of about 40,000 km. A spacecraft that occupies this orbit spends most of a revolution at the apogee (which in the case of the Molniya satellites is located over the Russian territory), allowing it to provide better coverage of the country than a geostationary satellite.

Molniya satellites are relay satellites for general-purpose military and civilian communication. To maintain the constellations, Russia launches about one satellite of each type annually. There have been some exceptions to this, but the pattern of launch activity suggests that Russia will continue to maintain these systems. On December 24, 2006, Russia launched a Meridian communication satellite (NORAD 29668), which is believed to be a follow-on to satellites of the Molniya type.

Another class of relay systems includes satellites of two different types deployed in GEO. Satellites of one type, Raduga-1/Globus-1, are used for general-purpose communication and are reported to have secure channels for communication between military leadership. Raduga-1 satellites are deployed at four points on GEO over the Indian Ocean. The system has been in operation since 1989 and is maintained with regular launches.[22]

The second military communication system on GEO, Geizer, is used as a relay for low earth orbit satellites, including imaging and communication satellites. The satellites also appear to have spare bandwidth capacity that can be used for civilian applications. Geizer satellites have operated since 1982. A full constellation would include three satellites, but Russia has had only one operational satellite of this type in orbit since 2000.

22. Yu. Zhuravin, "Na orbite—novaya Raduga," *Novosti kosmonavtiki*, no. 10 (2000).

Launch Sites

By the beginning of the 1990s, the Soviet Union had two primary space-launch centers—Baykonur (also known as Tyuratam) in Kazakhstan and Plesetsk near Arkhangelsk in northern Russia.[23] The centers were Ministry of Defense test sites and, along with space launch facilities, they included a number of military installations used for tests of ICBMs. The Military Space Forces operated the centers with the participation of the Ministry of General Machine Building, which had the responsibility for the Soviet space program.

Baykonur has always been the main space-launch site, from which all launches of manned spacecraft and all launches into GEOs have occurred. The unique role of the Baykonur site forced Russia to seek a leasing agreement with Kazakhstan after the breakup of the Soviet Union. The agreement asserts Kazakh sovereignty over the site and requires Russia to pay an annual fee for its use. A January 2004 agreement extended the lease until 2050 and made provisions for the development of joint Russian-Kazakh projects.[24]

The terms of the lease apparently allow the Russian armed forces to continue to use the site for military-related space and ballistic missile launches. At the same time, Russia has sought ways to move all its military activity to sites on the Russian territory, a stated long-term goal.[25] In order to do so, Russia has initiated construction of a new launch complex at the Plesetsk launch site, built some launch facilities in Svobodnyy on the Far East. It also commissioned a new launch facility at the ICBM base at Dombarovsky. The goal is to transfer all military launches to sites on Russian territory. Baykonur will most likely continue as a primary launch site for manned flights and for scientific and commercial activity.

Baykonur. The Baykonur space-launch site, established in 1955, is located in Kzyl-Orda region of Kazakhstan, at the latitude of 46° North and longitude of 63°40’ East. The northern location of the site limits the range of inclination of orbits that satellites can be inserted into, as no orbits with inclinations less than 46 degrees are possible. The location also imposes a penalty in payload weight as compared to launch sites closer to the equator.

The launch-site territory contains a number of launch complexes, each designed to support launches (and rocket and satellite preparation) of a specific launcher type. Each complex includes one or two launch pads (or silos).

Two launch complexes with one launch pad each—launch complexes Nos. 1 and 31—support launches of the so-called R-7 family, which includes space launchers based on the R-7 ICBM design. Among these are Vostok, Voskhod, and Soyuz launchers used for the manned space program, Molniya

23. Another test site used for launching small spacecraft, Kapustin Yar in Orenburg oblast, has not been used in this capacity for military purposes since 1988. In 1999, the site was used for a commercial launch and may be used in auxiliary role in the future.

24. Agreement between Kazakhstan and Russia on further development of cooperation in effective operation of Baykonur, Astana, January 4, 2002.

25. A. Bogatyrev, “Severnye starty,” *Krasnaya zvezda*, October 30, 2003.

Figure 1: Space Launch Sites and the Network of Control and Measurement Complexes

launchers used for launching satellites into HEO, and modified versions of these launchers used for various missions. The launchers of the R-7-family can deliver a payload of up to eight metric tons into a low earth orbit, depending on configuration.

Launch complexes 81 and 200 service the Proton heavy launcher. Each complex has two launch pads. Proton can lift up to about a twenty-ton payload into a low earth orbit and about five metric tons into a geosynchronous orbit. It has the greatest lifting capability of Russian space launchers and is used for all launches of geostationary satellites. Baykonur is the only launch site that has Proton launch facilities.

Another dedicated space-launch complex at Baykonur is launch complex 45, which includes two launch pads for Zenit launchers. One of these launch pads was almost completely destroyed during a failed launch in 1990. Zenit is a relatively new launcher, which began operation in 1985. It can deliver about 13 metric tons into a low earth orbit and its military use has been primarily for launches of reconnaissance and signal intelligence satellites.[26] Because the launcher is produced in Ukraine, its use for military launches will probably decrease.

Launch complex 90 is used for launches from a Tsiklon light launcher, also produced in Ukraine. The launcher is a modified R-36 (SS-9) missile and is used for a variety of military and civilian applications. It can deliver about 3.5 metric tons into a low earth orbit and has been recently used for the launch of a new US-PU naval intelligence satellite.

Other launch complexes at Baykonur are ICBM silos, modified to accommodate space launches performed by converted missiles. These are launch complex 175 Rokot launcher (a converted UR-100NU/SS-19 missile) and launch complex 109 of Dnepr launcher (a converted R-36M/SS-18 missile). Used as launchers, these missiles can deliver into a low earth orbit about 1.8

26. A. Zak, "Rockets: the Zenit Family," *Russian Space Web*, http://www.russianspaceweb.com/zenit.html, accessed October 12, 2003.

and 4.5 metric-ton payloads, respectively. Despite their military origin, these launchers have not been used in the military space program.

Launch complexes 110 and 250 were built for the Buran-Energia project, although some facilities date back to the N-1 lunar program. These complexes were used for the Energia heavy launcher in 1987 and 1988. Since then, the program has been terminated and the launch facilities mothballed. It is highly unlikely that the Energia system will resume or that these facilities could be used without substantial modification and upgrade.

Russia and Kazakhstan agreed in January 2004 to begin joint work on a project that would include a new launch complex for the Angara launcher. This launcher was developed in Russia, with the intention of moving launches of military satellites from Baykonur to Plesetsk. The launch complex in Baykonur will be used for commercial launches.

Plesetsk. Established in the late 1950s as a base for R-7 ICBMs, the Plesetsk site later became a major space-launch site for the Soviet space program as well as a test site for the development of ballistic missiles. After the breakup of the Soviet Union, Plesetsk was the only launch site in the Russian territory. The site is located in the northern Arkhangelsk region of Russia (63° North and 41° East). Compared with Baykonur or other launch sites, the northern position of the Plesetsk imposes further limits on both the range of inclinations of directly accessible orbits and the maximum payload. Despite this, Russia is developing Plesetsk as its main launch site, particularly for military space operations, primarily because the site already has extensive launch-support infrastructure.

Plesetsk has two launch complexes for missiles of the R-7 family (Soyuz and Molniya). These are complex 43, with two launch pads, and complex 16, with one; both have been used for launches of reconnaissance satellites, communication satellites, and early-warning satellites deployed in HEO.

Launch complexes 132 and 133 each have one launch pad for the Kosmos-3 rocket. This light launcher, which can place about 1500 kilograms into a low Earth orbit), is a modification of the R-14 ballistic missile. It has been used to deliver communication, navigation, and signal intelligence satellites into low Earth orbit. Launch complex 133 also includes a launch pad that was converted from a Kosmos-3 to a Rockot launcher.

Until recently, the Plesetsk site supported launches of Tsiklon rockets. These launches were conducted from two launch pads at launch complex 32 used for launches of naval reconnaissance satellites. After a launch in December 2004, Space Forces announced that it would no longer conduct Tsiklon launches from Plesetsk.

In the 1980s, the Soviet Union began to construct a complex that would support launches of Zenit rockets. After a series of delays, the plans were reconsidered and the complex was reoriented for Angara launchers. The initial plans called for Angara launches beginning in 2003–2004, but it is clear that the work is far behind the schedule.[27]

27. Yu. Zhuravin, "Plestsk poluchit razvitiye," *Novosti kosmonavtiki*, no. 3 (2002).

Svobodnyy. Until 1991, the Svobodnyy launch site was one of the operational bases for UR-100/SS-11 ICBMs. After the missiles were decommissioned during Strategic Arms Reduction Treaty (START) reductions, the base was chosen as a location of a new space-launch site. The site, located at the latitude of 52° North, can potentially provide access to a wider range of orbits than the site in Plesetsk.

Initial development plans for the site envisioned construction of launch complexes for Rockot and Angara launchers.[28] However, in 2006 the Russian government indicated that it will limit the activity in Svobodnyy.

So far, the only space launches conducted from the site have been those of Start-1 launcher—a converted Topol/SS-25 ballistic missile, which can deliver about a 600 km payload to a low earth orbit. It is launched from a road-mobile platform and therefore does not require construction of a launch pad.

Dombarovsky. The most recent addition to the family of Russian space-launch sites is Dombarovsky (also known as Yasnyy). Dombarovsky is an active ICBM base—forty-two R-36M/SS-18 missiles were deployed at the site in 2007 and the site has been used for ICBM test launches as well as for a commercial space launch in July 2006.

The Strategic Rocket Forces plan to use the base for launches of the Dnepr launcher, which is a converted SS-18 missile. This missile has been used for space launches already, though only from Baykonur. Unlike all other launch sites, Dombarovsky will be operated by the Strategic Rocket Forces. Dnepr launch services, whether from Baykonur or from Dombarovsky, will be marketed by a company named Kosmotras. The Rocket Forces expect to conduct up to seven space launches from the site annually.

Satellite Control and Space Surveillance Networks

The scale of the Soviet space program, both civilian and military, necessitated substantial investment in ground facilities and infrastructure to support satellite operations. In addition to space-launch sites, the Soviet Union built a network of ground-control and measurement facilities to control satellites, as well as stations to receive and process information supplied by space-based sensors and to deliver this information to military and civilian users. The Soviet Union also developed a network of satellite-tracking facilities that allowed it to monitor the space activities of other countries.

Control and Measurement Centers. Every space system includes a ground component from which operators control satellites and process data. The ground equipment is usually installed at one of twelve stationary control and measurement complexes (OKIKs), which are dispersed throughout the territory of the Soviet Union (see Table 6 and Figure 1). Some of these complexes specialize in certain tasks—the center in Galenki in the Far East, for example, has an antenna that allows it to communicate with interplanetary spacecraft. However, a center's mission usually is determined by the requirements of a

28. "Zapuski s kosmodroma Svobodnyy nachnutsya ne ranshe 2005 g," SpaceNews.ru, http://www.spacenews.ru/spacenews/live/full_news.asp?id=9209, accessed June 24, 2004.

Table 6: Control and Measurement Complexes

Location	Designation	Comment
Russia		
Eniseisk	OKIK-4	
Vulkannyy	OKIK-6	
Barnaul	OKIK-7	Measurement complex
Krasnoye Selo	OKIK-9	
Kolpashevo	OKIK-12	
Nizhniye Taltsy	OKIK-13	
Shchelkovo	OKIK-14	
Galenki	OKIK-15	Deep-space communication
Solnechnyy	OKIK-17	
Vorkuta	OKIK-18	
Lekhtusi	Training OKIK	
Ukraine		
Dunayevtsy		Navigation and communication
Yevpatoriya		Deep-space communication
Simferopol		
Kazakhstan		
Priozersk		Navigation and communication
Uzbekistan		
Kitab		Included laser ranging systems

particular system. Different programs may share installations if possible, but for the most part each program has its own dedicated equipment.

In the breakup of the Soviet Union, Russia lost a significant part of the Soviet control and measurement infrastructure. Ukraine had three complexes of this type, one of which, in Yevpatoriya, was dedicated to deep-space communication and served as a node in the regional network. One complex in Ukraine served as a regional center for navigation and communication satellites.[29] A similar complex at Priozersk in Kazakhstan, close to the major missile defense test site at Sary-Shagan, provided support for communication and navigation satellites. A complex of a different kind was located in Kitab, Uzbekistan. It was one of the newest additions to the control and measurement network and was equipped with laser measurement systems.[30]

In addition to the network of control and measurement centers, Russia maintains a network of smaller orbit-measurement facilities; this network includes more than a dozen small centers that provide trajectory and orbit measurements. Some of these facilities are situated along the trajectories followed by ballistic missiles during tests; others are located in the vicinity of space-launch sites. To supplement stationary systems, Russia operates and deploys as necessary a number of smaller mobile trajectory-measurement sys-

29. *Voyenno-kosmicheskiye sily,* vol. 3 (Moscow, 2001) p. 180.

30. *Voyenno-kosmicheskiye sily*, pp. 187–188.

tems. The Soviet Union also had five ship-based measurement systems, but none are in use today.

Most of these control and measurement complexes and facilities are managed by the Main Space Systems Center (GITsIU KS) located in Krasnoznamensk (also known as Golitsyno-2), near Moscow. The center is a main control unit for the Space Forces. It directs activities and accumulates data about operations for almost all military space-based systems. Although the Space Forces manage the launch of all satellites, the military usually transfer control of civilian satellites to their separate control facilities shortly after launch. However, some civilian systems use the hardware of the Space Forces' control and measurement network.

Subdivisions within the main center are responsible for specific programs. For example, a separate center, also located in Krasnoznamensk, is responsible for control of the Glonass system.[31] Some military systems, however, are managed completely separately. Among these are the US-KS and US-KMO early-warning systems, which have their own control center in Kurilovo, Serpukhov region,[32] and the US-PU naval intelligence system, which traditionally has been managed by the Navy.[33]

Space Surveillance and Tracking Systems. As with many other components of the space program, the space-surveillance and space-tracking systems that Russia inherited from the Soviet Union were adversely affected by the breakup of the Soviet Union. The Soviet space-tracking system relied primarily on early-warning radar stations deployed along the periphery of the Soviet territory. At the time of the breakup, most of the newer Daryal/Pechora radar systems were under construction; after 1992, they were left outside Russian territory. As a result, Russia has had to rely on older radar systems, some of which have been in operation since the early 1970s, for its space-tracking (and early-warning) needs.[34]

At the core of the radar network, which provides Russia with the capability to track objects in space, are: the Dnestr-M/Dnepr/Hen House radar systems at Olenegorsk (Murmansk region, Russia), Mishelevka (Irkutsk region, Russia), Balkhash (Kazakhstan), Sevastopol (Ukraine), and Mukachevo (Ukraine); the Daryal/Pechora radar systems at Olenegorsk, Pechora (Russia), and Gabala (Azerbaijan); and the Volga radar system in Baranovichi (Belarus). Many of these are outside Russia, which as a result must negotiate terms of use with the host country.

In addition to using dedicated early-warning radar systems, Russia also tracks objects in space using the radar of the Moscow missile-defense system. It has been reported that the Don-2N/Pushkino radar provides the most accurate tracking information.

31. I. Gorbunov, "Troistvennaya druzhba," *Vremya novostey*, April 5, 2004.

32. Pavel Podvig, "History and the Current Status of the Russian Early-Warning System."

33. A. I. Savin, G. F. Zotov, and Yu.Ye. Petrushchenko, "Sistema morskoi razvedki i tseleukazaniya," http://www.navy.ru/science/sor7.htm, accessed October 14, 2003.

34. Podvig, "History and the Current Status of the Russian Early-Warning System."

Other space-tracking capabilities are located at the Krona facility in Zelenchukskaya, Karachaiyevo-Cherkessia. The facility includes dedicated space-surveillance radar systems, which will be soon complemented by a laser ranger system.[35]

To track objects at high altitudes, where radars cannot see, Russia operates optical surveillance facilities. The most advanced of these systems is the Okno system, located in Nurek, Tajikistan. Construction of this system began in the 1980s, which reached operational status only in 1999. The Okno system can detect spacecraft at altitudes up to 40,000 km.[36] Scientific telescopes of the Academy of Sciences can also be assigned to track space objects if necessary.

ANTI-SATELLITE SYSTEM

The Soviet Union was the only country that developed and operationally deployed an anti-satellite (ASAT) system to attack satellites in low earth orbits. The United States worked on an ASAT system during the cold war, but abandoned these efforts during the early stages of development.

The development of the Soviet ASAT system began in the early 1960s, and the first test flights of maneuverable spacecraft were performed in 1963–1964. The TsNII Kometa design bureau of the Ministry of Radio Industry managed the development of the system. The space launcher used in the system was a modified R-36 (SS-9) missile, developed by OKB-586 design bureau (now Yuzhnoye Design Bureau). In addition to the launcher and the interceptor spacecraft, the system included a network of space-surveillance radar and the command and control center.

Initial tests of the system were conducted in 1968. During subsequent tests, the system demonstrated its ability to destroy satellites in low orbits, with altitudes of up to 1000 km. The system was tested with different intercept geometries, onboard sensors, and proximity fuses (infrared and radar).

The system was accepted for service and commissioned for active duty in 1979. The launchers were deployed at the Baykonur test site, where testing continued until 1982. In November 1983, the Soviet leadership announced a unilateral moratorium on further ASAT tests.

The status of the ASAT system deployed in Baykonur has never been officially disclosed, but it is certain that the system is no longer operational. Some reports indicate that the system underwent modernization that was completed in 1991. Parts of the space-surveillance network that were integral to the ASAT system were lost to Russia during the breakup of the Soviet Union. Russia formally decommissioned the system in 1993.

35. Sergey Kurushkin, in “Vysoty goda,” *Krasnaya zvezda*, October 2, 2004.

36. M. Sevastianov, and M. Davidenko, “Okno v kosmos,” *Novosti kosmonavtiki*, no. 9 (2003).

Space Forces

The current structure of the military space program is the result of a series of reorganizations conducted in the last decade. Today, the Space Forces manage all military space-related activities in Russia. These forces form a separate branch of the armed forces, and are directly subordinate to the General Staff. This makes the Space Forces independent from the main services of the armed forces (i.e., from the Air Force, Navy, or Army). The current configuration of the Space Forces was created in June 2001 by a presidential decree that transferred all units responsible for operating space-related facilities and satellite systems to the newly created branch of the armed forces. The Space Forces also currently include the units that operate the early-warning system, space-surveillance and space-tracking systems, and the Moscow missile defense system.

In the Soviet Union, space operations and early-warning and missile defense systems belonged to different services and branches of the military. Initially, all space-related activity was part of the Strategic Rocket Forces and its predecessor, where it was managed by a separate directorate, the Main Space Systems Directorate (GUKOS). In 1982, GUKOS was removed from the Strategic Rocket Forces and subordinated directly to the General Staff, and in 1986, its name was changed to the United Space Systems Directorate (UNKS). In 1992, shortly after the breakup of the Soviet Union, the units of UNKS were transformed into the Military Space Forces, which remained under the direct control of the General Staff.

During a major reorganization of the Russian armed forces in 1997, the Military Space Forces were again subordinated to the Strategic Rocket Forces. This time, the Strategic Rocket Forces also included early-warning, space-surveillance, and missile defense units, which were transferred from the disbanded Air Defense Forces. Reorganization in 2001 created the Space Forces as a separate branch of the armed forces, and all the above units were transferred to the Space Forces.

