5

MILITARY SPACE

Expanded Uses and New Risks

Military purposes have been part of national pursuits in space since the beginning of space activity. Just as all countries undertake defensive activities on Earth, nations have sought to further their national security through the use of space assets. The fact that relatively few dedicated space weapons have been tested to date and even fewer deployed suggests either that the technology to deploy them efficiently has not yet been developed or that countries have chosen not to do so for political, strategic, or environmental reasons. Analysts are divided over which of these explanations is correct. But the answer matters to the future, because if countries believe that large-scale weaponization of space is inevitable, they are not likely to agree to halt such efforts. By contrast, if the world's major spacefaring countries believe that space weapons are likely to do more harm than good, they are more likely to work to develop restrictive treaties and establish new types of international verification to enforce them.

To date, most military space activities consist of support functions—that is, technologies that allow military forces on the ground, at sea, and in the air to operate more effectively. These include weather forecasting, communications, precision timing and navigation, reconnaissance (of various types), and early warning. Space assets make military systems work better and thereby enhance the tools that can be used in other environments, including improving weapons accuracy to reduce casualties and collateral damage. Reconnaissance and early-warning technologies can help support arms control and prevent conflict in the first place by providing accurate data on long-range delivery systems, thus making it more difficult to cheat. The advantages that the United States gained in many areas of military space during the Cold War have enabled it to project power and preserve peace much more effectively than any other country. Although Russia still possesses significant capabilities, it is further behind the U.S. military in space than it was during the Cold War.

But a variety of other countries are now seeking to enter the military space realm. Most are deploying technologies for reconnaissance, secure communications, targeting, electronic intelligence, and space situational awareness. A few are trying to develop space weapons capabilities, ranging from electronic jammers that interrupt signals to kinetic weapons that destroy spacecraft. Why would they want to do this? The goals of such programs have historically been to try to deny an adversary's "eyes and ears" in space, which could be extremely useful in a conflict. But, as seen in the Soviet anti-satellite (ASAT) test program from 1968 to 1982, the U.S. ASAT test in 1985, and China's ASAT test in 2007, kinetic programs (those based on weapons that collide with their targets) have significant negative implications for the space environment, since they put all other satellites in the same orbital band at risk from the indiscriminate debris they produce. Still, having a potential capability can be considered to serve a deterrent role, making the adversary think twice before engaging in a conflict if there is a risk of losing one's critical space assets. As judged by debates in India since China's ASAT test, the mere fact of having conducted a successful test is perceived as putting one's military space program in a privileged class above others, providing power and prestige.[1] But these very factors make arms control to halt development of such weapons difficult, as countries may be unwilling to sign away options that others have demonstrated, even though none of these weapons have ever been used in warfare and would create long-lasting environmental damage to Earth-orbital space.

In order to understand current trends in the military space realm, it is important to examine what capabilities exist and what pressures might cause an arms race to occur in space, as was threatened at various times during the Cold War (but never took place). Will emerging conditions and the presence of multiple actors make the military space environment more threatening, or will costs, technological limitations, and a desire to pursue peaceful space development trump the use of force and again cause countries to step back from crossing this threshold?[2]

MILITARY MISSIONS AND SPACE PHYSICS

As we saw in chapter 1, the physical characteristics of space greatly influence what kinds of activities are best suited for orbital space and also what they cost. Put simply, the fact that satellites in low-Earth orbit must travel at speeds exceeding 17,000 miles per hour makes them expensive to launch and means that *many* of them are needed in a formation (or "constellation") in order to provide coverage over any specific area of the globe at any given time. Reconnaissance is best done close to Earth in low orbits, but very few countries can afford to orbit enough satellites to make timely passes over single points of interest on the globe more than a few times a day. As in other areas, you get what you pay for, at least if you want to control the information and how often it is provided. Increasingly, commercial imaging satellites can provide "good enough" pictures for those who lack the funds for their own reconnaissance or who want to supplement their limited assets. But national militaries may or may not be able to keep their purchases secret from the governments that have jurisdiction over the satellite companies taking the pictures, and the images may not be as timely as a military purchaser might like.

Beyond photographs, which are now transmitted digitally to computers on Earth and sent to clients electronically (rather than deorbiting film and recovering it manually as in the old days), military customers are often interested in other information: infrared images (which detect the heat signatures of objects) or radar images (which provide information on materials and construction).[3] Unlike visual imaging systems, infrared technologies can work in darkness and radar satellites can operate in rain or shine.

Other information of interest to militaries includes signals intelligence, which captures electronic emissions from radar as well as telemetry from missile tests. Such information is critical for militaries seeking to determine what foreign facilities might target their aircraft with missiles in a conflict and what the capabilities of these systems might be. Signals intelligence satellites may also intercept wireless communications of various sorts.[4]

Medium-Earth orbit is home to most position, timing, and navigation satellites. These satellites are of special interest to military services because of the importance of knowing where enemy (and your own) forces are and where they are going. During wartime, when a military needs to target enemy forces or a specific facility with great precision, these systems are extremely valuable. Such technologies have revolutionized the way the United States fights, giving it stark advantages in accuracy and effectiveness. Despite the fact that the U.S. GPS system is available free of charge to any user around the globe, a number of foreign militaries are seeking to develop their own networks for fear that Washington might shut off or encrypt GPS signals during some future conflict. They may also wish to develop more precise locational signals for their particular region. Russia already has this capability through its GLONASS satellite constellation, China's Beidou system is now reportedly operating on a regional scale, and India, the European Union, and Japan are all in the process of developing such networks.

