Chapter 20:

Preserving Freedom of Action in Space:
Realizing the Potential and Limits of U.S. Spacepower

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Our working definition of *spacepower* is the sum total of capabilities that contribute to a nation's ability to benefit from the use of space. Space-power, like other types of power, can wax or wane depending on a country's choices and those of its potential adversaries. Wise national decisions can lead to cumulative increases in spacepower, but even they can be negated, if, for example, significant debris-increasing events in space impair spacepower for all nations.

There is widespread agreement on what most of the key elements of spacepower are, but not all those elements are equal. Key elements would surely include possessing the relevant technology base, physical infrastructure, and workforce necessary to excel in space. Space prowess is also measured by how purposefully and successfully these essential elements are applied to specific missions. Many missions increase the sum total of a nation's capability in space. Metrics would include utilizing space for exploration and the advancement of knowledge; facilitating commercial transactions, resource planning, and terrestrial economic development; monitoring planetary health; mapping; providing a medium for telecommunications and broadcasting; assisting first responders, search and rescue operations, and disaster relief; providing early warning of consequential events; and utilizing space assets to enhance military and intelligence capabilities. The commercial, communication, and military uses of space have become less separable.

Since meaning is partly defined by circumstances—and since circumstances, with respect to the utilization of space, are so favorable for the United States—it is understandable why passionate and articulate American advocates of spacepower often define this term in a muscular way. Many forceful advocates equate spacepower with military missions because U.S. forces are extraordinarily dependent on space assets that confer significant advantages while saving countless lives on the battlefield, and because the negation of these assets would be so harmful.[1]

While the military uses of space are growing for the United States and other spacefaring nations, sweeping analogies between spacepower and terrestrial military power are unwise. In space, power is not accompanied by weapons—at least not yet. And in space, weapon-enabling technologies are widely applicable to nonmilitary pursuits. Weapon capabilities—or hard power—that can be utilized in space are currently confined to gravity-bound battlefields. In contrast, the soft power aspects of space prowess are unbounded, with satellites used for direct broadcasting and communication becoming conveyor belts for the projection of national culture and economic transactions. The long

history of international cooperative research among civil space agencies reflects another element of soft space-power. Collaborative efforts such as the Apollo-Soyuz mission, the International Space Station, and the space shuttle attest to the utility of soft spacepower as a diplomatic instrument. China, an emerging spacepower, is following this well-trodden path, at least in part, by forging space cooperation agreements with nations such as oil-rich Venezuela and Nigeria.

Nowhere is soft spacepower more evident than in the commercial realm, where economic competition is sometimes fierce but multinational cooperation is nonetheless required. The world relies at present on five major multinational corporations for the provision of global telecommunications. Global and national reliance on space assets has become intertwined not only for communications, but also for banking, disaster monitoring, weather forecasting, positioning, timing and navigation, and myriad other activities central to modern life. Many satellites primarily operated for commercial and civil uses can also serve military purposes. The use of space for commercial and economic development, as well as for other soft power applications, can be jeopardized if the deployment and use of weapons in space occur. This is because once weapons are used in space, their effects may not be controllable, as it is difficult to dictate strategy and tactics in asymmetric warfare. Consequently, weapons effects may not be limited to a small subset of satellites or those of a particular nation. In this sense, hard and soft spacepower cannot be decoupled. The misapplication of hard spacepower could therefore have indiscriminate effects, particularly if a destructive strike against a satellite produces significant and long-lasting debris.

The misapplication of hard power on Earth could also adversely affect relations between major powers, friends, and allies. However, the interconnectedness of hard and soft spacepower means that poor decisions by one spacefaring nation are more likely to negatively affect all other spacefaring nations, a situation that does not arise in nonnuclear, terrestrial conflict. Recovery from poor decisions in space also takes far longer than from nonnuclear, terrestrial conflict. For example, when conventional battles take place on the ground, sea, and air, debris is a temporary and geographically limited phenomenon. Minefields can be marked or cleared, and chemical spills can be contained or cleaned—although this may take large amounts of both time and money. Battlefield debris in space, however, can last for decades, centuries, or even millennia, thereby constituting an indiscriminate lethal hazard to space operations. Debris generated in space also tends to spread to other orbits over time, and environmental cleanup technologies in space do not appear promising at present.[2] In gravity-based warfare, the victor's spoils are gained through unhindered access. But such access is likely to be lost in the event that weapons are used in or from space, even for the "victor."