The 1997 reorganization constituted a major change in the traditional structure of the Soviet/Russian armed forces. Historically, early warning of a missile attack, tracking space objects, and operating missile defense systems were included among the missions of the Air Defense Forces, a separate service of the armed forces responsible for strategic defense of the country. In many important ways, its structure and responsibilities were different from those of the space directorate or Strategic Rocket Forces; integration of these units into the Military Space Forces after the 1997 reorganization was a difficult process, although the transition appeared to improve after the 2001 reform.

As a result of all reorganizations, the Space Forces currently include the following main units:

- space launch sites, at Baykonur, Plesetsk, and Svobodnyy;
- the Space Systems Control Center and a network of control and measurement centers;

- the Space and Missile Defense Army, which includes divisions that provide early warning, space surveillance, and missile defense; and
- other units, which include military academies and a directorate responsible for the construction of space and missile defense facilities.

The Space Forces are headed by Lieutenant-General Vladimr Popovkin, who was appointed to this post in March 2004. His predecessor, Colonel-General Anatoly Perminov, was transferred to the Federal Space Agency, which is responsible for the civilian space program.

Space Industry

In the Soviet Union, the defense industry played a very prominent role in the process of research and development. The armed forces were responsible for developing the technical requirements for new systems and then accepting these systems for service. Industry was responsible for financing research, development, and subsequent production of a new system. A special interagency government body, the Military-Industrial Commission, coordinated the efforts of various ministries involved in large research and development projects.[37]

The Ministry of General Machine-Building held responsibility for the development and production of space systems. The ministry handled development and production of ballistic missiles, space launchers, satellites, and the equipment to support these technologies. It managed most of the civilian space programs and provided oversight for military space programs.

Another defense ministry—the Ministry of Radio Industry—developed missile defense and early-warning systems. Design bureaus and enterprises of this ministry worked directly on the development of large radar systems used in early-warning, missile defense, and space surveillance and integrated their work in these areas into projects that involved other ministries of defense industry. For example, the Ministry of Radio Industry was responsible for the space-based early-warning and the anti-satellite systems, but the launchers and spacecraft used in these programs were developed and produced by the Ministry of General Machine-Building.

In the years after the breakup of the Soviet Union, the defense industry underwent a radical transformation, which significantly changed the structure of the industry and the way it handles the development and production of new military systems.

In the early 1990s, as old Soviet defense ministries were being abolished, the key design bureaus and production plants of the space industry were transferred to the Russian Space Agency. At the same time, the role of the new agency was not as far-reaching as that of the old Soviet ministry; it was largely limited to handling civilian projects in space, including projects that involved international cooperation.

37. "The Structure and Operations of Strategic Forces," in *Russian Strategic Nuclear Forces,* ed. Pavel Podvig (Cambridge, Mass.: MIT Press, 2001), p. 44.

The reorganization of other enterprises in the military industry, including those of the Ministry of Radio Industry, differed. They were first transferred to the Ministry of Economics, and later to its successors, as this ministry underwent a number of reorganizations. However, none of the successor governmental agencies had the authority or the necessary organizational structure to manage or coordinate new development projects. Besides, in the 1990s, the Russian government could not sustain spending in the defense industry at the level that had existed in the Soviet Union. As a result, much of the organizational and physical infrastructure of the defense industry has been lost.

In recent years, the Russian government has attempted several times to restructure the defense industry and streamline the development and acquisition processes. The reorganizations resulted in a structure that repeats that of the Soviet era in some important aspects; however, in other aspects, no less important, it differs. The acquisition process in the armed forces is still managed by special departments inside individual services. However, these departments must deal with defense industry design bureaus and companies directly, rather than through interagency processes managed by defense industry ministries and the Military Industrial Commission. The Ministry of Defense is also supposed to manage the development and production budget, which previously went directly to the industry.[38]

The main difference between the traditional Soviet system of research and development and the current Russian one is that the latter lacks an agency that coordinates the efforts of various defense industry companies and determines the long-term research and development plan. This difference occurs in both the defense industry in general and in its individual branches. For the purpose of this analysis, it is important to note that, in the past, neither the military space industry nor the industry responsible for missile defense and anti-satellite weapons retained an organizational component that managed the development of new systems. Development work in these fields has traditionally required a significant amount of coordination among various companies and ministries; the current lack of a central ministry for the oversight of development indicates that Russia probably does not have the capability to undertake large development programs in military space or in related fields.

An effort to correct this situation was undertaken during a major reorganization of the Russian government carried out in March 2004. As part of the reorganization, the Russian Space Agency was transformed into a Federal Space Agency and was subordinated directly to the prime minister. As discussed above, the new director of the agency, Colonel-General Anatoly Perminov, was the commander-in-chief of the Space Forces before his appointment to lead the civilian space program, an appointment that indicated the government's intent to strengthen both the civilian and the military space programs.

Despite these efforts, Russia has yet to demonstrate that it can successfully manage a large-scale research and development project in space, whether

38. N. Poroskov, "Kaska davit na mozgi," *Vremya novostey*, May 31, 2004.

military or civilian. In fact, as we have seen, even without new programs Russia has experienced problems maintaining the programs and infrastructure inherited from the Soviet Union.

CONCLUSION

Despite recent downturns, several aspects of the Russian space program and related industries—the scale of the space program, the existing industrial infrastructure, and the breadth of expertise retained by Russian companies—will make Russia an important actor in any development related to the militarization or weaponization of space. At the same time, the exact role that Russia would play in this process is still to be determined.

One possibility would be for Russia to compete with the United States in space (and militarily, in general), as the Soviet Union did in the past. This view of the future, fairly popular among Russian political and military leaders, may be explained by the fact that space technology is one of the few areas in which Russian technologies remain internationally competitive. Leaders see space as an area in which Russia can, and therefore should, maintain parity with the United States.

The Russian leadership has been paying close attention to the space program in recent years, which seems to indicate that Russia has set the goal of developing and supporting a full range of military space systems. If these plans materialize, Russian military satellites could become potential targets for space-based weapon systems (or ground-based anti-satellite systems). In addition, the history of missile defense and anti-satellite programs of the Soviet Union suggest that Russia could initiate new development efforts in these areas as well. Programs in these areas would enable Russia to deploy its own space-based weapons to counter the military space systems deployed by the United States. Although it is highly unlikely that the relationship between Russia and the United States would reach the point of a competition or even an arms race in space, this possibility has been widely used to justify space-weaponization programs. It is therefore important to consider whether the current state of the Russian space program supports the idea of Russia as a competitor to the United States in space.

First, Russia's ability to deploy a range of space-based military systems that would support the operations of the Russian armed forces—optical reconnaissance, navigation, and signal intelligence systems—is an essential component of competition in space. Russia does operate a number of systems of this kind, but, as discussed, none of them operates at full capacity. In addition, most of these systems were developed in the 1980s and have not been modernized for a substantial period of time, which hardly makes them suitable for support of modern military operations.

In many cases, Russia has to deal with the low reliability of satellites developed in the Soviet Union. This was not a serious problem when the military had access to a virtually unlimited launch capacity. It is a problem for

Russia now, however, as a large number of launches are required just to maintain constellations in a very limited configuration.

There is another problem, potentially more serious, with the current Russian military space program. Realizing the full potential of space requires a significant investment in the creation of an infrastructure that would allow troops to use information and capabilities provided by the space-based components of the system. Although Russia has been improving its capability to launch satellites and to maintain and operate satellite constellations, the development of infrastructure on the ground remains the weakest link, limiting much of the effort to broaden the use of space systems.

The Glonass satellite navigation system illustrates these points particularly well. It was developed in the 1970s and became operational in the mid-1980s. In recent years, Russia has invested considerable effort into having a full constellation of 24 Glonass satellites in orbit. In order to achieve this deployment, it had to upgrade the spacecraft to extend their lifetimes, as it could not otherwise provide enough launches to replace the satellites in orbit.[39] However, even if the plan to populate all slots in the constellation succeeds, the ground infrastructure does not seem to be ready to take advantage of the system. For example, it was reported that the aircraft of Military Transport Aviation do not have Glonass receivers onboard and rely on the GPS system of the United States instead.[40]

Most of the same problems are common to photoreconnaissance and signal intelligence systems. Although Russia has the capability to collect imaging information and to monitor communications, these capabilities are not integrated into the command structure of the armed forces to the extent that would make these systems directly usable in military operations. The launch schedule of the satellites that provide these capabilities confirm this lack of integration—for example, there have been no serious efforts to constantly maintain the presence of imaging satellites in orbit. The same is true of signal intelligence satellites— Russia does not maintain fully operational constellations. Although this may be explained in part by a lack of sufficient funding, success with other systems, namely communication satellites, shows that funding was probably not the only, or even the main, factor. As the recent history of communication-satellite launches demonstrates, Russia has been investing considerable effort into its space-based communication network. This was due partly to the dual-use nature of the satellites, which are used for both military and civilian communications; however, military systems like the Strela system have been maintained at close to full capacity.

The situation with early-warning satellites is also very characteristic of the current Russian space program. Although the space-based early-warning system is considered an important element of the strategic command and control system, Russia in effect discontinued its efforts to maintain a full constel-

39. Andrey Liscovich, "Global Navigation Satellite System."

40. N. Poroskov, "My vynuzdeny letat po amerkansroi sisteme," *Vremya novostey*, July 1, 2004.

lation of satellites in orbit after 2001, seemingly satisfied with the limited capability provided by the few satellites it can support. Expansion of the system does not appear to the have the urgency that would justify efforts to deploy the constellation in its full capacity.

All of these factors make Russia's space systems unlikely targets for space-based or anti-satellite weapons. Although an attack on some Russian military—or civilian—space assets could theoretically have adverse effects on Russia's capability to conduct military operations, in practice none of the currently deployed military space systems is advanced enough for an attack to make a significant difference militarily.

This situation could change if Russia were to modernize its military systems in space and better integrate them into the operations of the armed forces. For example, if Russia completes deployment of its Glonass navigation system, it could employ the system to expand the use of high-precision munitions. Another development of this kind would be the deployment of a naval intelligence system of the US-P/US-A (EORSAT/RORSAT) type, which would enable the detection of aircraft carriers and other ships. This example is usually cited (although in the context of the United States and China) as a potential justification for the development of an anti-satellite capability that would prevent deployment and operation of a naval intelligence system of this kind.[41]

Although a large-scale development effort of the kind described above cannot be ruled out completely, experience of the last several years has demonstrated that it is highly unlikely. For example, as discussed, Russia is experiencing substantial difficulties with the Glonass system. Similarly, deployment of a new naval intelligence system (or of any other military system) would require the kind of development effort that Russia has not yet been able to manage successfully.

The possibility that Russia will develop its own capability to deploy weapons in space or to build an anti-satellite system seems to be even more remote. First, Russia would certainly not become the first country to develop and deploy a space-related weapons system, as this would contradict its long-standing policy on the weaponization of space and its practice of following the United States in most technological developments. Besides, it is unlikely that without the United States committing itself to space-weapons development Russia would be able to make a decision to initiate any substantial effort of its own.

Even if the United States decided to introduce weapons in space, Russia would be unlikely to follow. Its experience with anti-satellite programs is discouraging—the capabilities of the Soviet system were very limited and if used would have had virtually no impact on the ability of the United States to operate its own space-based systems. With the increase in U.S. capabilities in space, a system of the kind that the Soviet Union had in the 1970s would be even less useful today. Among other factors that would make development of

41. Michael E. O'Hanlon, *Neither Star Wars nor Sancturary: Constraining the Military Uses of Space* (Washington, DC: Brookings Institution Press, 2004).

space-related weapons systems less likely are the very high cost of such systems and the lack of a proper organizational structure to support a development project in this area.

It is more likely that Russia would turn to a policy of "asymmetric response," planning measures to counter the systems developed by the United States should they present a threat to Russia's space assets. This policy would be relatively easy to implement, for, as already noted, Russia's limited reliance on space systems does not make its armed forces overly susceptible to an attack on space assets.

Russia does not have many options for the development of its own weapon systems in space or for its reaction to the development of this capability by other countries, namely the United States. However, this does not mean that Russia will not react should the United States move forward with the weaponization of space. As was the case with the U.S. withdrawal from the ABM Treaty, the Russian reaction might not be very visible, but it will be strong nonetheless. For example, Russia has used the abrogation of the ABM Treaty as an excuse to extend the service life of its multiple-warhead ballistic missiles and has taken other measures that have not made nuclear arsenals safer or more secure.

Eventually, measures such as extending the life of missiles are the most significant and dangerous global effects of new military developments, whether missile defense or space-based weapons. The fact that these measures and their costs are not immediately apparent does not mean that they do not exist or that they should not be taken into account. The benefits of introducing weapons into space are highly questionable—there are few if any cases that could possibly justify the development of space-based weapons capabilities. When these benefits are weighed against the costs, the case for weaponization of space is virtually indefensible.

CHAPTER 2

Chinese Perspectives on Space Weapons

HUI ZHANG

Chinese officials have expressed a growing concern that U.S. missile defense and "space control" plans, particularly the development of space weapons, will stimulate a costly and destabilizing arms race. In April of 2002, Vice Foreign Minister Qiao Zonghuai summarized the official Chinese view of U.S. plans:

> Considerable progress has been made in outer space-related weapons research and military technology. It will not take long before drawings of space weapons and weapon systems [are] turned into lethal combat instruments in outer space. Meanwhile, military doctrines and [concepts] such as "control of space" and "ensuring space superiority" have been unveiled successively, and space operation [command] headquarters and combatant troops are in the making. If we should remain indifferent to the above-mentioned developments, an arms race would very likely emerge in outer space in the foreseeable future. Outer space would eventually become the fourth battlefield besides land, sea and air. If such a scenario should become reality it would be virtually impossible for mankind to continue their anticipated exploration, development and utilization of outer space, and all economic, cultural and social activities in connection with the utilization of outer space would be severely interrupted.[1]

Although those in the Chinese scientific community have more nuanced perceptions than many officials, particularly regarding the feasibility and ultimate result of U.S. space plans, they share in the widespread concern over U.S. ambitions. The prevailing view in China is that U.S. space weaponization plans will have disastrous consequences for international security and the peaceful use of outer space.

Through space weaponization, the United States seeks to neutralize China's nuclear deterrence capabilities. Many in China worry that this would free the United States to intervene in China's affairs and to undermine efforts at reunification with Taiwan. These concerns have prompted China to clearly express—with sufficient frequency to merit an acronym—that the Prevention

1. Qiao Zonghuai, "An Effective Way to Prevent an Arms Race in Outer Space The Early Negotiation and Conclusion of an International Legal Instrument," speech presented at the China/UN Disarmament Conference, April 3, 2002, http://www3.fmprc.gov.cn/eng/29794.html.

of an Arms Race in Outer Space (PAROS) is an urgent and realistic objective. A 2004 white paper on China's national defense emphasized, "Outer space is the common property of mankind. China hopes that the international community would take action as soon as possible to conclude an international legal instrument on preventing the weaponization of and arms race in outer space through negotiations, to ensure the peaceful use of outer space."[2]

In recent years, the UN General Assembly has adopted resolutions—annually, and with an overwhelming majority—calling for the UN Conference on Disarmament (CD) to begin negotiations on PAROS. China and other nations have also advocated at the CD in Geneva for a negotiation of PAROS. Despite these efforts, the United States staunchly opposes any official discussion on outer space in this forum. The dispute has resulted in a deadlock at the CD in recent years. To resume and facilitate the CD negotiations on arms control, the issue of space weapons will have to be examined.

In this paper, I first examine in detail the major Chinese security concerns that are prompted by U.S. ambitions for missile defense and control of outer space. Second, I explore possible measures that China might consider in response to U.S. plans. Finally, I suggest technical and legal measures that the international community could take to protect the broad range of scientific, commercial, and military activities of all countries in space.

CHINA'S MAJOR SECURITY CONCERNS

U.S. missile defense and space weaponization plans could affect China's national interests, security environment, and commercial and civilian space activities. What are the various Chinese perspectives on U.S. plans and proposals? How does the U.S. pursuit of space dominance affect China's security? What is China's view on the effect of U.S. plans on the prospects for arms control, the nonproliferation regime, and the protection of the environment of space?

What China Perceives

The United States is pursuing a "Space Control" strategy. Many Chinese officials and security experts have read with great interest the U.S. military planning documents issued in recent years.[3] These documents explicitly envision U.S. control of space and the achievement of global military superiority through the use of weapons in or from space. The United States has issued a series of official statements in recent years that discuss the vulnerability of

2. Information Office of the PRC State Council, "White Paper on China's National Defense in 2004," December 27, 2004, http://www.china.org.cn/e-white/20041227/index.htm.

3. See, e.g., Hu Xiaodi, "Chinese Statement on Joint Working Paper," delivered at the CD on June 27, 2002; Fu Zhigang, "The Joint Working Paper by China and Russia," *INESAP Bulletin* 20, 2002; Yu Xiaoling, "Prevention of Weaponization in Outer Space—An Urgent Task," Presentation at the Eighth ISODARCO Conference on Arms Control, Beijing, October 14–18, 2002; and Li Hechun, transcript of "Prevention of Weaponization in Outer Space Tolerates No Delay," Beijing, 2002.

U.S. space assets to attack without warning and the need to protect U.S. satellites from all possible threats. The statements propose that the U.S. respond with the forceful domination of space and denial of access to those who may intend harm.[4]

Space control would assure U.S. access to and freedom of operations in space, and would deny others' use of space. This mission includes: space surveillance, protection of U.S. space systems, prevention or negation of an adversary's ability to use space systems and services for purposes hostile to U.S. national security interests, and direct support for battle management, command, control, communications, and intelligence.[5] The negation mission would include "measures to deceive, disrupt, deny, degrade, or destroy an adversary's space capabilities."[6]

A number of high-level official documents show the intention of the United States to develop, deploy, and use space weapons. In 2001, the report of a special commission on U.S. national security in space, chaired by current Defense Secretary Donald Rumsfeld, warned of the need "to avoid a 'space Pearl Harbor.'" The commissioners recommended "the U.S. government… vigorously pursue the capabilities called for in the National Space Policy to ensure that the president will have the option to deploy weapons in space to deter threats to, and, if necessary, defend against attacks on U.S. interests."[7]

In its 2003 report, *Transformation Flight Plan*, the U.S. Air Force lists a number of space weapon systems desirable in the event of a space war.[8] These include space-based kinetic kill vehicles, space-based lasers (SBL), hypervelocity rod bundles, space-based radio-frequency energy weapons, space maneuver vehicles, and evolutionary air-and-space global laser engagement. In August 2004, the Air Force released the doctrine document *Counterspace Operations*, which defines space superiority as the "freedom to attack as well as the freedom from attack" in space.[9] Counterspace operations include of-

4. These ideas are spelled out in a series of documents including: U.S. Space Command, *Vision for 2020* (Peterson AFB, Colo.: U.S. Space Command, 1997), http://www.fas.org/spp/military/docops/usspac/visbook.pdf; U.S. Space Command, *Long Range Plan*, (Peterson AFB, Colo.: U.S. Space Command, March 1998), http://www.fas.org/spp/military/docops/usspac/lrp/toc.htm; *Report of the Commission to Assess United States National Security Space Management and Organization*, Jan. 11, 2001, http://www.defenselink.mil/pubs/space20010111.pdf; U.S. Department of Defense, *Quadrennial Defense Review Report*, September 30, 2001, http://www.defenselink.mil/pubs/qdr2001.pdf; *The U.S. Air Force Transformation Flight Plan* (2003, 2004), http://www.af.mil/library/posture/AF_TRANS_FLIGHT_PLAN-2003.pdf, http://www.af.mil/library/posture/AF_TRANS_FLIGHT_PLAN-2004.pdf; and U.S. Air Force, *Counterspace Operations*, Air Force Doctrine Document 2-2.1, August 2, 2004, http://www.dtic.mil/doctrine/jel/service_pubs/afdd2_2_1.pdf.