Geostationary orbit is the location of a variety of other military satellites. Much useful information can be gleaned with various sensors when they are parked above a country (or region) and can "stare" at these locations for long periods of time. While it is not a favorable venue for taking images (due to its great distance from Earth), it is perfect for fixed communications, missile early warning, nuclear test detection, and certain types of signals intelligence.

SPACE WEAPONS

Any consideration of the question of space weapons raises the issue of definition. Some observers make the case that space weapons are already widespread and range from jammers that interrupt the functioning of satellites to past systems like the U.S. space shuttle (which was capable of taking satellites into its cargo bay for repair or, in theory, destruction) to devoted kinetic ASAT systems.[5] Such a broad definition makes space already "weaponized" and renders notions of a "ban" on space weapons impossible. Other analysts argue that only technologies that physically damage or destroy space assets should be counted as "weapons."[6] Far fewer of these latter systems have been developed, and very few of them tested. Prohibiting space weapons through a ban on use, deployment, and future tests may be possible, since destructive testing is highly transparent in space. But no such treaty would be perfect. Non-destructive tampering systems would be harder to limit and would likely require some form of space-based monitoring. Yet the process of elaborating such limits in itself might well be useful, particularly if it improved transparency and provided leverage and incentives for countries to blame, shame, and sanction, thereby raising the costs considerably for violating weapons non-testing or non-deployment norms.

Before discussing national capabilities and specific existing and emerging threats, it is worthwhile to review some basic factors that would affect any country's deployment and use of space weapons. A detailed study of space security by a group of physicists for the American Academy of Arts and Sciences sets forth key parameters that affect military space activities,[7] among them the following:

1. "Satellites are intrinsically vulnerable to attack and interference. However, satellite systems can be designed to be less vulnerable than the individual satellites that compose the system."
2. "A nation could not use space-based weapons to deny other countries access to space, although it could increase the expense of such access."
3. "No country can expect to have a monopoly on deployed ASATs."
4. "Being the first to deploy space-based weapons would not confer a significant or lasting military advantage."[8]

The report goes on to explain some of the technical details about the difficulties of deploying space weapons for various purposes: space to Earth, Earth to space, and space to space. In the first category, the most significant hurdles include the high cost of launching weapons into space and operating them, as well as the need to orbit large numbers of them in order to be able to stop ground-based missiles or attack specific ground targets in a timely manner. Except in distant GEO, weapons do not "sit" above a country but instead fly over very rapidly and then have long gaps between revisit times. This "absentee" problem makes orbital systems more costly and less reliable than air-, sea-, or ground-based systems, particularly for militaries with long-range missiles and GPS access for accuracy.

In the second category, Earth-to-space weapons, the report notes the limited ability of ground-based systems to attack orbital space assets, since specific assets come within range only periodically. Attacking space assets operating in sunlight is relatively easy with an infrared seeker because the target appears warm against the cold background of space. Less-sophisticated optical seekers work too, since the target appears bright against the blackness of space. Attacking in darkness is more difficult, thus limiting the timing of possible attacks, or forcing the use of more easily spoofed radar seekers. Once an attack began, a country whose assets were being attacked could move its space assets to avoid passing over the aggressor country (dependent on timely warning and communications), while potentially taking offensive countermeasures against the attacker's ground systems. Debris accumulation in low-Earth orbit would also quickly become a problem for both sides. Primitive attackers would be unlikely to hit specific assets and would succeed only in spreading debris (or possibly electromagnetic pulse radiation in case of nuclear use) that would be harmful to all countries, thus bringing international scorn and possibly concerted counterattacks.

Lasers—possessed by many countries and used widely for the purposes of determining the altitude of satellites—could be effective in blinding critical assets short of destruction. They can overload the pixels on imaging satellites and cause them to register useless images or even cause permanent damage to their imaging capability. Higher-power lasers could also cause destruction, such as by overheating a satellite and causing a fuel tank to explode. But certain countermeasures can reduce the effectiveness of lasers. For example, some sophisticated military satellites can reportedly detect attempts at laser interference and protect their focal arrays with shutters.[9] Rotating a satellite can also reduce the heating effects of high-powered lasers. In addition, high-power, ground-based laser facilities typically use large quantities of liquid chemicals to power their systems, making them highly vulnerable themselves to cruise missile or aircraft strikes. Overall, Earth-to-space attacks are feasible but are likely to have limited effectiveness, while creating costs for all spacefarers.