Battlefields in space are therefore fundamentally different from those on land, at sea, or in the air. The potentially disabling problem of space debris is now well recognized even by advocates of hard spacepower. Therefore, hit-to-kill kinetic energy antisatellite (ASAT) weapons that have been tested occasionally constitute a significant potential danger to space operations, as was most evident in China's test in January 2007, which created the worst debris-generating event in the history of the space age.[3] The earliest

ASAT weapons—nuclear warheads atop ballistic missiles—would produce indiscriminate and lethal effects, as the United States learned after conducting a series of atmospheric nuclear tests in 1962. Nonetheless, this method of space warfare could still be employed. Currently, the preferred U.S. methods of using force to maintain "space control" entail nondestructive techniques (although U.S. officials and military leaders have not ruled out destructive methods). But bounding the unintended negative consequences of warfare in space depends on questionable assumptions, beginning with the dictation of rules of warfare against weaker foes. In unfair fights, however, weaker foes typically play by different rules. And if debris-causing space warfare hurts the United States severely, it is reasonable to expect that U.S. fastidiousness in engaging in warfare in space may not be reciprocated—as the Chinese kinetic-kill ASAT test seemed to indicate.

While appreciation of soft spacepower has expanded, arguments over the military uses of space have actually narrowed over time. In an earlier era, there were heated debates over the propriety of using space for monitoring secret military activities. Beginning in the 1970s, national technical means used to monitor nuclear forces received formal treaty protection. Subsequent debates focused on the propriety of using space to assist military operations. During the administrations of Presidents Jimmy Carter and Ronald Reagan, Soviet negotiators sought expansive definitions of space weapons (including the space shuttle) to constrain perceived U.S. military advantages in space. These negotiating gambits have long since lost their audience. The use of satellites to assist military operations on Earth is no longer controversial; instead, it has become the primary (and widely envied) metric of spacepower.

While debates over spacepower and its advancement have become more narrowly drawn, they continue to be quite heated. Current debates focus not on the military uses of space but rather on its weaponization. This dividing line is admittedly not clear-cut and is fuzziest on the issue of jamming, when disruptive energy is applied not against satellites per se, but against satellite communication links. Another gray area in the spectrum leading from militarization to weaponization relates to lasing objects in space.

While acknowledging gray areas (and discussing them further below), we submit that they do not absolve or oblige us to obliterate useful distinctions between the militarization and weaponization of space. It is true, for example, that long-range ballistic missiles that carry deadly weapons transit space en route to their targets. But ballistic trajectories constitute ground-based weapons aimed at ground-based targets, rather than being weapons based in space or aimed at space-based targets. Thus, we distinguish between transitory phenomena and permanent conditions. Similarly, we differentiate between the use of lasers for range finding, space tracking, and communication purposes, and the use of lasers to temporarily disable or destroy satellites. One type of activity provides substantial benefit while the other invites great risk. We further argue that U.S. national security and economic interests are advanced by working to clarify this distinction and by seeking the concurrence with and reinforcement of it by other key spacefaring nations.

By distinguishing between the militarization and the weaponization of space, we argue that analogies between spacepower and other forms of military power have only limited utility. In other realms of military affairs, we measure power by metrics such as the number of weapons available, various characteristics that make them more effective, and their readiness for employment. Accordingly, the distinction between militarization and weaponization is meaningless when we discuss air, ground, and naval forces. In contrast, spacepower is defined at present in the absence of the deployment and use of weapons in space. We argue that the absence of "dedicated" space weapons is favorable to the United States.

While some have compared space to another "global commons," the high seas, we believe this analogy to be deeply flawed. Warships provide backup for sea-based commerce, but they are essentially instruments of warfighting. Satellites, on the other hand, usually serve multiple purposes in both military and nonmilitary domains. A ship damaged in combat can seek safety and repairs at a friendly port. The debris from combat at sea sinks and rarely constitutes a lingering hazard. Defensive measures are easier to undertake at sea than in space. If space weapons are deployed and used, no nation can expect there to be safe havens in space. And if the most indiscriminate means of space warfare are employed, debris will become a long-lasting hazard to military and nonmilitary satellite operations.