5. *Counterspace Operations*.

6. U.S. Joint Chiefs of Staff, *Joint Doctrine for Space Operations*, Joint Publication 3-14, August 9, 2002.

7. *Report of the Commission to Assess United States National Security Space Management and Organization,* Washington, DC, Jan. 11, 2001.

8. *U.S. Air Force Transformation Flight Plan*, 2003.

9. *Counterspace Operations*.

fensive and defensive counterspace measures. To preclude an adversary from exploiting space to its advantage, offensive counterspace operations would attack, possibly preemptively, an adversary's space capability, including: satellites, space stations, or other spacecraft; communication links; ground stations; launch facilities; command, control, communication, computer, intelligence, surveillance, and reconnaissance systems; and space systems operated by third party providers. As the document indicates, these offensive operations would be conducted using a number of space weapon systems, such as anti-satellite weapons (ASATs) that "include direct ascent and co-orbital systems that employ various mechanisms to affect or destroy an on-orbit spacecraft,"[10] and directed energy weapons (DEWs), such as land-, sea-, air-, or space-based lasers.

Although there has been no formal public change in U.S. space policy, many Chinese are convinced by official statements and visible activity that U.S. policy is driving toward space weaponization—the development of weapons able to destroy targets in or from space. These weapons would presumably provide the United States with control over access to space and activity in space. Professor Du Xiangwan, vice president of the Chinese Academy of Engineering, said that the 2003 *Transformation Flight Plan* indicated that "many types of space based weapons will be developed" and that "the tendency of space weaponization is obvious and serious." He further pointed out that achieving military supremacy on Earth is not enough, as "the U.S. also seeks to dominate space."[11] Ambassador Li Daoyu, President of the China Arms Control and Disarmament Association, recently stated, "As we cheer for every success of peaceful exploration and use of outer space, we also hear the approaching bugling of war. The space military technology is advancing rapidly. New military and combat concepts and theories like 'control of space' and 'occupation of space' are emerging. Research and development programs of space weapons are in implementation. The danger of the weaponization of and an arms race in outer space is ever more imminent."[12]

In addition to the U.S. space control theory and doctrine, other U.S. actions suggest to China that the move toward space weaponization is real. For example, as discussed in detail below, the United States is developing and deploying missile defense systems, and has a number of active space weapons programs. Moreover, the U.S. has withdrawn from the 1972 Anti-Ballistic Missile (ABM) Treaty. Though not a party to the treaty, China viewed it as a cornerstone of strategic stability and an important legal instrument for preventing the deployment of weapons in space. Since withdrawing from the

10. *Counterspace Operations*, p. 33.

11. Du Xiangwan, "Preventing Pollution in Space," presentation at "Symposium on the Sustainability of Space Resources & Technology," Beijing, China, April 13–15, 2004.

12. Li Daoyu, "Prevention of the Weaponization of and an Arms Race in Outer Space: An Urgent Task With No Time to Delay," statement at the UN Institute for Disarmament Research conference on "Safeguarding Space Security: Prevention of an Arms Race in Outer Space," Council Chamber, Palais des Nations, Geneva, March 21, 2005.

ABM Treaty, the United States has had free reign to accelerate its space weaponization plans if it so chooses.

It is expected that the Bush administration will soon issue a new statement on military space policy—providing strategic guidance to the armament of the U.S. forces and the development of military technology in the foreseeable future.

Missile defense is one important step toward U.S. space control. The United States has promoted the development and deployment of missile defense, particularly of an integrated, layered system, and it has increased the budgets for missile defense programs. Since 2004, the United States has begun deployment of a ground-based midcourse defense (GMD) system. The system—comprised of seven interceptors in Alaska and another two in California—was activated in the summer of 2006. As many scientists and experts in the United States have pointed out, this initial GMD system would likely be ineffective against a real attack by long-range ballistic missiles[13]; however, from a Chinese perspective, there is no guarantee that the system would not someday, with the help of a breakthrough technology, become effective. Moreover, this GMD system could be the first step toward a more robust, layered system, capable of targeting missiles at various points in their flight trajectories.

Some Chinese observers view this GMD system as a space weaponry system. The scope of space weaponry, as generally defined in China, includes not only space-based weapons, but also any weapons that target objects in outer space, regardless of where they are based. Objects in outer space would include satellites as well as intercontinental ballistic missiles (ICBMs) traveling through outer space.[14] Because this GMD system would intercept its target at an altitude that China has defined as outer space (above 100 km), it would be considered space weaponry. Many Chinese feel that the U.S. plan to deploy a missile defense system is an intentional first step toward space weaponization.

Most important, controlling space requires ASAT weapons to negate an adversary's space capabilities, including their satellites. Even if the GMD system does not effectively intercept incoming missiles, it will have an inherent anti-satellite capability.[15] Many experts realize that it is technically easier to intercept a satellite than to kill a ballistic missile. As Bruce DeBlois and his colleagues explain, "Almost any midcourse missile defense system could threaten satellites, which are more fragile and more predictable (and therefore easier

13. Lisbeth Gronlund, David C. Wright, George N. Lewis, and Philip E. Coyle III, *Technical Realities: An Analysis of the 2004 Deployment of a U.S. National Missile Defense System* (Cambridge, MA: Union of Concerned Scientists, May 2004).

14. This interpretation of space weaponry is very popular in several authoritative Chinese publications. See Du Xiangwan, *Science and Technology Foundation For Nuclear Arms Control* (Beijing: National Defense Industry Pub., 1996); Liu Huaqiu, ed., *Arms Control and Disarmament Handbook*, (Beijing: National Defense Industry Pub., 2000).

15. See, e.g., Qiu Yong, "Analysis on the ASAT Capability of the GMD Interceptor," presentation at the Sixteenth International Summer Symposium on Science and World Affairs, Beijing, China, July 17–25, 2004; David Wright and Laura Grego, "Anti-Satellite Capabilities of Planned US Missile Defence Systems," *Disarmament Diplomacy* 68 (December 2002/January 2003).

to hit) than ballistic missile warheads."[16] The SBL, kinetic kill vehicles, GMD system, sea-based midcourse defense system, and theater high altitude area defense (THAAD) system would all be capable of attacking satellites in low Earth orbit (LEO) and, given an augmented booster, could reach higher orbits as well.[17] As David Wright points out, GMD "could intercept a large fraction of those satellites even from two deployment sites." He further notes that "the missile defense tests that have been done so far are much more relevant to demonstrating an ability to intercept satellites than to intercept missile warheads."[18] Aware of this technical reality, some in China have argued that the Bush administration's rush to deploy GMD is primarily motivated by a desire to acquire ASAT capability. Fu Zhigang, the First Secretary of the Permanent Mission of the People's Republic of China (PRC) to the UN in Geneva, stated, "To pursue missile defense programs is part and parcel of the relevant country['s] long-term strategy to control…outer space."[19]

It is not difficult to understand why Chinese officials hold this view. To control access to space and defend U.S. space assets requires a missile defense system with global coverage. As shown in some military documents, missile defense is considered an important part of U.S. "space control" strategy. For example, the U.S. Space Command document *Vision for 2020* made clear that national missile defense is a "key" to "Global Engagement Capabilities."[20]

Current U.S. ballistic missile defense (BMD) strategies aim to engage ballistic missiles in all phases—boost, midcourse, and terminal. The 2002 U.S. Nuclear Posture Review (NPR) included guidance for missile defense program development. The NPR states, "Missile defense is most effective if it is layered; that is, able to intercept ballistic missiles of any range in all phases of their flight."[21] It is expected that a robust BMD system capable of global coverage would start intercepting an ICBM as early as the boost phase,[22] which would require the use of space weapons such as the SBL and the space-based interceptor (SBI). Both of these systems would be deployed in LEO and used to destroy ICBMs in their boost phase. A layered BMD system would also include space-based sensors, such as early-warning satellites (e.g., Defense Support Program

16. Bruce M. DeBlois, Richard L.Garwin, R. Scott Kemp, and Jeremy C. Marwell, "Space Weapons: Crossing the U.S. Rubicon," *International Security* 29, iss. 2 (Fall 2004).

17. See, e.g., Li Hechun, transcript of "Prevention of Weaponization in Outer Space Tolerates No Delay," Beijing, 2002.

18. David Wright, "Technical Issues of Anti-Satellite (ASAT) Weapons," presentation at UCS-BUAA Workshop, Beijing, China, April 13–15, 2004.

19. Fu Zhigang, "Concerns and Responses: A Chinese Perspective on NMD/TMD," contributed paper of "Consultation on NATO Nuclear Policy, National Missile Defense & Alternative Security Arrangements," Ottawa, Canada, September 28–30, 2000.

20. U.S. Space Command, *Vision for 2020*.

21. "Nuclear Posture Review," December 31, 2001 (excerpts available at http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm).

22. See, e.g., American Physical Society, *Report of the APS Study Group on Boost-Phase Intercept Systems for National Missile Defense* (Washington, DC: APS, July 2003); Bob Preston, Dana J. Johnson, Sean Edwards, Michael Miller, and Calvin Shipbaugh, *Space Weapons, Earth Wars* (Washington, DC: RAND, June 2002), http://www.rand.org/publications/MR/MR1209/.

satellites, Space-based Infrared System–High [SBIRS-high]) and a space tracking and surveillance system (now STSS, previously referred to as Space-based Infrared System–Low [SBIRS-low]). Thus, a global BMD system would result in the deployment of weapons in space. In fact, the U.S. Department of Defense indicated in December 2002 that the United States would continue the "development and testing of space-based defenses, specifically space-based kinetic energy (hit to kill) interceptors and advanced target tracking satellites."[23]

The current U.S. budget for missile defense shows continued interest in a number of other programs related to space weapons.[24] First, in April 2007, the Near Field Infrared Experiment (NFIRE) satellite was launched into LEO. The satellite's infrared sensors gather data to assist in distinguishing a rocket body from a rocket plume during boost phase. The data from these tests would be used to develop space-based boost-phase interceptors. Moreover, if the NFIRE payload is to include a kill vehicle, as the Missile Defense Agency (MDA) is planning in a follow-on mission, it will effectively serve as an ASAT weapon. Second, the space-based interceptor test-bed program is funded to develop and test plans for a lightweight, kinetic-kill SBI. MDA expects the program to conduct its first experiment around 2012 and to be comprised of a few satellites armed with interceptors in orbit to test the functionality of a space-based BMD system.[25] This small number of interceptors would offer little defense against missiles because global coverage requires thousands of interceptor satellites in LEO.[26] However, these few satellites could have very significant ASAT capability, including against satellites in geosynchronous orbit.[27] Third, research on the SBL was conducted for some time as part of boost-phase missile defense. Although MDA cancelled the program in 2002, directed energy initiatives can still be found in other programs, and the possibility of reviving the SBL program in MDA still exists. All three of these space-based anti-ballistic missile weapons—the NFIRE satellite, SBIs, and the SBL—would also function as ASAT weapons and as a means to deny adversaries access to space.

The United States has space weapons programs beyond missile defense. The United States is pursuing a number of other ASAT weapons programs. For instance, the army launched the Kinetic Energy Anti-Satellite program in 1990 to develop a ground-launched kinetic kill vehicle capable of destroying an enemy satellite. The program currently is limited to the development of three flight-test ASATs that are to be shelved for possible future use. Another potential ASAT weapon system, the ground-based mid-infrared advanced chemical

23. U.S. Department of Defense, "Missile Defense Operations Announcement," December 17, 2002, http://www.defenselink.mil/releases/2002/b12172002_bt642-02.html.

24. See, e.g., Federation of American Scientists, *Ensuring America's Space Security: Report of the FAS Panel on Weapons in Space,* October 2004; Jeffrey Lewis, "Programs to Watch," *Arms Control Today*, November 2004.

25. U.S. Missile Defense Agency, "The 2006 President's Budget Request," MDA Exhibit R-4A (PE0603886C), http://www.dtic.mil/descriptivesum/Y2006/MDA/0603886C.pdf.

26. American Physical Society, *Report of the APS Study Group on Boost-Phase Intercept Systems*.

27. David Wright, "Technical Issues of Anti-Satellite (ASAT) Weapons."

laser originally conceived for the Strategic Defense Initiative (SDI), is under development. The United States also is developing counterspace systems to disrupt enemy satellites, e.g., the mobile, ground-based Counter Communications System used to disrupt an adversary's satellite-based communications for military purposes. This system was delivered recently to the Seventy-Sixth Space Control Squadron. Moreover, the U.S Air Force has a research project on small satellites, such as the Experimental Satellite Series, which could be used for surveillance and as ASATs. The air force launched the first satellite in the series in January 2003, and a second in April 2005.[28]

Several documents have proposed that the U.S. military develop space-based weapons for prompt global force projection through space.[29] Space-based global strike would provide the United States with the ability to target any point on the earth in less than 90 minutes and the capability for flexible—and surprise—strike for a range of target types, including hard and deeply buried targets and mobile targets. Recently, a number of these weapons—including the common aero vehicle, long-rod penetrators, and SBLs—have been widely discussed.[30] The common aero vehicle would be an aerodynamic reentry vehicle with increased range and accuracy. Delivered by a military space plane, conventional ballistic missile, or orbital system, it would strike against hard and deeply buried land targets, naval bases and surface combatants, massed forces, mobile targets, air bases, and other targets.[31] The military space plane, a reusable, unmanned space vehicle, would support a wide range of military missions. As proposed, these capabilities would include "precision strike capability; rapid unpredictable reconnaissance; new space control and missile defense capabilities; and both conventional and new tactical space lift missions that enable augmentation and reconstitution of space assets."[32]

Long-rod penetrators, often called "rods from God" by proponents of space-based weapons, are another tool for global power projection.[33] The orbited log-rod penetrators, which are tungsten or uranium rods in the shape of cones, would be de-orbited on command to strike a fix target on Earth. High-powered SBLs to be used against terrestrial targets have also been pro-

28. *Space News*, April 18, 2005.

29. See Larry G. Sills, "Space-Based Global Strike: Understanding Strategic and Military Implications," Occasional Paper No. 24 (Maxwell Air Force Base, Ala.: Center for Strategy and Technology, Air War College, August 2001); Terry Torraca, "Space Meets Sand at Lucky Sentinel," *Military Review* 8, no. 6 (2001).

30. Bob Preston et al., *Space Weapons, Earth Wars*.

31. Office of the National Security Space Architect, "National Security Space Roadmap" (Washington, DC: Office of the Secretary of Defense, U.S. Department of Defense, July 12, 1999), http://www.fas.org/spp/military/program/nssrm/initiatives/cavmsp.htm; Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

32. ONE Team (of National Aeronautics and Space Administration and U.S. Air Force), "The Military Space Plane: Providing Transformational and Responsive Global Precision Striking Power" (Peterson Air Force Base, Colo., January 2002), http://www.spaceref.com/docs/DOD/military_spaceplace_utility.pdf.

33. See Bob Preston et al., *Space Weapons, Earth Wars*; Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

posed.[34] As discussed, the SBL would threaten some targets with almost instantaneous destruction, including combustibles, aircraft canopies, and thin-skinned storage tanks.[35]

What China Fears

The United States has legitimate concerns about its space assets. Its military, economy, and society increasingly depend on these assets, which are inherently vulnerable to attack from many sources including ground-based missiles, lasers, and radiation from a high-altitude nuclear explosion. However, it does not necessarily follow that there are credible threats to those vulnerabilities.[36] Most Chinese analysts do not believe that other countries pose a serious threat to U.S. space assets. Only the United States and the Soviet Union explored, developed, and tested ASATs or other space weapons. The Soviet Union placed a moratorium on its ASAT program in the early 1980s. Although a number of countries are capable of attacking U.S. satellites by launching a nuclear weapon into space, there is no reason to believe that any government would risk incurring a deadly U.S. response. Indeed, most countries, including China and Russia, have been urging negotiations to prevent the deployment of weapons in and through space.

As many experts point out, space-based weapons cannot protect satellites, as these weapons are vulnerable to the same types of attack as the objects they are meant to protect.[37] Chinese officials believe the real purpose of U.S. space plans is not to protect U.S. assets but rather to further enhance U.S. military dominance. As one official pointed out, "Space domination is a hegemonic concept. Its essence is monopoly of space and denial of others' access to it. It is also aiming at using outer space for achieving strategic objectives on the ground."[38] Ambassador Hu Xiaodi warned, "It is rather the attempt towards the domination of outer space, which is expected to serve in turn the absolute security and perpetual superiority (many people call this hegemony) of one country on earth. The unilateralism and exceptionalism that are on the rise in recent months also mutually reinforce this."[39]

34. See Bob Preston et al., *Space Weapons, Earth Wars,* app. A, pp. 109–130. See also a discussion by Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

35. See, e.g., Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

36. See, e.g., Federation of American Scientists, *Ensuring America's Space Security: Report of the FAS Panel on Weapons in Space*, Federation of American Scientists, October 2004.

37. See, e.g., David Wright et al., *The Physics of Space Security: A Reference Manual* (Cambridge, Mass.: American Academy of Arts and Sciences, May 2005); Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

38. Wang Xiaoyu, "Development of Antiballistic Missile Systems vs. the Prevention of an Arms Race in Outer Space," Presentation at the WILPE Seminar, "Prevention of an Arms Race in Outer Space," Geneva, March 10, 1999.

39. Hu Xiaodi, remarks at panel discussions on "A Treaty to Prohibit Weapons and War in Space?" and "Missiles: How Can We Reduce the Dangers They Pose?" sponsored by the NGO Committee on Peace and Disarmament, in cooperation with the UN Department for Disarmament affairs and the UN Department of Public Information, October 11, 2001.

Washington's missile defense plans and ambitions to dominate the use of space would very likely spark competitive military dynamics in space. As China's proposal on PAROS at the CD states, "Outer space is the common heritage of mankind and plays an ever-increasing role in its future development." China fears that the U.S. space weaponization plans will have disastrous effects on the peaceful use of outer space.[40] U.S. plans will also have harmful consequences for China's political, military-strategic, commercial, and international security interests. Of particular concern is the effect of U.S. actions on China's modest deterrent capabilities, its capacity to pursue unification with Taiwan, its commercial stake in space development, and its broader interest in a stable security environment.

Arms competition in space. Because space-based weapons are at once threatening to other countries and vulnerable to attack, it is reasonable to assume that countries capable of blocking their use would do so. One possible response would be the development of ASATs to target space-based weapon systems. It is widely believed that space-weapons platforms and sensor satellites would become prime high-value targets and the most vulnerable to defense suppression attacks. Destroying a satellite is far simpler than destroying a warhead carried on a reentry vehicle. As a result, for systems that rely on strike weapons or crucial sensors based in space (e.g., BMD), as Ashton Carter stated, "ASAT attack on these components is probably the cheapest and most effective offensive countermeasure."[41] It is reasonable to believe that other countries could resort to asymmetric methods to counter critical and vulnerable space-based components in LEO, such as weapon carrier vehicle satellites and space-based tracking satellites.