In the third category, space-to-space weapons, which are the least developed today, problems arise in terms of useful range, collateral damage, and countermeasures. While it is possible to place a kinetic or explosive space mine in similar orbit as a target satellite, such behavior would likely be transparent in low-Earth orbit and could be difficult to maintain if evasive action were undertaken (depending on which satellite had more fuel). The debris created from an attack would also pose a hazard for all satellites passing through the same orbital band, including those of the attacker. Shooting at targets with a laser would require launching significant amounts of chemical fuel, which would dramatically raise costs for the attacker and possibly explode the target and generate harmful debris. Thus, while a variety of space-to-space weapons options exist, they are technically difficult, relatively transparent (likely resulting in immediate political, economic, or military countermeasures), and costly. Nevertheless, the possibility of space-to-space attack cannot be ruled out, particularly with non-kinetic systems that cause less-than-catastrophic damage (where attribution can be more complicated).

In this regard, another potential means of nullifying a satellite is to jam its signal with electronic systems based in space, in the air, on ships, or on the ground. This method has the great advantage that it does not destroy the satellite, which would likely bring legal or military action by its owner. (To date, no country has destroyed any other country's satellites, only their own in tests.) Interference is normally achieved through electronic means—that is, by sending a signal that overrides the satellite's intended commands, disrupts its receipt of a coherent signal, or prevents its signal from being received on the ground. Such activity represents a violation of commercial satellite regulations, and countries have been reported to the International Telecommunications Union for engaging in jamming. But jammers are widely available in the international marketplace and can be highly effective against commercial systems and satellites that broadcast on fixed, known frequencies. Jamming is less effective against sophisticated military communications satellites, which may incorporate evasive systems that allow them to change frequencies and thus avoid jamming. Compared to ground-, sea-, and air-based systems, orbital jamming is by far the least-developed option. The attacking satellite would have to maneuver into a blocking position relative to Earth and maintain it, as well as have adequate technology to avoid frequency hopping or other evasive measures by the target satellite, again raising costs. But the problem of jammers is likely only to increase as more countries acquire systems for use against civilian and military communications satellites, as well as precision navigation signals.

DEFENSIVE SYSTEMS AND CONCEPTS

While space assets are vulnerable because of their fixed orbits and relative ease of tracking (at least for moderately sophisticated attackers), space systems can also be defended in various ways. A country being threatened, if it has reliable intelligence, might preempt the attack in the first place on the ground. However, that would require an act of war, making it unlikely, unless a conflict had already begun. If it suspected targeting of a specific asset—such as a large intelligence satellite—it might be able to engage in a maneuver to avoid interception. Such a step might be effective if taken early enough, by moving the target spacecraft out of range of a specific country's ground-based missiles, especially if they are being launched from fixed sites. If such a warning were not available, however, a country would find it considerably harder to evade an ASAT attack from the ground. Even short of attack, if the threat of ASAT attack were to cause disruption in an adversary's space constellation by forcing it to take preventive action, it may have achieved at least part of its objective by deterring overflight of sensitive sites.[10]

In sum, while there are some mechanisms to reduce vulnerability, the first shot is still likely to be successful if undertaken by a well-tested ASAT system. Sustaining such a campaign against multiple spacecraft, however, is much more difficult. Fortunately, not many ASAT weapons have undergone multiple tests or are readily deployed in significant numbers.

U.S. anti-ballistic missile defenses—including those based on Aegis ships—have had the most operational testing of any system with either a devoted or a dual-use ASAT capability. Foreign critics of U.S. space policy raise this point frequently, and it does complicate space arms control efforts. While there are differences between satellite and ballistic missile interceptions, missile defense is generally harder. Missiles come in various sizes and speeds, and their warheads that travel through space are typically much smaller than satellites. Also, satellite orbits can be observed beforehand, and the spacecraft themselves are often large and reflect sunlight well, making them easier to target. Finally, satellites offer multiple passes, allowing an attacker to prepare for the shot over days and weeks. In missile defense, there is only one shot, whether the intercepting country is ready or not.

In seeking to defend one's satellites, employing so-called non-offensive defenses may be the most effective strategy for both deterring attacks against satellites and preventing them once a conflict begins. As the Canadian space expert Phillip J. Baines explains, these options include five categories: (1) denial and deception (for example, the use of black, carbon-impregnated thermal blankets to mask a satellite's optical signature); (2) hardening and shielding (for example, onboard shutters to protect against lasers); (3) maneuvering (for example, the addition of stored fuel for possible evasive actions); (4) redundancy and reconstitution (for example, the use of commercial or allied systems to provide service in case of attack on one's own assets); and (5) dispersion (for example, the creation of small, hard-to-attack modular satellite networks to replace constellations of large and vulnerable multipurpose satellites).[11]

At present, no country is known to have any significant stockpile of ready ASAT weapons. Thus attackers face a significant deterrent if they consider that their limited weapons will be rendered irrelevant by defensive countermoves. In addition, retaliatory strikes on the attacker's ground systems (launch sites, communications nodes, radars, and command/control)—once a conflict started—could be swift and devastating, given the fragility and vulnerability of many of these installations.

Short of direct attacks on space systems, space war could occur through several other means. Indeed, as space powers know, the most vulnerable part of most constellations is not the space-based portion. Existing ASAT systems, as noted above, are relatively expensive, few in number, and of limited effectiveness and reach. By contrast, ground-based radars, launch sites, control facilities, and communications nodes, as well as the radio signals themselves, are often vulnerable to simple conventional attack. However, since these systems are located in another country's national territory, the threshold of war would have to be crossed for such an attack to be undertaken.

Possible Space War Scenarios

What might a space war look like? It could begin with an increase in tensions over terrestrial issues and build into a conflict in which space assets (such as those for navigation, reconnaissance, and targeting) would play a critical role and might quickly become desirable targets. An advanced space power might target an enemy's satellites in low-Earth orbit and seek to destroy them with kinetic weapons in order to "blind" enemy forces. Such attacks would release large amounts of debris, quickly putting other countries' spacecraft in the same orbits at risk. A less-developed country with little reliance on space might seek to carry out an even less discriminating attack using a nuclear weapon, although at the risk of destroying or disabling all satellites passing through that region of space. The country that had been targeted in space might respond by trying to take out launch sites in the aggressor country, causing casualties on the ground as well as destruction of critical facilities. This would be more difficult with mobile launchers, although the strikes could focus instead on vulnerable command and control sites. Space assets of that country might also be targeted for counterattack, increasing the field of orbital debris even more. Once these attacks are carried out, that country's launch sites might then come under attack, escalating the conflict even further. At this point, the war might spiral out of control as each side sought to take out more facilities and troops to render space unusable to its opponent. Depending on the armaments involved, this could lead to limited nuclear exchanges. Alternatively, the rapid rise in lethality and damage might bring the two sides to their senses and cause the two capitals to seek a cease-fire. But wars often make people mad, rendering sensible outcomes less likely.

A less escalatory but effective means of negating an adversary's space systems is ground-, air-, or possible space-based jamming of the adversary's satellite signals. Of these different technologies, ground-based systems are generally cheap and fairly effective, at least for temporary effects. The dilemma, though, facing countries that might attempt to jam GPS signals and communications in a theater of conflict is that the more advanced militaries already train to operate under degraded conditions. The United States, for example, is developing systems to reroute GPS signals and distribute other communications through nontraditional means. Thus, a major investment in anti-space technology could be rendered moot. That said, it is undeniable that valuable space assets could suffer significantly from a concerted attack by a peer or near-peer adversary, reducing overall combat effectiveness. However, deterrence might also prevail. The United States considers attacks on its critical military space systems as possible precursors to nuclear war. Thus, the attacker would have to think very carefully about the risks of undertaking such actions.

Indeed, one of the stabilizing characteristics of the Cold War was the understanding that attacks on strategic space reconnaissance and early-warning systems could indeed be interpreted as the first stage of a nuclear attack. For this reason and because of the need for such systems to verify U.S.-Soviet arms control agreements, the two sides agreed by treaty to exempt such systems from attack and by consensual norm not to interfere with each other's military satellites more generally. A question for the future, however, is whether this understanding has been adequately instilled in the minds of officials among new space powers. In this regard, political and diplomatic mechanisms provide another important line of defense in space.

NATIONAL MILITARY SPACE CAPABILITIES

Dedicated space weapons have been developed only by Russia, the United States, and China to date, with relatively limited capabilities. The one exception is nuclear weapons, which represent a blunt and powerful anti-space instrument that a number of other nuclear- and missile-capable countries might use against space if they wanted to cause indiscriminate damage to all space assets. Nuclear weapons have been used only in U.S. and Soviet test programs early in the space age. Since then, no such tests have occurred in space and almost all space-faring countries have agreed to the terms of the 1963 Partial Test Ban Treaty or the 1996 Comprehensive Test Ban Treaty and have sworn off the use of nuclear systems. Of course, it remains possible that a country might violate these agreements. But the threat of destruction of large numbers of satellites and the deaths of astronauts in low-Earth orbit should serve as a significant disincentive, unless a country is willing to bear the wrath of all countries with space assets. Conflict in orbit, however, remains difficult to predict. In part, this confusion has to do with the broad range of military capabilities present among current and emerging space actors.

Today's dynamics pose a different kind of military space competition than the one that existed during the Cold War. It is slower and more diffuse, but it is beginning to accelerate. The big question is whether national militaries will by and large limit themselves to military support activities and force enhancement technologies or will instead venture into costly and provocative force-application programs for space.