China fears that U.S. space weaponization plans, if acted on, will inevitably lead to an arms race in outer space and risk turning space into a battlefield. Richard Garwin, among others, speculates that "if there are weapons in space, then there will be extensive development and deployment of ASAT, in order to negate those weapons."[42] Chinese Ambassador Hu Xiaodi expressed China's concerns about an arms competition in space:

> The country that takes the lead in deploying weapons in space will enjoy an advantage for a period, but it will not be able to monopolize space weapons. Other states, when they find it affordable economically, scientifically and technically, will follow suit at a different pace and scale. This many not generate *a space arms race* in its strict sense (because other states are not really competing with the leading power),

40. China and Russia, together with Indonesia, Belarus, Viet Nam, Zimbabwe, and Syria, co-sponsored a working paper, "Possible Elements for a Future International Legal Agreement on the Prevention of the Deployment of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects," CD/1679, June 2002.

41. Ashton Carter, "The Relationship of ASAT and BMD Systems," in *Weapons In Space*, ed. Franklin Long et al. (New York: W.W. Norton & Company, 1986).

42. Richard Garwin, "Space Weapons or Space Arms Control," Presentation at the general meeting of the American Philosophical Society, April 2000.

but the space weapon arsenal will inevitably develop and increase both qualitatively and quantitatively. As soon as the weapons are deployed in outer space, the international community will have to change its efforts from preventive ones to the aim of *space disarmament*. Soon afterwards, as a few other countries (major powers) also have put their weapons in the arena of outer space, there will be an attempt towards *space weapon non-proliferation*—that is, let the *haves* continue their privileged position, while prohibiting other *have-nots* from accessing space weaponry. In other words, an old story will unfold in a new form.[43]

A loss of strategic nuclear deterrent capability. China developed its nuclear weapons to break up the nuclear monopoly of the two cold war superpowers and to prevent nuclear blackmail. China's nuclear policy is clearly expressed in its 2002 defense white paper: "China has always exercised utmost restraint on the development of nuclear weapons, and its nuclear arsenal is kept at the lowest level necessary for self-defense only."[44] The PRC has one of the smallest nuclear arsenals of all the nuclear weapons states. On the day it declared its possession of nuclear weapons, China adopted a nuclear no-first-use policy, and a nuclear no-use policy against non-nuclear weapons states or nuclear weapons free zones. China has consistently urged all nuclear weapon states to arrive at a nuclear no-first-use agreement.

It is reported that China has about twenty ICBMs with a range of 13,000 km, capable of reaching the United States. Unlike the warheads of other nuclear powers, as reported, China's nuclear warheads are not on launch-on-warning status because China does not have an effective early-warning system. Thus, China's nuclear deterrence is based on the retaliatory capability it retains after absorbing a nuclear attack. Unless it could confidently eliminate China's twenty ICBMs in an initial strike, the United States would in theory be deterred from initiating a nuclear attack. If the United States were to deploy missile defense systems, this situation would change completely. A space-based, boost-phase defense would be particularly threatening.

Within China, it is widely believed that U.S. missile defense and space planning targets China. Many Chinese are skeptical of U.S. statements that the purpose of missile defense is to protect against "rogue" states. Even if North Korea successfully deployed a small number of nuclear-tipped ICBMs—a principal U.S. concern—it is highly unlikely that it would use them. What leader would risk national suicide by launching a nuclear attack on the United States? From China's perspective, it seems untenable that the United States would expend massive resources on a system that has only "rogue" states in mind.[45] Some missile defense advocates in the United States have not minced their words about the utility of the system for addressing Chinese

43. Hu Xiaodi, Remarks on "A Treaty to Prohibit Weapons and War in Space?"

44. Information Office of the PRC State Council, "White Paper on China's National Defense in 2002," December 9, 2002.

45. See, e.g., Shen Dingli, "What Missile Defense Says to China," *The Bulletin of the Atomic Scientist* 56, no. 4 (July/Aug 2000): 20–21.

capabilities. For example, Peter Brookes, advisor on East Asian affairs to the international relations committee of the U.S. Congress, said that the major motive that drives the United States to develop and deploy missile defense systems is China's missile capability.[46] Recently, Lieutenant General Henry A. Obering III of the U.S. Air Force, director of the MDA, expressed clearly that the United States is expanding its preliminary missile defense system to address potential threats from China and others. He told defense reporters, "What…we have to do is, in our development program, be able to address the Chinese capabilities, because that's prudent."[47] Chinese government officials are more inclined to believe these comments than stated U.S. purposes. As Ambassador Sha Zukang said, "Though the U.S. government has publicly denied that China is a major target of its NMD program, the history of missile defense programs and the acknowledged design capabilities of NMD show that the proposed system can be directed against China and can seriously affect China's limited nuclear capability."[48]

Even a limited missile defense system could in principle neutralize China's twenty single-warhead ICBMs capable of reaching the United States.[49] Chinese officials realize this danger. "It is evident," said Ambassador Sha Zukang, who until recently was the director general of the Department of Arms Control and Disarmament at the Chinese Ministry of Foreign Affairs, "that the U.S. NMD will seriously undermine the effectiveness of China's limited nuclear capability from the first day of its [NMD] deployment. This can not but cause grave concerns to China."[50] Many Chinese fear that whether or not U. S. missile defenses are as effective as planned, decision-makers could become incautious in their actions, willing to risk a disarming first strike because they believe they have the capability to intercept any surviving Chinese missiles.[51]

Some Chinese analysts argue that deployment of U.S. missile defenses will also support offensive operations.[52] China is concerned about the U.S.

46. Peter Brookes, "The Case for Missile Defence," *Far Eastern Economic Review*, September 7, 2000.

47. Ann Scott Tyson, "U.S. Missile Defense Being Expanded, General Says," *Washington Post*, July 22, 2005.

48. Sha Zukang, "US Missile Defense Plans: China's View," *Disarmament Diplomacy* 43 (2000).

49. See, e.g., Shen Dingli, "What Missile Defense Says to China"; Li Bin, "The Effects of U.S. NMD on Chinese Strategy," *Jane's Intelligence Review*, March 7, 2001; Qu Changhong, "Can IDO Intercept Chinese Missiles?" presentation to the Seventeenth International Summer Symposium on Science and World Affairs, Princeton University, NJ, July 23–31, 2005.

50. Sha Zukang, "The Impact of the US Missile Defense Programme on the Global Security Structure," paper presented at the CPAPD/ORG Joint Seminar on Missile Defense and the Future of the ABM Treaty, Beijing, March 13–15, 2000.

51. Li Bin, "Impact of U.S. NMD on Chinese Nuclear Modernization," Presentation to Pugwash Meeting No. 261, Seoul, South Korea, April 2001, http://www.pugwash.org/reports/rc/rc8e.htm. See also Fu Zhigang, "Concerns and Responses."

52. Tan Han, "The Impact of the Development of the NMD by Bush Administration on International Stability," presentation at the eighth ISODARCO Conference on Arms Control, Beijing, October 14–18, 2002.

refusal to declare a no-first-use policy, and the 2002 NPR has fed these anxieties. The NPR specifically described conditions for the use of nuclear weapons in the event of conflict in the Taiwan Strait, and the possible use of tactical nuclear weapons.[53] The United States' lack of a no-first-use policy, in combination with a deployed BMD system, would lower the nuclear threshold and increase the reliance on nuclear weapons, making nuclear conflict with China more likely. According to John Steinbruner, China and other countries have good cause for concern: "A defensive missile deployment operating in conjunction with a preemptive attack would pose a formidable threat to the deterrent capability of any military establishment operating outside of the United States alliance system."[54]

There is also concern in China about U.S. plans for global force projection. Current Chinese nuclear modernization plans call for the development of mobile ICBMs. Some proposed space weapons (such as common aero vehicles) would be used against hard and deeply buried land targets and mobile targets, and would pose a huge threat to mobile ICBMs. The NPR recognizes the value of enhancing U.S. capacity to target mobile missiles. As the report says, "A U.S. demonstration of the linkage between long-range precision strike weapons and real-time intelligence systems may dissuade a potential adversary from investing heavily in mobile ballistic missiles."[55]

Consequently, China worries that U.S. space weapons and its missile defense system could subject China to political or strategic blackmail and infringe on China's sovereignty. These capabilities would free the United States to intervene much more in China's affairs, including efforts at reunification with Taiwan. This concern has been underscored in recent years by U.S. efforts to boost cooperation with Japan, and potentially with Taiwan, in research and development of advanced theatre missile defense.

Damage to arms control and nuclear proliferation regimes. The inherent offensive and first-strike capabilities offered by space weapons would likely provoke destabilizing military and political responses from other countries. As Ambassador Hu points out, "With lethal weapons flying overhead in orbit and disrupting global strategic stability, why should people eliminate WMD [weapons of mass destruction] or missiles on the ground? This cannot but do harm to global peace, security and stability, hence be detrimental to the fundamental interests of all States."[56] Nuclear experts have warned that deploy-

53. See, e.g., Paul Richter, "U.S. Works Up Plan for Using Nuclear Arms," *Los Angeles Times*, March 9, 2002, http://www.latimes.com/news/printedition/la-000017501mar09.story; William M. Arkin, "Secret Plan Outlines the Unthinkable," *Los Angeles Times*, March 10, 2002, http://www.latimes.com/news/opinion/la-op-arkinmar10.story. Excerpts from the Nuclear Posture Review are available online at http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm.

54. John Steinbruner, statement to the Parliament of Denmark at the Hearings on Missile Defense, April 25, 2001, http://www.puaf.umd.edu/CISSM/Publications/Copenhagen NMDStatement.htm.

55. "Nuclear Posture Review."

56. Hu Xiaodi, Remarks on "A Treaty to Prohibit Weapons and War in Space?"

ing even limited missile defenses would increase the difficulty of reducing the numbers of warheads.[57] Russia has threatened to respond to any country's deployment of space weapons.[58]

The Chinese government holds that a secure international environment and strategic stability are the foundations for advancing the international nuclear disarmament process.[59] However, U.S. missile defense and space weaponization plans will destroy these foundations. Ambassador Hu made this point clearly in remarks to the CD:

> It should be stressed that efforts to prevent an arms race in outer space and those on nuclear disarmament go hand in hand. In this perspective, it is of crucial importance for nuclear disarmament that a missile defense system undermining strategic stability should not be developed, and that no weapons should be deployed in outer space. It is hard to imagine that once a full-fledged missile defense system is put in place or weapons have been introduced into outer space there can be business as usual in nuclear disarmament. At best, such moves would never be conducive to nuclear disarmament.[60]

If China, or any other nation, felt a need to build new warheads to enhance deterrent capabilities in response to perceived provocation in space, this would increase demand for plutonium and highly enriched uranium to fuel those weapons. The process could harm the chances of negotiating a successful Fissile Material Cutoff Treaty (FMCT), which has long been seen as a key building block for controlling nuclear weapons proliferation and for eventual disarmament. Failure to proceed with the nuclear disarmament process, to which the nuclear weapon states are committed under the Treaty on the Non-proliferation of Nuclear Weapons, would undermine the already fragile nuclear non-proliferation regime. In short, China, as evidenced in Chinese statements at the CD, is concerned that the deployment of space weapons "will disrupt strategic balance and stability, undermine international and national security and do harm to the existing arms control instruments, in particular those related to nuclear weapons and missiles, thus triggering new arms races."[61]

Limitations on China's civilian and commercial space activities. China's most urgent national objective is economic growth. It needs a stable international security environment to concentrate its resources on economic development. Chinese security analysts are mindful that the United States' Strategic De-

57. See, e.g., Charles Glaser and Steve Fetter, "National Missile Defense and Future of U.S. Nuclear Weapons Policy," *International Security* 26, no. 1 (Summer 2001): 40–92.

58. Steve Gutterman, "Reports: Russia Threatens Retaliatory Steps if any Country Deploys Weapons in Space," *AP Worldstream*, June 2, 2005.

59. Hu Xiaodi, statement at the Plenary of the Second Part of the 2005 Session of the CD, June 23, 2005.

60. Ibid.

61. Ibid.

fense Initiative in the 1980s induced the Soviet Union to waste resources in response. They argue that the intention of U.S. missile defense plans could be to bring China into an arms race that would exhaust its resources and harm its economic development. Though any response to U.S. missile defense measures would cost China much less than the development of comprehensive missile defense, it would nevertheless divert resources from economic development. In particular, space weaponization could limit China's civilian and commercial space activities.

Since launching its first satellite in 1970, China has made steady progress in launch vehicle design and other areas of space technology development for civilian and commercial purposes. China has operational civilian satellites, a family of launchers, a modern space launch complex, and a growing list of customers in the international satellite-launch market.[62] By October 2000, China had developed and launched 47 satellites of various types, including recoverable remote-sensing satellites and satellites for telecommunications, meteorological research, Earth observation, and other scientific and technological research. China also initiated a manned space flight program in 1992, which has developed both manned spacecraft and a high-reliability launching vehicle. Between November 1999 and December 2002, China launched four unmanned experimental *Shenzhou* ("magic ship") spacecraft. China successfully launched the *Shenzhou* 5 manned spaceship in October 2003, and the *Shenzhou* 6 manned spaceship in October 2005. China is now planning to explore the Moon with unmanned spacecraft.

The global economy is intimately tied to assets in space.[63] During the last two decades or more, China has participated in bilateral, regional, multilateral, and international space cooperation in different forms, such as commercial launching services, and these have yielded significant achievements. In 1985, the Chinese government opened the "Long-March" rockets to the international commercial launching market. Since then, China has a growing list of customers in the international satellite-lunch markets,[64] and seeks to acquire a greater share of the international commercial launching market.

China's space launch complexes are relatively large and comprehensive. Three different facilities provide the capability to launch objects into LEO, geosynchronous, and polar orbits. With these launch complexes, China has positioned itself to support any requirement for a space launch, commercial, military, or scientific. Though these matters are not linked explicitly in official public documents, China perceives itself as a developing space power, in need of free access to space for its own economic growth. The U.S. pursuit of space control would threaten China's civilian and commercial space activities, and even deny China access to space.

62. Information office of PRC State Council, "White Paper on China's Space Activities," Nov. 22, 2000, http://www.china.org.cn/e-white/8/.

63. Yao Yunzhu, "BMD: A Step to Weaponize the Outer Space," presentation to the *Workshop on Moving Beyond Missile Defense*, Shanghai, China, Nov. 30–Dec. 2, 2001.

64. "White Paper on China's Space Activities," 2000.

Space debris. Development and use of space for military and civilian purposes over four decades has resulted in a large amount of man-made space debris. Man-made space debris includes dead spacecraft, discarded rocket bodies, launch- and mission-related castoffs, remnants of satellite breakups, solid-rocket exhaust, and frayed surface materials.[65] These artificial objects, along with natural objects (i.e., meteoroids), contribute to the particulate environment of Earth. A collision with even a tiny piece of space debris can damage or destroy a spacecraft, because its approach velocity is very high. The increasing amount of space debris poses a considerable hazard to all kinds of spacecraft, which concerns many Chinese scientists.[66]

Currently, there are about 16,000 space debris objects larger than 10 cm in size, of which 13,000 are in LEO (below 3,000 km), 2,000 are in medium Earth orbit (MEO) (3,000–30,000 km), and 600 are in geosynchronous orbit (36,000 km).[67] However, the probability of collision with a spacecraft remains low. Because the larger pieces are tractable, and spacecrafts can take measures to avoid them, they do not yet pose a significant threat. Space objects smaller than 1 cm probably exceed tens of millions and are hard to detect, but spacecrafts are can be protected against them by shielding, depending on the shield type.

The main threat to spacecraft is medium-size debris (1–10 cm), which is numerous and cannot be tracked and evaded. A spacecraft with insufficient shielding would be destroyed upon collision with such an object. It is estimated that there are over 300,000 medium-size debris objects—120,000 in LEO, 170,000 in MEO, and 20,000 in geosynchronous orbits.[68] At present, these objects do not pose an unacceptably high risk for spacecraft. For example, the mean time between debris impacts on a spacecraft with a cross-sectional area of 100 m^2 is about once in 245 years at an altitude of 800 km and once in 534 years at an altitude of 1500 km.[69] However, if space activity continues in a business as usual scenario (i.e., no space weaponization), and if there were no mitigation measures to limit and control the future growth of the space debris population, the risk from space debris, in particularly in LEO, would be increased within decades to a level that would pose unacceptable

65. N. L. Johnson, "Controlling Debris in Space," *Scientific American* 279, no. 2 (August 1998): 62.

66. See a number of research papers presented at "Symposium on the Sustainability of Space Resources & Technology," Beijing, China, April 13–15, 2004, including: Chen Shenyan and Hu Zhendong, "Recent Developments on Hypervelocity Impact and Simulation Software for Space Debris"; Huang Hai and Jia Guanghui, "Study on Hypervelocity Impact Simulation of Space Debris"; and Wang Ting, "Research on Collision Probability between Debris Clouds and Spacecraft." See also Dong Yunfeng, "NMD, Arms Race and Space Debris," Presentation at the Fourteenth International Summer Symposium on Science and World Affairs, Urbana, Illinois, July 15–21, 2002.

67. R. Walker et al., *Update of the ESA Space Debris Mitigation Handbook,* Executive Summary, July 2002, http://www.esa.int/gsp/completed/execsum00_N06.pdf.

68. Ibid.

69. Ibid.

risk to spacecrafts.[70] In recent years, scientists and engineers have investigated different debris mitigation measures and spacecraft protection techniques to reduce the risks to future missions.

Weaponizing space would worsen the space debris problem. Under U.S. space plans, a larger number of space weapons could be deployed. A BMD system would include dozens or possibly hundreds of SBL weapons, and hundreds or thousands of SBI and sensor satellites; additional weapons for attacking satellites or Earth targets could be added to the total. Most of these systems would be stationed in LEO. The deployment of these weapons would increase the object population, and the launching and testing of these weapons would increase space debris. Moreover, the deployment of unlimited space-based weapons in the increasingly crowded LEO would limit orbit resource usage for civilian purposes.

Even worse, if ASAT weapons are used to destroy and fragment satellites, more orbital debris will be generated. As part of an ASAT test in September 1985, the United States used an air-launched miniature homing vehicle to fragment the *Solwind* spacecraft. More than 200 catalogued pieces of debris were produced, and most remained in orbit for several years.[71] Although the fragments created by the impact of an SBI on a boost-phase missile would not significantly contribute to the orbital debris in LEO,[72] an SBI would fragment a satellite into hundreds of pieces of tractable debris (larger than 10 cm) and far more medium-size pieces of orbital debris. These medium-sized objects, with mass ranging from several grams to tens of grams, at a collision velocity of about 10 km/s could fragment another hundred-kilogram to several ton satellite. The mass distribution of fragments generated in hypervelocity impacts have demonstrated that a two-ton satellite can be broken into several hundred thousand medium-size pieces, hundreds of larger ones, and billions of fragments smaller than 1 cm. Thus, fragments from several shattered satellites could result in a several-fold increase in the orbital debris population in LEO.