The United States

The United States' military space program is the most comprehensive in the world, dwarfing all others, including those of Russia and China. According to published sources, combined U.S. spending on military and intelligence activities in space is about $42 billion a year,[12] a figure that surpasses the combined figure for all other world military space programs. Of the approximately 1,000 operating spacecraft currently in orbit, some 170 are military satellites and about half of those are operated by the U.S. military and intelligence communities.[13]

The United States has a long history of experimenting with offensive and defensive space systems. Notably, very few of these technologies have been deployed in anything beyond "hedge capability" numbers because of cost, concerns about strategic stability, and calculations of their likely limited operational effectiveness. Nuclear-tipped ballistic missile defense (BMD) systems for use in space, nuclear-tipped ASAT weapons, and air-launched kinetic ASAT weapons have all been tried and abandoned. Offensive U.S. capabilities for use against foreign space assets are limited largely to dual-use capabilities from programs with other primary uses. The sea-based Aegis BMD system proved effective in destroying a falling and unresponsive U.S. satellite laden with hydrazine in February 2008 and presumably could be used again. U.S. laser-ranging facilities in New Mexico have dual-use capabilities as dazzlers (capable of temporarily blinding foreign reconnaissance satellites) and could perhaps have destructive (permanently blinding) capabilities, depending on their power and the length of time a target could be engaged.[14] The U.S. military has also experimented with satellite proximity operations: the 2005 Demonstration for Autonomous

Rendezvous Technology (DART) project, during which the test vehicle inadvertently collided with the target satellite, and the *Experimental Satellite System* (*XSS*)-*11*, first tested in 2005–2006.[15] Analysts also presume that the U.S. military has satellite-jamming capability "effective out to geo-synchronous orbit," although the United States is not known to have operated such capabilities.[16] The U.S. military also has sophisticated satellites equipped for such missions as signals intelligence, synthetic aperture radar detection, optical detection, and infrared missile detection. It is the only country to date to have used GPS-guided weapons in war. The U.S. military has tested a small, experimental, unmanned space plane (the *X-37B*), apparently for the possible delivery of weapons or small satellites, space-based equipment testing, or military reconnaissance.[17] U.S. missile defense programs, ranging from ground-based interceptors in Alaska and California to mobile sea-based Aegis destroyers, also have an inherent dual-use capability as possible ASAT weapons.[18]

Russia

Russia is the next most capable military space actor, based on its long history of military space operations during the Cold War. While many of these capabilities deteriorated in the 1990s, the Russian government has sought to reconstitute a number of them. These include the direct-ascent Naryad ASAT system (although not tested in a destructive mode), the GLONASS precision navigation and timing constellation, and various signals intelligence, photo-reconnaissance, communications, and meteorological satellites. Moscow tested co-orbital ASATs during the Cold War and has conducted experiments with other space weapons. Russia today has laser facilities and is known to produce satellite jammers, some of which were sold to Iraq before the second Gulf War in 2003 in an attempt to negate the U.S. GPS system (but they were destroyed by U.S. forces).[19] In his third term in office, President Putin has pledged major increases in military space spending. Moscow recently modernized the Plesetsk military launch site to increase Russia's capacity to reconstitute its former military satellite constellations.

Also, various organizational reforms have placed more emphasis on Russia's Space Forces, which number some 40,000 members.[20] Still, the major questions facing Russian military space capabilities are ones related to research and development, quality control, and long-term political and budgetary support.

China

China is a relative newcomer to the military space club, but it has been making up for lost time. In the past decade, it has made major investments and conducted tests of counterspace systems, including kinetic ASATs, small satellites capable of proximity operations, and jammers. China is also known to have laser facilities capable of disrupting space assets. A survey of Chinese military space writings by Dean Cheng argues that "PLA authors . . . would seem to support an approach that balances disruption (soft-kill) and destruction (hard-kill) of an opponent's space systems."[21] A 2011 U.S. government report makes the case that, besides Beijing's 2007 ASAT test, "China is also developing other kinetic and directed-energy (e.g., lasers, high-powered microwave, and particle beam weapons) technologies for ASAT missions. Foreign and indigenous systems give China the capability to jam common satellite communications bands and GPS receivers."[22]

Besides these programs, analysis of recent launches suggests that the bulk of China's military space expenditures has gone to expansion of traditional military support capabilities, as Beijing seeks to catch up with the United States and Russia and to develop assets that will be useful for modern combat operations and global force support. China has focused on expanding the size of its constellation of reconnaissance satellites, as well as improving their previously poor resolution, while also developing new radar satellites and expanded space-based electronic intelligence-gathering (another earlier weak point).[23] Nevertheless, China continues to purchase commercially available visual spectrum and infrared imagery, suggesting that gaps remain or that the resolution of Chinese military satellite technology is not yet adequate.[24]

China is also moving rapidly to populate its Beidou precision timing and navigation satellite network, which will likely have a separate military signal for use in missile guidance. The question that observers watching China's military space expansion ask is, "Where exactly is this program headed?" Some experts believe that China is seeking a limited "hedge" capability to enable it to deny possible U.S. space dominance in case of a conflict over critical national interests, such as the status of Taiwan, which China claims as an integral part of its territory. As the military space expert Barry Watts argued in 2011 testimony before a congressional commission, U.S. fears of a "Space Pearl Harbor" proved a poor predictor of China's military space aims during the decade from 2000 to 2010.[25] While not ruling out future expansion of Beijing's capabilities, Watts concluded that, overall, China's military space efforts "would be unlikely to produce a decisive advantage over the United States in conflicts in the western Pacific through the end of this decade," and even less so at the global level.[26] But others believe that China's military space growth is aimed at developing options for full-scale space war. One analyst of Asian affairs, Gordon Chang, argued in 2009 that Beijing had "announced its intention to begin the space arms race in earnest" and had adopted a policy to "dominate space."[27] Thus far, the evidence seems to point to more-limited Chinese aims in the space weapons sector focused on developing deterrent capabilities and limited offensive systems, rather than a full-scale war-fighting arsenal for space. But time will tell.

The next tier of space actors—as a group—devotes far fewer resources to military space activities than do the top three. Thus far, they have tended to limit themselves almost exclusively to support operations, such as reconnaissance and communications. But this situation is beginning to change.

European Space Agency Countries

Several countries in the European Space Agency (ESA) have military space activities, with France being the most experienced. These activities have historically been conducted strictly on a national basis because of

ESA's original charter requirement that joint activities have solely civilian purposes. France has used its Satellite pour Observation de la Terre (SPOT) system for military reconnaissance as well as civilian remote sensing. It followed with two generations of higher-resolution *Helios* satellites, with Germany as a partner. Since 2012, an even more sophisticated Pleiades satellite constellation has provided 70-centimeter-resolution images to France's military, but also sells imagery commercially.[28] In addition, France continues to develop its space-based missile early-warning system. Germany operates highly capable synthetic aperture radar satellites under the SAR-Lupe program, which has a ground station in France as well. Italy operates the Constellation of Small Satellites for the Mediterranean Basin Observation (Cosmos-SkyMed) radar system, whose data it swaps with France for optical imagery. These countries are being joined by Belgium, Greece, Italy, and Spain in working toward the Multinational Space-Based Imaging System (MUSIS).[29] Given the high costs of national systems, MUSIS is an effort to pool resources and share data from various national platforms and ground stations. Finally, the United Kingdom has long operated a military communications system (Skynet) and is working toward greater cooperation in the military space sector. Recently, as a result of pressure from member governments and in the context of Europe's planned Galileo GPS system, ESA nations agreed to allow joint military activities. European militaries plan to equip various defensive and offensive systems with Galileo devices to provide precise tracking and targeting.

Discussions are also ongoing within the context of the NATO alliance to begin operational cooperation in some areas of military space, thus reducing the barriers that have long existed, even during the Cold War. Part of the reason is cost, but the increasing use of space assets in military operations requires greater cooperation if alliance effectiveness is to be maintained and expanded. U.S. military officers have largely abandoned the go-it-alone mentality of the Cold War period and recognize the advantages of positioning the United States in a leadership role among other like-minded countries in space. As General James Cartwright (U.S. Marines), at the time the vice chairman of the Joint

Chiefs of Staff, argued about military space cooperation at a national conference in 2011, "We can't afford these constellations ourselves."[30] He also noted the reality of "coalition warfare" in the modern age and emphasized the importance of breaking down secrecy barriers among allies in space. Otherwise, he said, "it's like having a guy in the foxhole with you who's not armed."

India

The expanded use of space by the world's leading militaries has not gone unnoticed by their rivals. Following China's 2007 ASAT test, India announced the formation of the Integrated Space Cell to coordinate a series of new efforts to make greater use of space assets for military purposes.[31] Indian officials also stated that they would match China's ASAT capability either through a kinetic missile defense interceptor or through ground-based lasers. This announcement shows the salience of "tit for tat" arming in regard to regional space dynamics. In recent years, India has teamed with Israel to acquire highly accurate satellite reconnaissance technology, although civilians have operated these services.[32] Given the Chinese challenge, however, India has now directed its civilian space agency to build dedicated military satellites for each branch of the Indian armed forces. For the first time in India's history, military personnel will operate these satellites. While figures for India's military space budget are not published, it is likely that defense efforts will at least match the double-digit increases in India's recent civil space budget as New Delhi struggles to remain competitive with China.

Japan

Japan is another recent and quite unlikely entrant into the military space realm. In the late 1990s, Japan reacted to North Korea's Taepodong-1 missile test (which overflew Japan before its third stage failed) by authorizing the country's first photo-reconnaissance system: the Information-Gathering Satellites (IGS). However, because a 1969 space law limited the country's space activities to civilian purposes, it was necessary to create a separate agency under the Cabinet Secretariat to manage this program. To the surprise of many outside observers, the Japanese legislature moved further toward military uses of space in reaction to China's ASAT test by passing a long-proposed reform of the 1969 law. This 2008 legislation allowed the use of space for military purposes. Japanese officials indicated that even space weapons might be allowed, as long as such systems were "defensive" in nature.[33] The military's possession of both Patriot and Aegis BMD systems creates at least a potential ASAT capability for Japan, although the military has never tested such systems against space objects or, as far as observers know, configured the system's complicated software for that purpose. But Japan's space industry is pushing strongly in the direction of expanded military space activity (including possible space-based defenses), seeking lucrative contracts to expand its long-stagnated domestic market.[34] Japan is also investigating possible development of a satellite-based early-warning system to detect foreign missile launches, despite the high costs. The country's biggest problem in seeking to maintain its place as Asia's technological space leader is budgetary.