Many scientists are concerned that once space debris reaches a "critical density" a process of collisional cascading—a chain reaction where collision fragments trigger further collisions—will start. As a result, the density of debris surrounding Earth would be too great to allow the stationing or penetration of any satellites. Some experts estimate that a critical density of space debris would be reached in LEO with only a few-fold increase over current levels.[73] Some scientists estimate that the density may already be sufficiently

70. See, e.g., P. Eichler and D. Rex, "Debris Chain Reactions," Paper AIAA-90-1365, AIAA/NASA/DOD, "Orbital Debris Conference: Technical Issues and Future Directions," Baltimore, Maryland, April 16–19, 1990; D. J. Kessler, "Collision Probability at Low Altitudes Resulting from Elliptical Orbits," *Advances in Space Research* 10, no. 3 (1990): 393; D. J. Kessler, "Collisional Cascading: The Limits of Population Growth in Low Earth Orbit," *Advances in Space Research* 11, no. 12 (1991): 63.

71. N. Johnson and D. McKnight, *Artificial Space Debris* (Malabar, Flor.: Orbit Book Company, Inc., 1987).

72. Federation of American Scientists, *Ensuring America's Space Security: Report of the FAS Panel on Weapons in Space,* October 2004.

73. P. Eichler and D. Rex, "Debris Chain Reactions."

great at 900–1000 km and 1500–1700 km to sustain a cascade of collisions.[74] Thus, it is not implausible to suggest that fragmenting several satellites at LEO could lead to a chain reaction, which would result in the elimination of satellites and vehicles in LEO. This includes those used for space exploration, such as the Hubble Space Telescope (at about 600 km), the Space Shuttle, International Space Station, Earth-observing satellites, photo-reconnaissance satellites, and some navigation satellites. As Joel Primack points out, "Weaponization of space would make the debris problem much worse, and even one war in space could encase the entire planet in a shell of whizzing debris that would thereafter make space near the Earth highly hazardous for peaceful as well as military purposes."[75]

Given concerns about space debris, some senior scientists in China emphasize that the definition of environmental pollution should not refer solely to Earth, but should include outer space, where human activities are also carried out. As Du Xiangwan, vice president of Chinese Academy of Engineering, recently noted, "Indeed prevention of pollution in space should be put on [the] agenda …as time goes by, this problem will become increasingly obvious." He continued, "In preventing space pollution, the following two issues are worth noticing: space garbage and weaponization of space."[76] Recent official Chinese statements at the CD directly addressed concerns about space debris: "The deployment and use of space weapons will seriously threaten the security of space assets and impair the biosphere of the Earth. The tests of space weapons in near-Earth orbit will exacerbate the already serious problem of 'space debris.'"[77]

CHINA'S OPTIONS FOR RESPONDING TO U.S. SPACE PLANS

Chinese analysts and policy makers are discussing whether and how to respond to U.S. missile defense and space weaponization plans. A few Chinese scholars argue that China should not respond at all because the U.S. missile defense program is not feasible and will likely be given up. However, conversations with Chinese experts and officials demonstrate that most Chinese believe that China must respond.

Historically, China developed nuclear weapons for the sole purpose of guarding itself against the threat of nuclear blackmail. Many Chinese officials and scholars believe that China should maintain the effectiveness of its nuclear deterrent by every possible means, to negate the threats from missile defense and space weaponization plans.[78] As one Chinese official

74. D. J. Kessler, "Collision Probability at Low Altitudes"; D. J. Kessler, "Collisional Cascading."

75. J. Primack, "Pelted by Paint, Downed by Debris," *The Bulletin of the Atomic Scientists* (September/October 2002).

76. Du Xiangwan, "Preventing Pollution in Space."

77. Hu Xiaodi, statement at the CD, June 23, 2005.

78. See, e.g., Sha Zukang, "US Missile Defense Plans: China's View"; Li Bin et al., "Missile Defense: China Will Have to Respond," *Bulletin of Atomic Scientists* 57, no. 6 (2001).

stated, "China is not in a position to conduct [an] arms race with [the] U.S. and it does not intend to do so, particularly in the field of missile defense. However, China will not sit idly by and watch its strategic interests being jeopardized without taking necessary measures. It is quite possible and natural for China to review its military doctrine and a series of policies on [its] relationship with big powers, Taiwan issues, arms control and nonproliferation, etc."[79]

In response to the pursuit of space weapons by the United States, the first and best option for China—and the option it is now pursuing—is to advocate an arms control agreement. However, if this effort fails and if security concerns perceived to be legitimate are ignored, China will very likely develop responses to neutralize any threat presented by U.S. actions.

The timing of such measures is still being debated. Because it is not clear what type of missile defense system the United States will finally deploy, or whether U.S. space control plans will be implemented, it is difficult to identify conclusively China's specific countermeasures. China's options for response include: building more ICBMs; adopting countermeasures against boost, mid-course, and terminal phase missile defense; developing ASAT weapons; and reconsidering China's commitments on arms control. In the discussion below, I examine the types of countermeasures that could be used effectively to neutralize U.S. missile defense and space control plans; China's technical capabilities in applying those countermeasures; and the other responses, diplomatic or legal, that might be expected. It should be noted that these discussions are based on China's capabilities, and should not be understood as a characterization of China's intentions.

Build More Warheads

One optimal countermeasure for China is to build more ICBMs.[80] Although some supporters of U.S. missile defense claim that China's nuclear modernization will go forward whether or not the system is deployed, many Chinese analysts believe that U.S. missile defense efforts will encourage an acceleration of China's nuclear modernization and influence its force both quantitatively and qualitatively.

China's strategic nuclear force is among the smallest forces of all declared nuclear powers and also the most outmoded in quality. China's silo-based, single-warhead ICBMs (the DF-5A), of which there are approximately twenty, are liquid-fueled missiles with warheads and fuel stored separately from the missile. They require about two to four hours of preparation time before launch. China has one nuclear-armed submarine, which entered service in the late 1980s; however, the twelve submarine-launched ballistic missiles (SLBMs) it carries have a fairly short range (Julang I, with a range of about 1700 km).

79. Fu Zhigang, "Concerns and Responses."

80. See, e.g., Shen Dingli, "What Missile Defense Says to China"; Charles Ferguson, "Sparking a Buildup: U.S. Missile Defense and China's Nuclear Arsenal," *Arms Control Today*, March 2000.

The submarine patrols close to the Chinese mainland and is infrequently at sea.[81] China's pursuit of nuclear modernization is understandable.

China initiated its nuclear modernization programs in the early 1980s. Current efforts focus mainly on enhancing the survivability of China's strategic nuclear force via greater mobility. It is reported that China is replacing its silo-based, liquid-fueled ICBMs with a road-mobile, solid-fueled missile (the Dong Feng-31, or DF-31). China conducted the first flight test of this missile in August 1999, with deployment anticipated to begin over the next several years. It is believed that the DF-31 has a range of about 8000 km and will be targeted primarily against Russia, India, and U.S. bases and facilities in the Pacific Ocean. It will not reach the continental United States.[82] It is reported that China is also developing the DF-31A, a road-mobile, solid-fueled missile with a range of up to 12,000 km. The Pentagon predicts the DF-31A will be deployed by the end of the decade, although others see this projection as overly optimistic.[83] In addition, China is reported to have begun work on the development of new nuclear-armed submarines (through Project 094), each carrying 16 Julang II SLBMs that may have intercontinental range. However, deployment of these submarines is most likely many years away.

Chinese nuclear modernization has proceeded at a very moderated pace. Were it not for U.S. missile defense plans, the pace might not be expected to change significantly. Because China's focus is on survivability rather than quantity, the size of its nuclear arsenals would likely be much smaller if they did not have to contend with U.S. missile defenses. China certainly did not rush to bring new missiles into its force in the past. Western sources report that China deployed two ICBMs in 1981, a total of four by 1987, a total of five by 1990, and about 20 by 2004.[84] Extrapolating from past experience, China would be expected to build no more than 50 ICBMs by 2015. In fact, the unclassified 1999 U.S. National Intelligence Estimate (NIE) on nuclear forces noted that by 2015 China "will likely have tens" of ICBMs capable of attacking the United States, having added "a few tens" since 1999.[85] In the most recent NIE estimate, China is projected to have about 75–100 ICBMs by 2015.[86] How-

81. See, e.g., Robert S. Norris and Hans M. Kristensen, "NRDC Nuclear Notebook: Chinese Nuclear Forces 2003," *Bulletin of the Atomic Scientists* 59, no. 6 (November/December 2003); Also, Defense Department, "Annual Report on the Military Power of the People's Republic of China," no date [2002], p. 22.

82. Robert Norris et al., "NRDC Nuclear Notebook: Chinese Nuclear Forces 2006."

83. Quoted in ibid.

84. John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goal," *International Security* 17, no. 2 (Fall 1992); Robert Norris et al., *Nuclear Weapons Databook Volume V: British, French, and Chinese Nuclear Weapons* (Boulder, Colo.: Westview Press, 1994); Anthony Cordesman and Arleigh Burke, *China and the US: National Missile Defenses and Chinese Nuclear Modernization: A Background Paper* (Washington, DC: Center for Strategic and International Studies, Jan. 2001).

85. National Intelligence Council, "NIE: Foreign Missile Development and the Ballistic Missile Threat through 2015," September 1999.

86. National Intelligence Council, "NIE: Foreign Missile Development and the Ballistic Missile Threat through 2015," December 2001.

ever, the U.S. intelligence community seems to often overestimate China's nuclear forces. For example, in 1984, the Defense Intelligence Agency set "the best estimate" for the projected number of Chinese nuclear warheads at 592 in 1989 and 818 in 1994.[87] In reality, according to western reports, it is estimated that there are approximately 400 warheads in the Chinese arsenal. Given that China is currently focusing on the quality of its force, and not on the number of its ICBMs, it might be expected that without a U.S. missile defense deployment, China would deploy no more than 50 ICBMs by 2015.

However, this situation would surely change significantly with the deployment of U.S. missile defenses. To maintain a credible minimum retaliatory capability, China would have to shift the size and quality of its nuclear arsenal. The nature of the response would depend on a number of factors, including technology, cost, and the specific missile defense system. Without knowing the specifications of U.S. missile defense system, including the numbers of interceptors and the firing doctrine, it is difficult to predict an exact response.

One could still project the potential changes in the size of China's nuclear arsenal based on a few simple assumptions. Assume that China keeps its no-first-use policy and that the survival rate of Chinese ICBMs after a U.S. first strike is expected to be about 50 percent. With no U.S. missile shield, this would leave China with 10 ICBMs for retaliation, a sufficient number to kill at least several hundred thousand people and to deter a first strike attempt by the United States. However, as the United States proceeds with deployment of its limited ground-based missile defense—for example, a deployment of 100 interceptors and a follow-up deployment of up to 250 interceptors, as envisioned by the Clinton administration[88]—China's nuclear force would need to grow to maintain a credible deterrent. Assuming a U.S. missile defense system would operate under a firing doctrine of two-on-one, shoot-look-shoot, which means that two interceptors would be first launched to hit every incoming warhead, and if these fail then another two interceptors follow, then one might assume that four interceptors would be deployed for every expected warhead. A Chinese military planner, however, would assume the worst case, i.e., that the first two interceptors would successfully hit their target warhead. Thus, if the United States deployed 100 interceptors, and if China wished to preserve for the purpose of deterrence its current retaliatory capability of 10 surviving ICBMs, then it would need a force of 120 ICBMs. Half of these would be wiped out in an initial strike, and the missile shield would intercept 50 of the remaining 60 missiles once they were launched in retaliation. This would leave 10 to find their targets. In the case of 250 interceptors, China would need at least 270 ICBMs.

87. Defense Intelligence Agency, "Nuclear Weapons Systems in China," DEB-49-84 (April 24, 1984), pp. 4, 6; see also Robert Norris et al., "NRDC Nuclear Notebook: Chinese Nuclear Forces 2003."

88. See, e.g., Andrew Sessler et al., *Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System* (Cambridge, Mass.: Union of Concerned Scientists/MIT, 2000).

Of course, many other factors could affect the survival rate of China's nuclear force, e.g., the ratio of mobile to silo-based missiles, the number of U.S. warheads targeted on each silo, the quality of U.S. intelligence on Chinese nuclear deployments, and the size and effectiveness of the missile defense system. In short, China could need between 100 and 300 ICBMs to defeat even a limited missile defense system. These numbers correspond roughly to the August 2000 NIE on the foreign response to U.S. national missile defense, which reportedly concluded that China would expand its arsenal in order to overwhelm a limited missile defense system and could deploy up to 200 ICBM warheads by 2015.[89] Others have offered similar estimates.[90]

Some arms control experts in China believe that adding several hundred ICBMs to China's arsenal would be economically feasible. It is estimated that building 200 ICBMs would cost China about $2 billion. This expenditure could be spread over several years and would represent less than 2 percent of China's current foreign currency reserve. The cost would be less than one-tenth of the expense to the United States of maintaining parity between Chinese missiles and U.S. missile interceptors.[91]

Some Chinese experts feel that China should pursue loading MIRV (multiple independently targeted reentry vehicle) warheads on its missiles, as a more effective countermeasure to the U.S. missile defense system. It is reported that China has had the technical capability to develop multiple reentry vehicles (MRVs) for over 20 years.[92] As the CIA speculated, if China needed near-term MRV capability, it would take only a few years to develop. China could also place MRVs or MIRVs on the DF-5 using a DF-31–type reentry vehicle. But MIRVing a future mobile missile would take several years.[93] Placing a MIRV on the silo-based ICBMs, as some Chinese have suggested, would make the force more vulnerable because China has so few nuclear warheads.[94] MIRVing the mobile ICBMs would seem to be a better choice; however, it is not clear whether China has this technology. Based on the 1998 National Air Intelligence Center's ballistic and cruise missile threat report, China's DF-31

89. See Steven Lee Myers, "Study Said to Find U.S. Missile Shield Might Incite China," *New York Times*, Aug. 10, 2000, p. 1.

90. Charles Glaser and Steve Fetter point out, "We believed that China would try to deploy at least an many warheads as the number of deployed U.S. NMD interceptors, subject to production constrains." See Charles Glaser and Steve Fetter, "National Missile Defense and Future of U.S. Nuclear Weapons Policy," *International Security* 26, no. 1 (Summer 2001): 40–92.

91. See, e.g., Charles Ferguson's citation of his communication with Dr. Shen Dingli in Ferguson, "Sparking a Buildup: US Missile Defense and China's Nuclear Arsenal," p. 15; see also Shen Dingli, "What Missile Defense Says to China."

92. "NRDC Nuclear Notebook Chinese Nuclear Force 2001," *Bulletin of Atomic Scientists* 57, no. 5 (September/October 2001).

93. Ibid.

94. Li Bin, "The Effects of U.S. NMD on Chinese Strategy," *Jane's Intelligence Review*.

and DF-41 (now DF-31A) ICBMs will not be MIRVed.[95] There is some suspicion that China's MIRV technology has been limited by the Comprehensive Test Ban Treaty. Nonetheless, it is believed that China should pursue MIRVing its mobile missiles as one option.

Some Chinese experts advocate China's developing more survivable SLBMs once this technology has matured. Others argue that SLBMs are not a viable option for a number of reasons: they are more expensive, they are vulnerable to advanced U.S. anti-submarine war, and China has limited technical capability in this area. Others propose that China adopt a "launch on warning" strategy to increase the survivability of its arsenal. However, China does not now have an early warning system capable of supporting such a strategy. Moreover, such a system would be vulnerable to U.S. anti-ballistic missile weapons during a U.S. first strike, given the latent ASAT capabilities of American weapons. Some Chinese security analysts argue that China should give up its no-first-use pledge, but many are suspect of such a move. How credible would a threat of nuclear attack be, if made with the knowledge that such an attack would be followed by a devastating U.S. retaliation? Finally, some security analysts suggest that China should deploy its own ballistic missile defense system to protect itself from U.S. missiles. With so many less expensive options, however, this proposal is unlikely to be persuasive.

Table 1: China's Strategic Nuclear Force

Missile	Type	Range (km)	Operational Status	Number Deployed
DF-5A (CSS-4)	ICBM (silo-based, liquid-fueled)	13,000	Deployed since 1981	20
DF-31	ICBM (road-mobile, solid-fueled)	8,000	Deployed around 2006?	0
DF-31A	ICBM (road-mobile, solid-fueled)	~ 12,000	Deployed 2007–09?	0
Julang I	SLBM	1,000–1,700	1986	12
Julang II	SLBM	8,000	2008–10	0

Source: Robert S. Norris and Hans M. Kristensen, "NRDC Nuclear Notebook: Chinese Nuclear Forces 2006," *Bulletin of the Atomic Scientists* 62, no. 3 (May/June 2006).

Missile Defense Countermeasures

In addition to building more warheads, there are a number of feasible and cost-effective measures that would aid China's warheads to penetrate a missile defense system. These measures are in many ways preferable to the MIRV op-

95. U.S. National Air Intelligence Center, "Report of Ballistic and Cruise Missile Threat," 1998, http://www.fas.org/irp/threat/missile/naic/index.html

tion.[96] Scientists have proposed numerous such countermeasures.[97] Most of these measures are not just theoretical possibilities, but rather something that every country possessing ICBMs or SLBMs, presumably including China, has already undertaken.

Midcourse missile defenses. A number of countermeasures could feasibly defeat midcourse missile defense. Chinese scientists have followed and discussed, for example, those countermeasures shown in the Union of Concerned Scientists/MIT report *Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System*.[98] One efficient and simple countermeasure would be the deployment of decoys with each ICBM. Decoys can "confuse" the interceptor's sensors system, making it unable to discriminate between the real warhead and the decoys. The decoys might replicate the warhead or appear slightly different from one another and from the warhead. China might also disguise the warhead—a technique known as "antisimulation"—by enclosing it in a radar-reflecting balloon, covering it with a shroud, hiding it in a cloud of chaff, or by using electronic or infrared jamming measures. These penetration aids, antisimulation and decoy technologies, are within China's capability.[99] China has reportedly made some missile flight tests with penetration aids, such as the first flight test of China's new DF-31 ICBM, which included decoys, on August 2, 1999.[100]

China could also employ countermeasures to reduce the radar and infrared signatures of the warhead, making detection more difficult. For example, China could reduce the radar cross-section of the nuclear warhead by shaping the reentry vehicle (or a shroud around it) as a sharply pointed cone and/or by coating it with radar-absorbing material. China could reduce the infrared signature of the warhead by covering it with a low-emissivity coating or by using a shroud cooled to low temperature by liquid nitrogen.

96. Richard Garwin points out, "MIRVs are not the optimal weapons if China anticipates encountering a U.S. national missile defense (NMD) system. Instead, China is far more likely to use effective countermeasures (such as light-weight decoy balloons) rather than multiple RVs on its future missiles." See Garwin, "Why China Won't Build U.S. Warheads," *Arms Control Today* (April/May 1999), p.28.

97. See, e.g., George Lewis, Theodore Postal, and John Pike, "Why National Missile Defense Won't Work," *Scientific American*, August 1999; Andrew Sessler et al., *Countermeasures*; APS Study, Science and Technology of Directed Energy Weapons, *Reviews of Modern Physics*, vol. 59, no. 3, Part II, July 1987. Du Xiangwan, *Science and Technology Foundation For Nuclear Arms Control*; American Physical Society, *Report of the APS Study Group on Boost-Phase Intercept Systems for National Missile Defense*; Bob Preston et al., *Space Weapons, Earth Wars*; Bruce DeBlois et al., *Space Weapons: Crossing the U.S. Rubicon*.

98. See, e.g., Huang Hai, "Technical Analysis of National Missile Defense and Its Effects on World Arms Control," Presentation at the Thirteenth International Summer Symposium on Science and World Affairs, Berlin, Germany, July 21–30, 2001; Li Bin, "The Effects of U.S. NMD on Chinese Strategy."