Additional Countries

Among other countries with military space programs, relatively few have the capability of building their own space assets. Israel is one exception, having long operated *Ofeq* high-resolution reconnaissance satellites, whose services and technology it has shared with such partners as India and Taiwan. Putting a premium on military-technological independence, Israel has also developed synthetic aperture radar satellites. North Korea, by contrast, has thus far proven incapable of developing modern satellite technology domestically, and its pariah status has hampered aquisition aims. But another group, which includes Australia, Brazil, Iran, Singapore, South Korea, Vietnam, and a range of others, are using a combination of foreign and some domestic sensors to develop military support programs. One advantage for today's late-developing space actors is that they can purchase foreign commercial imagery and bandwidth on commercial communications satellites while accessing freely available U.S. or other global positioning signals to assist in their military operations. The only risk is that access to some of these technologies might be cut off in times of war.

DEBATES OVER MILITARY SPACE STRATEGY AND POLICY

Despite the spread of military space capabilities, the sky is not falling and destructive space conflicts have not emerged. Self-interest has acted as a powerful constraint, at least in terms of deliberate tampering with, damaging, or destroying foreign space assets. Jamming has, however, occurred with increasing frequency and is almost inevitable in the context of possible future warfare. Some believe that kinetic weapons are inevitable too, although no country (except arguably the United States in the context of its missile defense program) has any significant number of weapons ready for possible use against space-based systems (and some modifications would be required). China could certainly expand the number of its mobile missiles equipped with ASAT seekers. Russia could do the same. Other countries might follow suit, if the leaders were to move in this direction.

Military strategy and policy are the final part of this equation that requires further analysis. How do countries see the future of military space activity and what factors are likely to guide their relations? Is conflict prevention, or at least management, possible? Few countries publish official space policies that cover their civil *and* military aims and intentions. The United States is the one major exception and has called on other countries to do the same.

In 2010 the United States issued a National Space Policy (NSP) that both reaffirmed past approaches (such as the inherent right to self-defense in space) and broke new ground in terms of its outlook toward the international space community. In part, the 2010 NSP represented a reaction to the 2006 NSP issued by the George W. Bush administration, whose go-it-alone approach to military space and rejection of new arms control or other legal mechanisms alienated other nations. The underlying assumption of the 2006 NSP was that in the face of expected future foreign threats, the United States needed to investigate a range of possible space weapons and deploy the ones it believed most effective to prevent or prevail in an inevitable space conflict. Such assumptions came out of the 2001 Rumsfeld Commission report on the management of U.S. space assets, which warned of dangerous U.S. vulnerabilities. Moreover, as Undersecretary of the Air Force Peter B. Teets argued in the introduction to the Air Force's *Counterspace Operations* guidelines issued in 2004: "Controlling the high ground of space is not limited simply to protection of our own capabilities. It will also require us to think about denying the high ground to our adversaries. We are paving the road of 21st century warfare now. And others will soon follow."[35] Building on these assumptions, the 2006 NSP identified a logical evolution among concepts of sea, air, and space "power" over time. But the experience of China's 2007 ASAT test, the absence of a U.S. political strategy for space, and further considerations of the harmful global implications of any space warfare led the Barack Obama administration to try a different tack.

The Obama team did not focus on inevitable space conflict and insist on complete U.S. freedom of action, which it saw as stimulating the development of foreign space weapons, signaling a tolerance for their space-weapons tests, and accepting the pollution of low-Earth orbit from increasing orbital debris. Instead, President Obama's policy advisors took a page from the Kennedy administration and decided to step back from the precipice of a seemingly brewing arms race. They outlined a "collective responsibility" approach to space security in an effort to halt what they saw as a dangerous and preventable trend by refocusing international attention on *shared* interests in safe access to space. As the 2010 NSP explained, "The . . . interconnected nature of space capabilities and the world's growing dependence on them mean that irresponsible acts in space can have damaging consequences for all of us."[36] With this in mind, the administration called upon all countries "to work together to adopt approaches for responsible activity in space to preserve [safe access to space] for the benefit of future generations."[37] While the 2010 NSP did not call for specific new treaties, it did renew the U.S. commitment to international cooperation in the pursuit of enhanced space stability through innovative partnerships, including working with "civil, commercial, and foreign partners to identify, locate, and attribute sources of radio frequency interference."[38] It also identified enhanced military space cooperation with allies and "bilateral and multilateral transparency and confidence-building measures" with others "to encourage responsible actions in, and the peaceful use of, space."[39] Internationally, the 2010 NSP received little of the criticism that greeted the 2006 U.S. document, and much praise.

Building on this foundation, the Obama administration issued a first-of-its-kind National Security Space Strategy (NSSS) in January 2011 that outlined how the U.S. military and intelligence communities would implement the new NSP. Instead of emphasizing the use of force in space and calling for deployment of U.S. space weapons, it sought to raise the bar, describing a vision of a cooperative environment that would benefit all users. This vision is worth quoting at length, as it represents a unique effort by the U.S. military to state clear objectives for all countries in space focused on restraint, communication, and cooperation:

> We seek a safe space environment in which all can operate with minimal risk of accidents, breakups, and purposeful interference. We seek a stable space environment in which nations exercise shared responsibility to act as stewards of the space domain and follow norms of behavior. We seek a secure space environment in which responsible nations have access to space and the benefits of space operations without need to exercise their inherent right of self-defense.[40]

In terms of working with others, the 2011 NSSS took a forward-leaning approach to international outreach, seeking to change traditional norms in space security affairs of non-communication, secrecy, and a focus on national-technical solutions. Part of the reason, clearly, was the failure of past policies to prevent events like the Chinese ASAT test and the collision of a U.S. *Iridium* and a Russian *Cosmos* satellite in 2009. The aim of the new approach was preventive, not simply reactive.

The NSSS section on deterrence of aggression against so-called space infrastructure stated that Washington would

> support diplomatic efforts to promote norms of responsible behavior in space: pursue international partnerships that encourage potential adversary restraint; improve our ability to attribute attacks; strengthen the resilience of our architectures to deny the benefits of an attack; and retain the right to respond, should deterrence fail.[41]

Overall, the 2011 NSSS emphasized a "multilayered deterrence approach" that put military means as the last resort and sought to exercise a range of economic, political, and diplomatic options to prevent conflict. Instead of terms like "space control" and "space dominance," the new U.S. approach stated in its conclusion: "Our objectives are to improve safety, stability, and security in space," and to work toward "creating a sustainable and peaceful space environment to benefit the world for years to come."[42] The document helps shift international attention toward diplomatic solutions, although much work remains to be done in order to bring the lofty visions of the 2010 NSP and the 2011 NSSS to fruition.

Critics within the United States, however, believe that the administration has begun to surrender the U.S. advantage in military space by failing to continue some of the more aggressive programs (such as the space-based laser, kinetic-kill interceptor, and Brilliant Pebbles) all revived in the Bush administration (although later denied funding by Congress for both technical and financial reasons). One critic, Everett Dolman of the Air Force's School of Advanced Air and Space Studies, writes of the inevitability of a coming war with China in space and the need for the United States to abandon collective security for a space dominance strategy based on control of low-Earth orbit through the deployment of orbital weapons.[43]

Notably, the current U.S. Defense Department counterpoint paints a very different picture of the future based on the potential ability of leading spacefaring nations to prevent conflict. An essay in 2012 by the head of Space Policy in the Office of the Secretary of Defense and one of his advisors puts future space security into an environmental context, emphasizing the need to "address the challenges of a domain that is increasingly congested, contested, and competitive."[44] They call upon all nations to develop a "common space 'rule set'" to allow "military space operators and intelligence analysts to more easily identify irresponsible actions by aggressive or rogue actors, enabling accurate attribution and possibly building consensus for coalition or international action to uphold freedom of access to the space global commons."[45] Their concept focuses new attention on the commercial notion of "best practices" for space and takes a preventive approach to possible conflicts. Rather than placing a priority on developing and immediately deploying large constellations of space weapons, they state that "broadly increasing dialogue between space-faring nations can help build understanding and strengthen relationships that could prove invaluable during a potential crisis."[46]

The question going forward is whether countries pursuing military space programs and possible weapons in the context of regional competitions will prove receptive to global notions of "responsible behavior" and "best practices." History suggests that countries will act selfishly and will cheat on agreements if given the chance. But the U.S. ability to attribute to specific actors dangerous space behavior through its Joint Space Operations Center and increasingly accurate network of radars and other sensors—possibly with international input in the coming years—could act as a serious deterrent to potential violators of such norms, at least in major spacefaring countries, such as China, India, and Russia. This "community policing" approach is one that has never before been attempted in space, but it may succeed because of shared military interests in maintaining safe access to the valuable information that travels through space and the unique observations possible from space-based assets.

The satellite non-interference principle has remained part of all U.S.-Soviet and U.S.-Russian arms control treaties since 1972. But it has not been extended to military space relations involving China, India, Israel, Japan, the European countries, or other emerging space actors, thus risking instability as new military space forces develop. If such a norm could be established among the major military space countries, it could promote a reduction in tensions and increase prospects for cooperation. But more serious efforts to stem the development and testing of new space weapons and to foster military-to-military cooperation are likely to be prerequisites for heading off currently dangerous trends, particularly as space becomes an added dimension of festering regional rivalries in East Asia, South Asia, and the Middle East.

CONCLUSION

Several areas in the military space realm merit additional attention in terms of emerging concerns. These include proximity operations, new kinetic systems, airborne or other mobile lasers, and the proliferation of hard-to-monitor micro-satellites. In some cases, there are military countermeasures that could effectively mitigate these threats. In others, the "fixes" might require additional space situational awareness or new political means, possibly including new forms of collective security or space "policing." In some areas of military security, use of the independent scientific and Internet communities could play an important supporting role in verifying compliance and sharing data on wrongdoers.

Overall, space security developments in the twenty-first century provide reasons for both worry and optimism. Military technology relevant to space is spreading to new actors, who may (at least initially) have less interest in preserving space and accepting norms of non-interference with other actors' spacecraft. The use of kinetic space weapons by both China and the United States (albeit against their own satellites) can be viewed either as a harbinger of future conflict or as a warning sign of what we need to prevent.