99. Huang Hai, "Technical Analysis of National Missile Defense and Its Effects on World Arms Control"; Li Bin, "The Effects of U.S. NMD on Chinese Strategy."

100. National Intelligence Council, "NIE: Foreign Missile Development and the Ballistic Missile Threat through 2015," p.16.

These countermeasures should be accessible to China. The 1999 NIE of the ballistic missile threat to the United States also stated, "Russia and China each have developed numerous countermeasures and probably are willing to sell the requisite technologies."[101] As Richard Garwin pointed out, "The fundamental weakness of midcourse intercept is that the countermeasures are all too simple. The money and skill needed to implement them are trivial compared with the effort required to design, build and care for the ICBMs themselves."[102]

Boost-phase defenses. The pursuit of a more effective missile defense, as envisioned by the Bush administration, would require space-based intercept components—such as the SBI and SBL—to catch missiles in their boost phase. As the recent report from the American Physical Society (APS) on boost-phase defense discussed, a number of countermeasures for SBI could be developed.[103] One of the most potent countermeasures would be a fast-burn boost. Because it reduces the boost time by using solid-fuel, the fast-burn booster would make the job of a boost-phase interceptor defense extremely challenging or infeasible. The APS study concluded, "Switching from liquid-propellant to typical solid-propellant ICBMs would cut the boost phase by a minute or more. Boost phases as short as 130 seconds are certainly possible; such missiles would be practically impossible to intercept." As reported, China is developing solid-fuel ICBMs, and may be able to develop faster-burn rockets in the future. Other possible countermeasures include: lofting or depressing the trajectory of the ICBM relative to the maximum-range trajectory to evade attacks from space weapons; spoofing the defender's tracking sensors by deploying small, rocket-propelled decoys from the missile that mast or mimic the radar and electro-optical characteristics of the booster; and changing the brightness and configuration of the exhaust plume of the ICBM to make it more difficult for infrared sensors to locate the real missile body. For SBL, countermeasures could include: rotating the missile to distribute the laser energy from SBL over a wide area and protecting the vulnerable parts of the ICBM with reflective or ablative coatings.[104]

Moreover, the attacker could simultaneously launch several ICBMs (possibly with theater or tactical ballistic missiles used as decoys) from a compact area to overwhelm these space-weapon systems.[105]

Terminal phase defenses. Terminal phase missile defense could be countered by making the high-velocity warhead maneuverable. This BMD countermea-

101. Bill Gertz, "China Develops Warhead Decoys to Defeat US Defenses," *Washington Times*, September 16, 1999, p. 1.

102. Richard Garwin, "Holes in the Missile Shield," *Scientific American* (November 2004).

103. American Physical Society, *Report of the APS Study Group on Boost-Phase Intercept Systems for National Missile Defense*.

104. Du Xiangwan, *Science and Technology Foundation For Nuclear Arms Control*; Bob Preston et al., Space *Weapons, Earth Wars*; Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

105. See, e.g., David Wright et al., *The Physics of Space Security: A Reference Manual*; Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

sure has been mentioned within the Chinese defense industry.[106] It is reported that China's test of a spacecraft intended for manned flight demonstrated a low-thrust rocket propulsion system that could be used to make warheads maneuver to defeat a BMD system.[107]

In short, China has access to a large tool kit of effective, accessible, inexpensive (compared to BMD systems) means that can be deployed to keep retaliatory capabilities at a sufficiently high level. The countermeasures would be significantly cheaper than an antimissile arsenal in space.

Table 2: China's Potential Passive Countermeasures against U.S. Missile Defense

Phase of Trajectory	Countermeasures to Missile Defense
Boost	• reducing the boost time by using fast-burn booster • lofting or depressing the ICBM trajectories • spoofing the defender's tracking sensors • changing the brightness and configuration of the exhaust plume of an ICBM • simultaneously launching several ICBMs (or with some theater or tactical ballistic missiles) from a compact area • protecting the missile body with reflective or ablative coatings (to counter an SBL) • rotating the missile (to counter an SBL)
Midcourse	• using decoys and anti-simulation • reducing the radar signature of the warhead • reducing the infrared signature of the warhead
Terminal	• making the high-velocity warhead maneuverable

Anti-Satellite Weapons

Once space-based weapons systems are deployed, the platforms of space weapons and sensor satellites would themselves become high-value targets and vulnerable elements to attack.[108] Thus, for BMD systems relying on weapons or crucial sensors based in space, as Ashton Carter wrote in 1986, "ASAT attack on these components is probably the cheapest and most effective offensive countermeasure."[109] In practice, destroying a satellite is far simpler than destroying a warhead carried on a reentry vehicle for several reasons. Richard Garwin explained, "The satellite is far more fragile than is a nuclear

106. Li Bin, "The Effects of U.S. NMD on Chinese Strategy."

107. Associated Press, "Space Technology Could Beat US Defense, Scientist Says," *South China Morning Post*, Nov. 22, 1999, p.1.

108. See, e.g., Ashton Carter, "The Relationship of ASAT and BMD Systems," in *Weapons In Space*, Franklin Long et al., eds. (New York: W.W. Norton & Company, 1986); Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon,"; David Wright et al., *The Physics of Space Security*; *Report of the APS Study Group on Boost-Phase Intercept Systems*; Bob Preston et al., *Space Weapons, Earth Wars*; John Tirman, and the Union of Concerned Scientists, *The Fallacy of Star Wars* (Cambridge, Mass.: Union of Concerned Scientists, 1984).

109. Ashton Carter, "The Relationship of ASAT and BMD Systems."

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."[110]

Therefore, it is reasonable to believe that China could resort to asymmetric methods including ASAT weapons to counter critical and vulnerable space-based components in LEO such as the SBI, SBL, and space-based tracking satellites (e.g., SBI/ former SBIRS-low).

It should be noted that although China has some technological capabilities that could potentially be used as ASAT weapons (as discussed below), this does not mean China that has already developed ASATs or intends to do so. Several recent editions of the U.S. Department of Defense annual report on Chinese military power claim that China is developing and intends to deploy ASAT weapons, including a direct-ascent ASAT system, ground-based laser ASAT weapons, and microsatellites for use as weapons. However, there is no evidence to support these claims.[111] In practice, the pursuit of ASATs would be politically damaging to China's position on PAROS, which it has been actively advocating since the development of SDI in the 1980s.[112] In the context of a deployed U.S. advanced missile defense system that includes space-based weapons, it might become politically acceptable for China to pursue ASATs as an effective countermeasure.

In what follows, I set aside political questions and examine Chinese technological capabilities that could potentially be used as ASAT weapons.

Over the past several decades, many types of ASAT weapons have been proposed, especially within the United States and, until its dissolution, the Soviet Union.[113] ASAT weapons may be based on the ground, in the air, at sea, or in space. They may be designed to destroy their target using a kinetic energy weapon (KEW), DEW, or an explosive charge, or disable their target temporarily with devices such as jammers or other electronic or electro-optical countermeasures or both. This paper defines ASAT *weapons* as devices designed to destroy or permanently disable their targets.

Nuclear-armed ASATs. Ordinary nuclear weapons such as ICBMs and SLBMs, when detonated in space, will kill nearby satellites via an electromagnetic pulse. Any country—including China—with nuclear-armed long- or intermediate-range ballistic missiles has the capability to attack a satellite in

110. Richard Garwin, "Space Weapons or Space Arms Control."

111. See, e.g., Jeffrey Lewis, "False Alarm on Foreign Capabilities"; see also Jeffrey Lewis's notes, "No Evidence To Back Up ASAT Claims in Chinese Military Power," July 28, 2005, http://www.armscontrolwonk.com/index.php?id=707.

112. Du Xiangwan et al., "Banning Space Weapons—An Urgent Issue in Arms Control," *China Report on Nuclear Science and Technology*, CNIC-00401, Beijing, 1990.

113. T. H. Karas, M. Callaham, R. DalBello, and G. Epstein, *Anti-satellite Weapons, Countermeasures and Arms Control* (Washington, DC: Office of Technology Assessment, 1985); Ashton Carter, "Satellites and Anti-satellites," *International Security* 10, no. 4 (Spring 1986).

LEO. With some modification, these weapons might also be capable of attacking satellites at higher altitudes.

Nuclear weapons could also be concealed aboard satellites as nuclear space mines, to be detonated on command when they are within lethal range of quarry satellites. These nuclear ASATs could be as small and inexpensive as many existing satellites and could be developed and tested covertly. Moreover, the operation of such ASATs would not require advanced satellite surveillance systems. Thus, China could have these ASAT capabilities without pursuing complicated technologies, and could feasibly use them to neutralize the space-based components of a missile defense system in LEO.[114] It should be noted that the 1967 Outer Space Treaty (OST) prohibits the use of nuclear ASATs. Moreover, the use of such weapons would damage not only the satellites of China's adversaries but also China's own assets. Use of nuclear ASATs seems unlikely except as a last resort in a nuclear conflict.

Kinetic-energy weapons. China might employ various types of KEWs, ground- or space-based, to attack satellites. All would be relatively cheap and technically easy in comparison with a missile defense system.

The most optimal ASAT system for China would comprise ground-launched small kinetic-kill vehicles, which destroy their targets by colliding with them at extremely high velocities. These vehicles can reach a satellite in LEO and, if mated with a larger booster, might be capable of reaching higher orbits. Another easy and inexpensive ground-based ASAT would be a pellet cloud delivered to LEO by a missile.[115] Space mines with conventional charges could also be used as space-based ASATs. All these kinetic energy ASATs are within China's technological capability.[116]

Effective non-nuclear ASATs require good space surveillance capabilities. China's satellite tracking system includes a domestic network, two foreign sites, and four tracking ships. China has also delivered satellites into geosynchronous orbit. As scientists have discussed, space-faring countries with the ability to place objects in orbit or lift them to geosynchronous orbit should also have the ability to closely track space objects and to develop homing ASATs to attack satellites in both LEO and geosynchronous orbit.[117]

China should be able to use ground-launched small kinetic-kill vehicles, pellet clouds, or space mines to attack SBI satellites. As Richard Garwin

114. Except DSP/SBIRS-high components, which are located in geosynchronous orbit, all other space-based components of a missile defense system including STSS/SBIRS-low and space weapons would be located in LEO. The SBI under discussion, for example, would be placed at altitude of around 300–500 km above the Earth.

115. Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

116. On January 11, 2007, China conducted an ASAT test in which it destroyed an aging Feng Yun-1C weather satellite. This test shows China indeed has had ASAT capabilities. See, e.g., "Chinese Test Anti-Satellite Weapon," *Aviation Week & Space Technology* (17 January 2007): www.aviationweek.com/aw/generic/story_channel.jsp?channel=space&id=news/CHI01177.xml. While Beijing stated the test was for peaceful purposes, a variety of interpretations have been proposed. See, e.g., Eric Hagt, "China's ASAT Test: Strategic Response," *China Security* (Winter 2007).

117. David Wright et al., *The Physics of Space Security*.

noted, "the same countermeasures would be even more cost-effective against…the space-based laser, which would be larger and more vulnerable than the interceptors."[118]

High-energy laser weapons. High-energy laser (HEL) weapons are devices that produce intense beams of electromagnetic radiation capable of damaging a satellite permanently or, at lower power levels, jamming optical communication and sensor systems. HEL weapons can be ground-, space-, air-, or sea-based. Since the 1980s, mainly encouraged by the U.S. Strategic Defense Initiative, many types of HEL weapons for ballistic missile defense or ASAT purposes have been proposed, such as ground-based deuterium fluoride chemical lasers and free-electron lasers (FEL); and space-based hydrogen fluoride chemical lasers, and nuclear-pumped X-ray lasers.

Since the 1980s, China has made a great progress in research on and development of HELs, perhaps prompted in part by the U.S. program on DEWs, and partly funded under China's "National 863" program for high-tech development. However, not all HELs would have ASAT capabilities—solid and gas lasers would not. Of HEL research in China, the technologies with potential ASAT applications are the FEL and chemical oxygen-iodine laser. Given the advantage the United States has in space, it might be expected that if China pursues HEL ASAT weapons, it would likely develop ground-based instead of space-based systems.

China began to investigate the FEL in 1985.[119] In May 1993, China activated its first FEL, the Shuguang-1 ("Dawn light"), developed by the Chinese Academy of Engineering Physics.[120] In September 1994, the academy used Shuguang-1 to generate 140 MW of power at 34.4 GHz.[121] FELs have a number of advantages. They can operate at short wavelengths, which pass through atmospheric windows with higher quality beams for long distance propagation, and can probably be made to operate more efficiently than other short-wavelength lasers. However, the size of FEL systems currently limits deployment options. Chinese scientists are working to reduce the size of these systems through the miniaturization of electronic devices.[122]

118. See Richard Garwin, "Holes in the Missile Shield." The vulnerability of SBLs is also noted in DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon." The authors write, "The problem with SBL for missile defense is not the ineffectiveness of an ultimate system, if it can be developed and judged worthy of deployment. Rather it is the system's susceptibility to being overwhelmed by large numbers of missiles and the vulnerability of the enormously expensive SBLs to low-cost and relatively low-technology attack—by pellet clouds in LEO and space mines"

119. Mark Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle, Penn.: Strategic Studies Institute, September 1999).

120. See, e.g., "SG-1 FEL, BFEL, Certified; Asia's First IR-Spectrum FEL Light Generated," *Keji Ribao* (*Science and Technology Daily*), June 8, 1993.

121. See, e.g., Zhou Chuanming, "Chinese FEL Amplifier Output Breakthroughs 100 MW," *High Power Laser and Particle Beams* 6, no. 3 (1994).

122. See, e.g., Liu Qingxiang et al., "A High Performance Short-Period Wiggler," *High Power Laser and Particle Beams* 4, no. 2 (1992).

China's HEL research and development could provide the technology base for ground-based laser weapons to dazzle or permanently blind optical sensors in space. At a higher power level, these weapons could damage satellites. In practice, ground-based HELs would be simpler and more effective means to destroy satellites than the lasers proposed for use as space-based boost-phase missile defense. Moreover, the mass, volume, energy resources, and efficiency requirements of ground-based lasers are far less restricted than those of SBLs. In addition, although the opportunities for ground-based lasers to attack satellites occur infrequently, they could shoot inexpensively and repeatedly. To widen its field of attack, a ground-based HEL system could use space-based reflectors to relay laser beams from the lasers to their targets.

However, HEL weapons would not operate through cloud cover, and the effects of atmospheric turbulence would pose a serious problem. For a ground-based weapons system, the use of adaptive mirrors must compensate for atmospheric turbulence, with numerous electronic devices needed to shape the optimal beam pattern. It was reported in the early 1990s that China had made progress on the development of adaptive optics.[123]

High-powered microwave weapons. High-powered microwave (HPM) weapons are devices capable of producing intense, damaging beams of radio frequency radiation. At high power levels, they could be used to overload and damage satellite electronic equipment, or, at lower power levels, merely to overload satellite electronic systems temporarily (i.e., for jamming).

Chinese scientists from a number of organizations reportedly have engaged in research, design, and testing of HPM devices.[124] One of China's first experiments in HPM research was the Flash-I (Shanguang) system. After completion in 1983, the Flash-I operated at approximately 1 GHz and had a microwave power of 1 GW.[125] However, it should be noted that HPM attacks would only be practical from space.[126] Thus, if China preferred to develop ground-based directed energy ASATs as discussed above, HPM weapons would not be a practical option.

Microsatellites. China is developing microsatellites for missions that include data transmission, Earth sensing, and other civilian programs.[127] A joint venture between China's Tsinghua University and Great Britain's University of Surrey is building the "Tsinghua" system, a constellation of seven microsatellites with 50 m resolution remote-sensing payloads. China's microsatellite program is mainly for civilian and commercial purposes including communications and meteorological applications. As Philip Saunders and

123. "Adaptive Optics Technology Is World-Class," *Keji Ribao* (*Science and Technology Daily*), October 30, 1992.

124. It should be noted that HPM technology can be applied to other civilian and scientific fields (e.g., communication, medical, and plasma physics).

125. See, e.g., Tao Zucong et al., "Development of Flash X-ray Machines at CAEP," *High Power Laser and Particle Beams* 3, no. 3 (1991).

126. David Wright et al., *The Physics of Space Security*.

127. Author's discussions with an expert at the minisatellite program of Tsinghua University, February 2002.

others noted, the technology "would potentially allow for lower-cost access to space, enhanced maneuverability, and increased ability to launch-on-demand."[128] However, these technologies could be also used for ASATs, as some western scholars have noted.[129] For example, the development of small satellites would enable more rapid launching and allow launchers to be mobile—important capabilities 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.[130]

There is no evidence that China is developing microsatellites for ASAT purposes. Both the 2003 and 2004 editions of the Pentagon's "Annual Report on the Military Power of the People's Republic of China" cite a Hong Kong newspaper (*Xing Dao Daily*) article of January 2001,[131] stating that China has "developed and tested an ASAT system described as a parasitic microsatellite."[132] A parasitic microsatellite is a small satellite that attaches itself to larger satellites to disrupt or destroy them on command. However, an examination of the January 2001 newspaper story—the only source cited by the Pentagon reports—by two experts at the Union of Concerned Scientists found that the source of the story was an October 2000 story on a Chinese website of dubious repute.[133] The original article, written by a self-described "military enthusiast,"[134] casts doubt on the credibility of the story.

In summary, China could consider a variety of ASAT capabilities to counter a U.S. space-based weapon system. Furthermore, if China is to pursue ASAT weapons, it is far more likely to develop ground-based ASAT weapons. Compared with space-based weapons, ground-based ASATs would be easier to control, cheaper to deploy, and, most important, less vulnerable to ad-

128. Philip Saunders, Jing-dong Yuan, Stephanie Lieggi, and Angela Deters, "China's Space Capabilities and the Strategic Logic of Anti-Satellite Weapons," *CNS*, research story of the week, July 22, 2002.

129. David Thompson and William Morris, *China in Space: Civilian and Military Development,* Air War College, Maxwell Paper No.24 (August 2001).

130. See, e.g., Howard DeVore, "China's Aerospace and Defense Industry," *Jane's Special Report* (December 2000): 197–200.

131. Tung Yi, "China Completes Ground Test of Anti-Satellite Weapon," *Hong Kong Sing Tao Jih Pao* (*Xing Dao Daily*, Internet Version), January 5, 2001.

132. Office of the Secretary of Defense, *Annual Report on the Military Power of the People's Republic of China* (July 28, 2003), p. 36, http://www.defenselink.mil/pubs/20030730chinaex.pdf; Office of the Secretary of Defense, *Annual Report on the Military Power of the People's Republic of China* (May 29, 2004), p. 42, http://www.defenselink.mil/pubs/d20040528PRC.pdf.

133. See "Some Question Report On Chinese Space Arms," *Washington Post,* August 14, 2004, http://www.washingtonpost.com/wp-dyn/articles/A63706-2004Aug13.html; Gregory Kulacki and David Wright, "A Military Intelligence Failure? The Case of the Parasite Satellite," Union of Concerned Scientists Report, http://www.ucsusa.org/global_security/china/page.cfm?pageID=1479.

134. Hong Chaofei, "China Will Deploy the Most Advanced ASAT in the World: A Parasitic Microsatellite," A web story posted at: http://www.armystar.com/html/new_page_1190.htm.

Table 3: China's Potential ASAT Measures

Weapon	ASAT Capability	China's Technical Capacity
Ground-based KEWS	Miniature homing vehicles or a pellet cloud could destroy these space-based weapons or sensors at LEO.	China has the ability to launch objects into orbit, and should be able to develop homing ASATs.
ICBMs and SLBMS	The current long- or intermediate-range nuclear missile can destroy LEO satellites. With some modifications, these weapons might be used to attack satellites at higher altitudes.	Currently China has such capacities. However, the use of nuclear ASATs would also destroy China's own satellites. This is banned by the 1967 Outer Space Treaty.
Ground-based HELS	HELs can damage a satellite permanently or, at lower power levels, can blind optical communication and sensor systems.	As reported, China began FEL research and development in the 1980s, and in 1994 China's Shuguang-1 achieved a power of 140 MW. It could be used as a jamming device, but no evidence shows it was developed as a weapons system.
Space-based ASATS	A space mine can destroy a nearby satellite when detonated on command. Microsatellites can also be used as ASATs.	Space mines could be within Chinese technological capacities, and China is currently developing civilian microsatellites.

vanced space capabilities of the United States once they have deployed missile defense and space weapons.

Reconsidering China's Arms Control and Nonproliferation Commitments

According to Ambassador Sha Zukang, "China cannot afford to sit on its hands without taking the necessary measures while its strategic interests are being jeopardized. China, *inter alia*, may be forced to review the arms control and non-proliferation policies it has adopted since the end of the Cold War in light of new developments in the international situation."[135] In response to perceived threats, China may be forced to withhold cooperation with respect to the negotiation of a FMCT and to revaluate its self-restraint on nuclear testing and other proliferation issues.

Participation in Fissile Material Cut-off Treaty. A conservative estimate of China's existing stockpile suggests about two tons of weapons-grade highly enriched uranium and one ton of separated plutonium.[136] The existing stockpile would be sufficient for modernizing China's nuclear forces under the as-

135. Sha Zukang, "US Missile Defense Plans: China's View."

136. David Wright and Lisbeth Gronlund recently estimated that China produced 2 to 5 metric tons of plutonium at its Jiuquan and Guangyuan plutonium production facilities. See details: David Wright and Lisbeth Gronlund, "Estimating China's Production of Plutonium for Weapons," *Science & Global Security* 11, no. 1 (2003). Estimates by Albright, Berkhout, and Walker suggest that China could have produced 2 to 6 metric tons of weapons-grade plutonium and 15 to 25 tons of weapons-grade uranium and that the total amount of this material in Chinese nuclear weapons is 1 to 2 tons of plutonium and about

sumption that the U.S. does not deploy a missile defense system. However, if U.S. missile defense deployments become operational, China would very likely be driven to expand its ICBM arsenal significantly, as described above, both in quantity and quality. In that case, China would deplete its existing fissile material stockpile and might find it necessary to produce more fissile material. China might then wish to keep open the option to restart production of fissile materials and therefore be unwilling to join a global fissile material cutoff treaty.[137]

In the 2000 white paper on China's national defense, China cited its dual concerns:

> In view of the fact that the US is accelerating its efforts for the development and possible deployment of a national missile defense system and space weapons, and that the US and Russia still possess nuclear arsenals large enough to destroy the world many times over, it is China's position that continued nuclear disarmament and the prevention of an arms race in outer space are multilateral fora of arms control that should be given more priority than the FMCT negotiations. Therefore, the Conference on Disarmament in Geneva should not emphasize the importance of only the FMCT negotiations to the neglect of the issues of nuclear disarmament and the prevention of an arms race in outer space, and should, at the minimum, give equal attention to all three issues by carrying out its substantive work in a balanced manner.[138]

Negotiations on a universal FMCT, which would ban the production of fissile material (separated plutonium, highly enriched uranium, and uranium-233), are now in limbo. Negotiations at the CD in Geneva remain deadlocked, due to recent U.S. plans regarding missile defense and space weaponization. A primary goal of the FMCT will be to attain the signatures of the five declared nuclear weapon states and three de facto nuclear weapon states (India, Pakistan, and Israel). In practice, the FMCT does not have much effect on U.S. and Russian stockpiles, because of their huge size. China's participation in an FMCT will be critical to its success, however. Without China's participation,

9–13.5 tons of uranium. See details: David Albright, Frans Berkhout, and William Walker, *World Inventory of Plutonium and Highly Enriched Uranium 1992* (New York: Oxford University Press, 1993). However, these estimates are uncertain because little is known about either the size of the Chinese arsenal or the amount of fissile material used in individual Chinese weapons. Moreover, little is known about how much fissile material is lost during weapons production or the recycling of fissile materials. To maintain a nuclear arsenal, China would want to hold some material in reserve; the amount would depend on the size of the arsenal China intends to build. Thus, in a conservative estimate, China's stockpile of fissile materials not in weapons is one ton or less of plutonium and two tons or less of highly enriched uranium. Assuming one Chinese weapon contains about 5 kg of plutonium or about 25 kg of highly enriched uranium, this stockpile could fuel about 300 new warheads.

137. See, e.g., Hui Zhang, " A Chinese View on Fissile Material Cut-off Treaty," *Journal of Nuclear Materials Management* 30, no. 4 (2002); Hui Zhang, "FMCT and PAROS: A Chinese Perspective," *INESAP Bulletin* 20 (2002).

138. Information Office of the PRC State Council, *White Paper on China's National Defense in 2000*, October 16, 2000.

India will not sign the FMCT, and Pakistan will not sign unless India does. Both South Asian countries and Israel are believed to be continuing production of fissile materials for their stockpiles. China is believed to have stopped the production of both highly enriched uranium and plutonium for weapons in the early 1990s,[139] and has consistently supported FMCT negotiations. In March 1999, Chinese President Jiang Zemin appealed to the CD, "Negotiations should be conducted as soon as possible for the conclusion of a universal and verifiable Fissile Material Cut-off Treaty."[140] However, with growing concern about U.S. missile defense and space control plans, China has clearly expressed since 2000 that the space issue "is just as important as fissile material cut-off, if not more."[141] However, the United States opposes any negotiation of the outer space issue. In response to the 2002 Chinese and Russian Joint Working Paper on the Prevention of an Arms Race in Outer Space, Eric M. Javits, the permanent representative of the United States to the CD, said, "the United States sees no need for new outer space arms control agreements and opposes the idea of negotiating a new outer space treaty."[142] The disagreement between China and the United States over the FMCT and PAROS negotiations for several years has prevented the CD from continuing any arms control negotiations.

Aiming to break the deadlock at the CD and to promote the international arms control and disarmament process, China in 2003 dropped its claims to links between the FMCT and PAROS, and agreed to a negotiation of the FMCT. However, given Beijing's major concerns (as discussed above), it can be expected that U.S. missile defense and space weaponization plans will definitely affect China's willingness to participate in an FMCT negotiation. China maintains that the purposes and objectives of arms control and disarmament "should serve to enhance the security of all countries; it should not become a tool for stronger nations to control weaker ones, still less should it be an instrument for a handful of countries to optimize their armament in order to seek unilateral security superiority."[143] In practice, China still firmly holds that the prevention of space weaponization is an urgent issue.[144]

Nuclear test ban ratification. China signed the Comprehensive Test Ban Treaty (CTBT) in 1996 and has not yet ratified it, partly because the U. S. Senate rejected it in 1999. However, U.S. missile defense and space weaponization plans make it politically difficult for China to consider ratification. The cessation of nuclear weapons test explosions and all other nuclear explosions, as called for in the CTBT, would constrain qualitative improvement of China's

139. Robert Norris et al., *Nuclear Weapons Databook Volume V*.

140. Jiang Zemin's speech at the CD, Geneva, March 26, 1999, http://un.fmprc.gov.cn/eng/7275.html.

141. Hu Xiaodi, statement at the Plenary of the 2002 Session of the CD, Geneva, March 28, 2002, http://un.fmprc.gov.cn/eng/27762.html.

142. Eric M. Javits, "U.S. Statement on Joint Working Paper," delivered at the CD, Geneva, June 27, 2002, http://www.inesap.org/bulletin20/bul20art13.htm.

143. See Chinese statements, http://www.fmprc.gov.cn/eng/24967.html.

144. Hu Xiaodi, Statement at the Plenary of the 2nd Part of the 2005 Session of the CD.

existing nuclear weapons and the development of new advanced weapons. In the event of a continuing challenge from the United States, China would need further nuclear tests to avoid a major degradation or neutralization of their limited retaliatory capability. For example, China may need additional nuclear tests to reduce the size of new warheads as needed for deployment of MIRVed missiles or complicated decoys. The development of maneuvering warheads would also require tests.[145]

Already, some Chinese scientists and arms control experts believe that China made significant sacrifices in signing the CTBT, arguing that the CTBT places more direct constraints on China's nuclear weapons program than on the weapons programs of other states.[146] However, to achieve the goal of complete prohibition and eventual destruction of nuclear weapons, China decided to sign the treaty despite its drawbacks. Many Chinese question why other nations, including China, should care about an international agreement such as the CTBT when the United States, in pursuing its own absolute security, damages the security of other nations and expresses no interest in international treaties.

China's concerns about missile defense and space weaponization could also affect its efforts on other nuclear proliferation issues. For example, though it has not yet done so, China could diminish its cooperation on the Korean peninsula and on South Asian issues. Given that China and Russia share a mutual concern about U.S. hegemony, both countries could seek closer collaboration on military and strategic concerns, and on political opposition to the United States. For example, Russia and China could cooperate on deploying military countermeasures to missile defense.

In summary, the development and deployment of U.S. missile defense systems, including weapons in space, would definitely encourage a number of responses from China including technological development, military countermeasures, and political realignment. The type of response would depend on the specific infrastructure of U.S. missile defense and space weaponization programs. At the moment and in the near future, China's major response would be to take an arms control approach, such as firmly advocating at the CD a legal instrument to prevent space weaponization. Facing very limited missile defense deployment, e.g., the initial GMD currently under deployment, China might focus on building more road-mobile ICBMs and developing a variety of penetration aids. If a stronger missile defense system with more interceptors is deployed, China would need to produce more fissile material to fuel more warheads, thus influencing its FMCT participation. If China is confronted with the deployment of a layered (or space-based) missile defense system, it could consider additional measures such as using ASAT weapons.

Consequently, the cumulative effect of U.S. space weaponization plans will have grave adverse consequences for global security that will not benefit any country's security interests. As Ambassador Hu said, "In a nutshell, the

145. See, e.g., Li Bin, "The Effects of U.S. NMD on Chinese Strategy."

146. See, e.g., Sun Xiangli, "The Implication of the CTBT for China's Security," CISAC Working Paper, Stanford University, 1997; Zou Yunhua, "China and the CTBT Negotiations," CISAC Working Paper, Stanford University, 1998.

weaponization of outer space will be detrimental to the interests and security of each and every State, including the very one that introduces weapons into outer space. Its consequences will be most serious and in no one's interest."[147]

ARMS CONTROL IN SPACE

The United States has expressed concerns about the vulnerability of its extensive assets in space. Technical measures—e.g., hardening satellite components to protect them against certain types of attack or adding redundancy to satellite systems—offer some mitigation of vulnerability. However, such measures are unlikely to suffice in the absence of strengthened international agreements on space activity. Hardening satellites would be very costly, even infeasible, in particular for civilian and commercial satellites. These technical measures would also impair the operational flexibility of satellites.

A number of U.S. analysts have suggested that it would be safer for the United States to maintain outer space as a sanctuary free of strike weapons.[148] China's opposition to the deployment of weapons in space has been detailed above. If the United States wants to reduce the potential vulnerability of its space assets, there are a number of ways to do so. However, weaponizing space can only worsen space security. As Chinese Ambassador Hu emphasized recently, "for ensuring security in outer space, political and legal approaches … can still be effective, while resorting to force and the development of space weapons will only be counter-productive."[149]

In this section, I examine a number of measures that would protect the broad range of scientific, commercial, and military activities in space, and begin to satisfy both China's concerns and those of the United States. What "rules of the road" might help to prevent misunderstandings and the inadvertent escalation of conflict in space? How might existing treaties governing the use of space be amended? What kinds of comprehensive agreements are

147. Hu Xiaodi, statement on Disarmament Affairs of China at the Plenary of the CD, Geneva, June 7, 2001.

148. In practice, an increasing number of experts including many Americans feel that there is little reason to believe that it is necessary for the United States to put weapons in space. These experts are concerned that the placement of offensive weapons in space could have a perverse effect on security because other countries would feel compelled to follow suit. See details, e.g., William Spacy II, "Does the United States Need Space-based Weapons?" dissertation, School of Advanced Air Power Studies, Air University, June 1998; Michael Krepon, "Lost in Space: The Misguided Drive Toward Antisatellite Weapons," *Foreign Affairs* (May/June, 2002); Bruce DeBlois, "Space Sanctuary: A Viable National Strategy," *Airpower Journal* (Winter 1998): 41; Howard Belote, "The Weaponization of Space: It Doesn't Happen in a Vacuum," *Aerospace Power Journal* (Spring 2000): 51; Karl Mueller, "Space Weapons and U.S. Security: The Dangers of Fortifying the High Frontier," prepared for the 1998 annual Meeting of the American Political Science Association, Boston, Mass.; Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon"; David Wright et al., *The Physics of Space Security*.

149. Hu Xiaodi, closing statement at the International Conference on "Safeguarding Space Security: Prevention of an Arms Race in Outer Space," Geneva, March 21–22, 2005.

worth discussing? In the context of a comprehensive agreement, what missile defense and space deployments would need to be prohibited?

Partial Arms Control Measures

Several measures on arms control in space—to protect space assets and prevent space weaponization—have been proposed recently. These include both partial and comprehensive arms control measures. Although many parties see broad arms control measures as the final goal, some analysts suggest that it would be more realistic to take a step-by-step approach, working from some partial measure towards more comprehensive measures.

A number of partial measures for space arms control have been proposed. These include:

- a ban on testing or use of any kind of ASAT weapons;
- a set of measures proposed by Clay Moltz prohibiting the use or testing of ASATs; prohibiting the stationing of weapons of any sort in LEO; allowing permitted testing of ground-based, sea-based, and air-based interceptors in LEO against ballistic missiles passing through space; and permitting the deployment of a non-space-based missile defense system;[150]
- a declaration not be the first to deploy weapons in space or to further test destructive antisatellite weapons;[151]
- a prohibition of the use of weapons above a certain latitude (perhaps 5000 km) to protect higher-altitude satellites; and
- an agreement to protect manned missions but prohibit manned military space operations.

A number of these measures could be secured by unilateral means and multilateral rules or agreements. Space-faring countries could also adopt a set of rules to ensure the safety of space operations. These “rules of the road” would be intended to reduce suspicion and encourage the orderly use of space. One model for a set of such rules might be the Soviet-American 1972 Agreement on the Prevention of Incidents on and over the High Seas, which has been widely replicated. Similar sets of rules for space have been discussed in the Committee on the Peaceful Use of Outer-Space in Vienna for some time. Most recently, the Stimson Center proposed a code of conduct for the prevention of incidents and dangerous military practices in space.[152]

Specific rules for the use of space might include:

- “keep-out zones,” i.e., agreed upon limits on minimum physical separation distance between orbiting satellites;

150. James Clay Moltz, “Breaking the Deadlock on Space Arms Control,” *Arms Control Today* (April 2002).

151. Richard Garwin, “Space Weapons: Good for Us or Bad?” Lynford Lecture at Polytechnic University of Brooklyn, November 4, 2004, http://www.fas.org/rlg/041104-lynford.pdf; see also, Michael Krepon and Christopher Clary, *Space Assurance or Space Dominance? The Case Against Weaponizing Space* (Washington, DC: The Stimson Center, 2003), http://www.stimson.org/pub.cfm? id=81.

152. See, Stimson Center, *A Model Code of Conduct for the Prevention of Incidents and Danger-*

- restrictions on very low-altitude fly-overs by manned or unmanned spacecraft;
- a non-interference rule for satellites, enlarging upon examples provided in the strategic arms limitation and reduction talks that prohibited interference with any national technical means of verification;
- stronger international cooperation on reducing space debris—in particular, clearer definitions of intentional and unintentional acts of debris creation;
- notification of space launch activities including pre-and post-launch information, and details about ballistic missiles in space launch, test flights and real launches (these rules could build upon the example of the U.S.-Russia Joint Data-Exchange Center);
- development of safer traffic management procedures; and
- other "confidence-building measures" such as hotlines between major missile and space powers.

It should be noted that although the above rules would reduce present risks, they would not by themselves remove the threat of ASAT attacks. For example, a rule on "keep-out-zones" would not prohibit an attack by an SBL at long distance. In short, with no control or limit on space weaponization, these rules could not completely secure space assets.

If a step-by-step approach to arms control and space security is taken, any multilateral attempt must consider all countries' interests. One of China's primary motivations for a ban on space weaponization is its concern about U.S. missile defense plans, which, as discussed, might negate China's current capabilities for nuclear deterrence. Thus, any partial arms control measure involving China should emphasize this concern. For example, a proposal that restricted ASATs but allowed the deployment of a U.S. missile defense system would be perceived by China as discriminatory for two reasons. First, ASATs would be an effective way for China to counter the threat posed by U.S. missile defense. Second, it is difficult to distinguish between ABM systems and ASATs, which possibly would create a source of tension.

A Treaty Banning Space Weapons?

In China's view, the most effective way to secure space assets would be a ban on space weaponization. Chinese Ambassador Hu Xiaodi stated, "If any country is really worried about possible menace to its space interests, this could certainly be alleviated through the negotiation and conclusion of a treaty on the prevention of space weaponization, as suggested by China… Such a legally binding international treaty will be the best tool to safeguard the interests of all sides."[153]

The U.S. position has been that an additional treaty to regulate the use of space is unnecessary. It is true that there are several treaties limiting certain

ous Military Practices in Outer Space, http://www.stimson.org/pub.cfm?id=106; Michael Krepon and Michael Heller, "A Model Code of Conduct for Space Assurance," *Disarmament Diplomacy* 77 (May/June 2004).

153. Hu Xiaodi, statement at the CD, June 7, 2001.

space-based military activities, and these have helped to curb an arms race in space. However, there is no treaty to prohibit testing or deployment and use of weapons in outer space, other than weapons of mass destruction.[154] For example, the 1967 OST, now involving 120 states, bans nuclear weapons or any other weapons of mass destruction in space or on the moon and other celestial bodies, but does not ban weapons in general. The 1963 Limited Test-Ban Treaty and the 1996 Comprehensive Test-Ban Treaty prohibited nuclear test explosions in space. The 1979 Strategic Arms Limitations Talks (SALT II) banned the development, testing, and deployment of systems for placing nuclear weapons or any other weapons of mass destruction, including fractional orbital missiles, into Earth orbit. The 1972 ABM treaty prohibited the development, testing, or deployment of space-based missile defense systems or components. Until the United States' withdrawal, the ABM treaty had been one of the most important agreements on the prevention of space weaponization. It remains apparent that, with or without the ABM treaty, existing treaties are not sufficient to restrict the weaponization of outer space. Moreover, another major loophole is the absence of any agreed upon ban on the threat or use of force from Earth (including from land, sea or air) against outer space objects.[155]

In recent years, most countries have supported efforts to negotiate a new treaty on PAROS. The UN General Assembly has consistently adopted a resolution against space weaponization by an overwhelming majority. In 1999, for example, almost 140 nations voted for such a resolution; only the United States and Israel abstained. The negotiation and adoption of an international agreement on PAROS remains a top priority of the CD, and a number of nations, including China, Russia, Canada, and the Group of 21, have presented proposals on PAROS.

Some U.S. participants in the CD argue that because there is at present no arms race in space, there is therefore no need to develop international treaties to prevent it. In 2002, John Bolton, then U.S. Undersecretary of State for Arms Control and Non-Proliferation, stated to the CD, "The current international regime regulating the use of space meets all our purposes. We see no need for new agreements."[156] Yet, as Richard Garwin noted, "The best time to introduce such treaties and regulations is when there is not active conflict or even an approach to conflict in space."[157] The dispute over space weaponization has paralyzed the CD, rendering it unable to advance any arms control negotiations.

Some experts suggest that amending the 1967 OST would be more expedient than negotiating a new treaty. George Bunn and John Rhinelander, legal advisers to previous U.S. administrations, argued that the OST created an

154. Non-paper by Chinese and Russian Delegations to the CD on August 26, 2004, "Existing International Legal Instruments and the Prevention of the Weaponization of Outer Space," http://www.china-un.ch/eng/cjjk/cjjzzdh/t199363.htm.

155. Non-paper by Chinese and Russian Delegations to the CD on August 26, 2004.

156. John Bolton, statement to the CD, Geneva, January 24, 2002, http://www.acronym.org.uk/docs/0201/doc09.htm.

157. Richard Garwin, "Space Weapons or Space Arms Control."

"overall rule [that] space shall be preserved for peaceful purposes for all countries."[158] By their logic, member nations may use this interpretation of the treaty to prevent unwanted activities by other member nations. As Rhinelander and Bunn explained, "If a state decided to test and possibly orbit in space an anti-satellite weapon…utilizing a laser or kinetic kill vehicle, other state-parties to the space treaty could request consultations. They could conclude that the treaty prohibits the orbiting of the proposed ASAT… Space testing or deployment of other future strike weapons that are inconsistent with 'the benefit and in the interests of all countries'…might produce a similar interpretation."[159] Amending the OST bypasses the negotiation and approval of a new treaty by the Senate, and, as Rhinelander and Bunn noted, also avoids the need for unanimity among parties to the treaty.

Opposing experts argue that the OST is now outmoded and should be abandoned, as it was written before significant recent advances in technology, and relies on vague terms such as "outer space" and "peaceful purposes" that now need clarification.[160] Some Chinese are also concerned that opting to amend the OST instead of drawing a new treaty neglects the urgency of addressing space weaponization. Thus, they believe a better approach—one that would also strengthen the OST—is to prepare a new treaty.

Broad vs. Focused Approaches to Arms Control in Space

Many Chinese believe that China should pursue a complete ban on any kind of space weapons system to effectively prevent space weaponization. China's stance on this issue has been consistent since 1985, when it first introduced a working paper to the CD describing its position on space weapons.[161] China's most recent working paper on the issue, introduced in June 2002, emphasized three basic obligations: 1) "Not to place in orbit around the Earth any objects carrying any kinds of weapons, not to install such weapons on celestial bodies, or not to station such weapons in outer space in any other manner"; 2) "Not to resort to the threat or use of force against outer space objects"; and 3)

158. George Bunn and John Rhinelander, "Outer Space Treaty May Ban Strike Weapons," *Arms Control Today* 5 (June 2002).

159. George Bunn and John Rhinelander, "Outer Space Treaty May Ban Strike Weapons."

160. D. Robert White, "Preserving Space for Peaceful Use: A Case for a New Space Treaty," Working Paper no. 10, Center for Peace Studies, University of Auckland, New Zealand, July 2001.

161. In 1985, China submitted a working paper entitled, "Basic Position on the Prevention of an Arms Race in Outer Space," CD/579. In 2000, China submitted a working paper entitled, "China's Position on and Suggestions for Ways to Address the Issue of Prevention of an Arms Race in Outer Space at the Conference on Disarmament" CD/1606. In 2001, China submitted another working paper entitled "Possible Elements of the Future International Legal Instrument on the Prevention of the Weaponization of Outer Space," CD/1645. In June 2002, China and Russia, together with Indonesia, Belarus, Viet Nam, Zimbabwe and Syria, co-sponsored a working paper, "Possible Elements for a Future International Legal Agreement on the Prevention of the Deployment of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects," CD/1679.

"Not to assist or encourage other States, groups of States, international organizations to participate in activities prohibited by this Treaty."[162]

In order to advance the CD work on PAROS, China (with Russia) prepared two "non-papers" in August 2004 on "verification aspects of PAROS" and "existing international legal instruments and the prevention of the weaponization of outer space."[163] The non-paper on verification argues that the verification regime of a future outer space treaty will be highly complex and will encounter great technological and financial challenges. The non-paper cited the 1967 OST to show that even without a verification mechanism, the treaty is still effective, and therefore, for the time being, a legal instrument for outer space can be formulated without a verification mechanism.[164] However, it does not exclude the addition of a verification protocol when conditions are ripe. The proposal attempts to bypass the problem of verification so that it does not become the principal obstacle to the urgently needed work on PAROS. The non-paper on existing international legal instruments emphasizes that there are no existing treaties that effectively prevent the testing, deployment, and use of weapons other than those of mass destruction in outer space. In addition, none of these instruments covers the threat or use of force from the Earth (including the land, the sea, and the atmosphere) against objects in outer space.

The interpretation of the scope or definition of "space weapon" will be of crucial importance in any future negotiation of a space weapons ban. It will not only affect China's judgment on the value of the ban, but also U.S. decisions on missile defense systems. There is at present no consensus on what constitutes a space weapon. Chinese documents define space weapons as: 1) any weapon stationed in outer space for the purpose of attacking objects in space, on the ground, in the air, or at sea; and 2) any space-, ground-, air-, or sea-based weapons that target objects in outer space.

Two key issues in defining the scope of space weaponry are where weapons are based and what constitutes an "object in outer space." On the first question, any weapon stationed in outer space should be classified as a space weapon. This interpretation is likely to be widely accepted, as the issue of space basing is key. For the question of what constitutes an object in outer space, if "the object" refers only to satellites, then the space weapons ban applies to any weapons stationed in outer space (as answered by the first question) and any ASAT weapons, regardless of location. I refer to this approach defining space weapons as *focused*. However, if "the object" refers not only to satellites but also to missiles traveling through space, then space weapons would be defined

162. "Possible Elements for a Future International Legal Agreement on the Prevention of the Deployment of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects," working paper presented at the CD, Geneva, June 2002 (CD/1679).

163. Two non-papers by Chinese and Russian Delegations to the CD, August 26, 2004: "Verification Aspects of PAROS," http://www.china-un.ch/eng/cjjk/cjjzzdh/t199364.htm; and "Existing International Legal Instruments and the Prevention of the Weaponization of Outer Space."

164. Hu Xiaodi, statement at the Third Part of the 2004 Session of the CD, Geneva, August 26, 2004, http://genevamissiontoun.fmprc.gov.cn/eng/66954.html.

as any space-based weapons, any ASAT weapons, and any ABM weapons intercepting missiles in outer space. I refer to this as a *broad* approach to defining space weapons. By definition, the focused approach would permit a non-space-based BMD system, while prohibiting space-based BMD system. In contrast, the broad approach would put a strong limit any mid-course missile defense system, such as the one currently being developed and deployed by the United States. Although the official Chinese documents do not yet further clarify whether "object in outer space" would exclude ICBMs traveling in outer space, authoritative publications in China have generally favored a broad approach to the definition of space weapons.[165]

To fully define space weapons, one also needs to define the boundary of outer space. There is currently no internationally accepted definition of the outer space boundary. China has defined the boundary of outer space as the Earth's atmosphere, i.e., all space beyond 100 km above the sea level of the Earth. Most scientists and experts generally support the definition of the boundary between 100 to 110 km.[166] The difference between 100 km and 110 km is not a significant concern, because all space-based weapons or "objects in space" discussed below are at much higher altitudes than 110 km.

A broad space weapons ban. An examination of missile defense systems illustrates the importance to any treaty negotiation of unambiguously defining the term "objects of outer space." In the case of a ban on space weapons defined broadly, all potential space-based missile defense systems, including space-based, boost-phase systems, would be banned. These space-based missile defense weapons would be typically deployed in polar or near-polar orbits much higher than 100 km. For example, the envisioned SBL weapons would orbit at around 1000 km or higher. Space-based KEWs would orbit at an altitude of about 300–500 km.[167]

The GMD system that is currently deployed would not be permitted under a broad definition, as the intercept altitude of ballistic missile defense is between about 200 km and 2000 km (a typical intercept altitude for a ICBM at range of 10,000 km is between about 1000 and 1500 km). It is reported that the actual national missile defense system will intercept at an approximate altitude of 1100 km and that the minimum intercept altitude of BMD is 130 km. Both would exceed the 100 km limit set by a broad interpretation of space weapons.[168] In addition, theater missile defense systems, such as THAAD and sea-based midcourse defense systems, are designed for exoatmospheric intercept.[169]

165. In China, the broad interpretation of space weapons is very popular. See, e.g., Du Xiangwan, *Science and Technology Foundation For Nuclear Arms Control*; Liu Huaqiu, ed., *Arms Control and Disarmament Handbook*.

166. See, e.g., Cheng Bin, *Studies in International Space Law* (Oxford: Clarendon Press, 1997) and references there.

167. See, e.g., *Report of the APS Study Group on Boost-Phase Intercept Systems*.

168. Andrew Sessler et al., *Countermeasures*, p. 28, and references there. The kill vehicles have a minimum intercept altitude, below which they cannot intercept a target. The Ballistic Missile Defense Organization is trying to achieve a minimum intercept altitude of 130 km.

169. Lester L. Lyles (Lt. Gen., USAF), director, Ballistic Missile Defense Organization, "Theater High Altitude Area Defense (THAAD) Media Update," July 9, 1998.

Moreover, even the proposed ground-based boost-phase missile defense system would intercept an ICBM at an altitude over 100 km.[170] For example, if the burnout time of an ICBM is between 200 and 250 seconds, and its burnout altitude is between 200 and 350 km, an interceptor (of 100 seconds burn-time, 8.5 km/s burnout speed, launched approximately 100 seconds after ICBM launch) within 1000 km of the ICBM launch location would intercept the ICBM at an altitude of approximately 200 km.[171]

The only missile defense system allowed under a broad space weapons ban would be the terminal-phase defense system, which would destroy warheads at low altitudes (tens of kilometers) through the use of a non-space-based antimissile weapon. However, the defense footprint of this system is small in comparison to other systems, as it is only a "point" defense for a localized area such as a missile silo. Without other overlapping systems, it would not provide global coverage.

Because a broad interpretation of space weapons would rule out almost all U.S. missile defense systems, Chinese officials who want to limit U.S. missile defense deployments would advocate a ban that used this interpretation. For the same reason, it is unlikely that the United States would accept such an interpretation. Many Chinese officials and experts have already used the broad definition of space weapons.[172]

A focused space weapons ban. If China wants to move past its complaints and toward an agreement, it will have to consider proposals that might conceivably be acceptable to the United States. A ban on space weapons that used a focused definition of these weapons, along with bilateral confidence-building measures, could be a first practical step to overcome the deadlock at the CD and to reduce the concerns of both the U.S. and China. The focused approach could include the following two core elements:

- Banning the testing and deployment of any weapons in outer space, including space-based KEWs, space-based DEWs, and any other space-based weapons for attacking space-, ground-, sea-, or air-based targets. This would rule out space-weapon components of missile defense and ASAT systems.
- Banning the testing and deployment of any "dedicated" ASAT weapons. This would include any weapon strike system—whether ground-based, sea-based, air-based, or space-based—against orbiting satellites.

170. Theodore Postol, transcript of, "A Preliminary Analysis of a Russian-US Boost-phase Defense to Defend Russia and the U.S. from Postulated Rogue-State ICBMs," presentation at Carnegie Endowment for International Peace, October 12, 1999; Richard Garwin, "Boost-Phase Intercept: A Better Alternative," *Arms Control Today* (September 2000); *Report of the APS Study Group on Boost-Phase Intercept Systems for National Missile Defense*.

171. Theodore Postol, "A Preliminary Analysis of a Russian-US Boost-phase Defense."

172. See, e.g., Wang Xiaoyu, "Development of Antiballistic Missile System vs. the Prevention of an Arms Race in Outer Space"; Du Xiangwan, *Science and Technology Foundation For Nuclear Arms Control*; Liu Huaqiu, ed., *Arms Control and Disarmament Handbook*.

Because all long- or intermediate-range ballistic missiles and high-altitude missile defense systems have inherent ASAT capabilities, it would not be practical to pursue a complete ban on ASATs. Although a ban on testing in "ASAT mode" would not eliminate all threats to satellites, it would reduce the cost and complexity of ensuring a reasonable level of satellite safety. Under such a regime, non-dedicated ASATs would not be able to reach high-value satellites in geosynchronous or high Earth orbit, including widely used weather satellites and civilian and military communications satellites, and some of the most stabilizing and defensive military satellites responsible for early warnings of missile launches and the detection of nuclear explosions.

What is the likelihood of both the United States and China considering a focused approach to banning space weapons?

The United States would likely find a focused approach more acceptable than a broad approach. Although a focused approach would ban space-based weapons and ASATs, it would allow deployment of the GMD system that is a major part of the MDA's current budget and development efforts.

A focused space weapons ban would reduce the proliferation of ASATs. It would reduce the risk of a "Space Pearl Harbor" for other military and civilian satellites. As many experts in the United States point out, the heavy dependence of the United States on its space assets means that it "has more to lose than to gain by opening the way to the testing and deployment of ASATs and space weapons."[173] For example, the United States is now more dependent on satellites to perform important military functions than is any other state. By placing weapons in space, the United States might stimulate others to balance symmetrically and asymmetrically against U.S. space assets. It would be very difficult for the United States to maintain unchallenged hegemony in space weaponization, and many have argued that the United States' current military advantage in space assets would be lost or degraded by weaponization. Space weaponization would also threaten U.S. civilian and commercial assets. The economy and society of the United States are highly dependent on the applications of commercial satellites. Placing weapons in space would make these satellites much more vulnerable.

Richard Garwin and his co-authors argue that "a regime that effectively prohibits the deployment of space weapons and the use of destructive ASAT before they can destroy U.S. or other satellites would be a smart, hard-nosed investment in U.S. national security, but would require U.S. leadership."[174] Although funding requests from the current administration show continued interest in space-based weapons systems, the actual level of funding is directed toward only a small portion of the missile defense program, which remains in the conceptual and research stages. At the current speed of development, the space-based BMD system would not reach fruition until around 2020. The United States still has time for serious reconsideration of its space activities.

173. David Wright et al., *The Physics of Space Security*.

174. Bruce DeBlois et al., "Space Weapons: Crossing the U.S. Rubicon."

From a Chinese perspective, a non-space-based BMD system would be less threatening to national security than a space-based missile defense system. As discussed above, countermeasures for mid-course missile defense systems would be less expensive and easier for China to develop. However, a space-based, boost-phase missile defense system would pose more threat than a non-space-based BMD system, because a boost-phase missile defense would have fewer targets, the target ICBM would be much larger and more fragile than the normal re-entry vehicle, and the target would be easily detectable due to the bright plumes of the burning booster. Moreover, a non-space-based, boost-phase missile defense system would not be able to cover ICBMs launched from China's interior. In fact, an ICBM at an altitude of 200 km is only detected within 1600 km by a sensor on the ground, and within 2000 km by a sensor at an altitude of 15 km. Because of the vastness of China's land holdings, the United States would have to destroy a Chinese missile in boost phase from space.[175] As such, even a limited ban on space weapons would significantly reduce the threat to China posed by U.S. missile defense systems, assuming that Chinese military planners have confidence in countermeasures for midcourse missile defense systems.

Other confidence building measures. Other bilateral confidence-building measures between the United States and China would facilitate China's consideration of a focused approach to space weapons negotiations. These measures might include:

- U.S. acknowledgment of the serious nature of China's concerns, including an assurance that a U.S. missile defense system will not target China.
- A U.S. pledge to adopt a bilateral no-first-use policy toward China. Because China already has a blanket no-first-use policy on nuclear weapons, many Chinese believe that a U.S. no-first-use policy would significantly reduce the threat of nuclear weapons. Such a policy would ease concerns about the possibility of a U.S. pre-emptive strike.
- The clear exclusion of Taiwan in the U.S.-Japan joint theater missile defense plan, and prohibition of the sale of theater missile defense to Taiwan. This measure would greatly reduce China's concerns about regional security and security in Taiwan.
- Additional limitations on the scale and scope of the envisioned U.S. non-space-based missile defense architecture. This would include placing a limit on the number of missile defense interceptors and restricting the system to the minimum required to deal with rogue threats. This would ensure that China's current stock of fissile materials would be sufficient to fill the number of new warheads needed to balance U.S. missile defense interceptors. Without any limitations on missile defense systems, China harbors concerns about whether its current fissile material stocks are sufficient to counter a larger U.S. missile defense system.

175. Richard Garwin, "Holes in the Missile Shield"; American Physical Society, *Report of the APS Study Group on Boost-Phase Intercept Systems for National Missile Defense.*

Not only does this directly affect China's willingness to participate in the FMCT, but it also ensures that China builds its nuclear arsenal in a predictable way—until it has the capacity to meet the threat of a U.S. missile defense system—which the United States should acknowledge and understand.

- The development of a cooperative early warning system between the United States and China, much like the current U.S.-Russian early warning system.

CONCLUSIONS

There is evidence to suggest that the Bush administration's move toward space weaponization is gaining momentum. A number of U.S. military planning documents issued in recent years reveal the intention to control space by military means. In practice, the United States is pursuing several space weapons programs that could be used to attack ballistic missiles in flight and also satellites and targets anywhere on Earth. Chinese officials have expressed a growing concern that U.S. space control plans would stimulate a costly and destabilizing arms race in space and on Earth. In particular, Beijing is concerned that the United States seeks to neutralize China's strategic nuclear deterrence capabilities, freeing itself to intervene in China's affairs and undermine efforts at reunification with Taiwan.

To respond to the move by the United States to deploy space weapons, the first and best option for China is to pursue an arms control agreement to prevent space weaponization, as it now advocates. A feasible, focused agreement would ban the deployment of weapons in space and the testing of weapons in ASAT mode. If this effort fails and if the security threats China perceives to be legitimate are ignored, China would likely develop responses to neutralize these threats. Possible responses might include building more ICBMs, adopting countermeasures against missile defenses, developing ASAT weapons, and reconsidering China's commitments to arms control including participation in the FMCT and ratification of the CTBT. Failure to proceed with the nuclear disarmament process eventually would undermine the already fragile nuclear non-proliferation regime. Consequently, U.S. space weaponization plans would have potentially disastrous effects on international security and the peaceful use of outer space. This would not benefit any country's security interests.

If Washington wants to reduce the potential vulnerability of its space assets, there are a number of ways to improve space security, including satellite hardening, accepting modest "rules of the road," and agreeing to more comprehensive arms control measures. Weaponizing space can only erode space security, which is in no one's interest. China believes that the most effective way to secure space assets is to agree to an international ban on space weaponization. In recent years, the UN General Assembly has adopted resolutions calling for the CD to start a negotiation on PAROS by an overwhelming majority. Washington has opposed these resolutions. If the history of nuclear weapons tells us anything, it is that banning the testing and deployment of weapons from the outset is much more effective than attempting disarmament and non-proliferation after the fact.

Outer space is the common property of mankind. The international community should take action now to prevent a space arms race and to ensure the continued peaceful use of outer space.

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