All countries would be victimized if a new precedent is set and satellites are attacked in a crisis or in warfare. As the preeminent space power, the United States has the most to lose if space were to become a shooting gallery. The best offense can serve as an effective defense in combat at sea, but this nostrum does not apply in space, since essential satellites remain extremely vulnerable to rudimentary forms of attack. The introduction of dedicated and deployed weapons in space by one nation would be followed by others that feel threatened by such actions. The first attack against a satellite in crisis or warfare is therefore unlikely to be a stand-alone event, and nations may choose different rules of engagement for space warfare and different means of attack once this threshold has been crossed.

Our analysis thus leads to the conclusion that the introduction and repeated flight-testing of dedicated ASAT weapons would greatly subtract from U.S. spacepower, placing at greater risk the military, commercial, civil, and lifesaving benefits that satellites provide. Instead, we propose that the United States seek to avoid further flight testing of ASATs while hedging against hostile acts by other spacefaring nations.

We argue that realizing the benefits of spacepower requires acknowledgment of four related and unavoidable dilemmas. First, the satellites upon which spacepower depends are extremely vulnerable. To be sure, advanced spacefaring nations can take various steps to reduce satellite vulnerability, but the limits of protection will surely pale beside available means of disruption and destruction, especially in low Earth orbit (LEO). Vulnerabilities can be mitigated, but not eliminated.

Second, the dilemma of the profound vulnerability of essential satellites has been reinforced by another dilemma of the space age: satellites have been linked with the nuclear forces of major powers. Nuclear deterrence has long depended on satellites that provide early warning, communications, and targeting information to national command authorities. Even nuclear powers that do not rely on satellites for ballistic missile warning may still rely on them for communications, forecasting, and targeting. To interfere with the satellites of major powers has meant—and continues to mean—the possible use of nuclear weapons, since major powers could view attacks on satellites as precursors to attacks on their nuclear forces.

The third dilemma of spacepower is that space disruption is far more achievable than space control. A strong offense might constitute the best defense on the ground, in the air, and at sea, but this principle holds little promise in space since a strong offense in this domain could still be negated by asymmetric means. Space control requires exquisitely correct, timely, and publicly compelling intelligence; the readiness to initiate war and to prevent another nation from shooting back; as well as the ability to dictate the choice of strategy and tactics in space. It takes great hubris to believe that even the world's sole superpower would be able to fulfill the requirements of space control when a $1 bag of marbles, properly inserted into LEO, could destroy a $1 billion satellite. The ability of the United States to dictate military strategy and tactics in asymmetric, gravity-bound warfare has proven to be challenging; it is likely to be even more challenging in space, where there is less margin for error.

The fourth overarching dilemma relating to spacepower therefore rests on the realization that hard military power does not ensure space control, particularly if other nations make unwise choices and if these choices are then emulated by others. The United States has unparalleled agenda-setting powers, but Washington does not have the power to dictate or control the choices of other nations.

These dilemmas are widely, but not universally, recognized. Together with the widespread public antipathy to elevating humankind's worst practices into space, they help explain why the flight-testing and deployment of dedicated space weapons have not become commonplace. These capabilities are certainly not difficult to acquire, as they are decades old. Indeed, tests of dedicated ASAT weapons have periodically occurred, and such systems were deployed for short periods during the Cold War. If the weaponization of space were inevitable, it surely would have occurred when the United States and the Soviet Union went to extraordinary lengths to compete in so many other realms. The weaponization of space has not occurred to date and is not inevitable in the future because of strong public resistence to the idea of weapons in space, and because most national leaders have long recognized that this would open a Pandora's box that would be difficult to close.

Much has changed since the end of the Cold War, but the fundamental dilemmas of space control, including the linkage of satellites to nuclear deterrence among major powers, have not changed. The increased post– Cold War U.S. dependence on satellites makes the introduction of dedicated space weapons even more hazardous for national and economic

security. Advocates of muscular space control must therefore take refuge in the fallacy of the last move, since warfighting plans in space make sense only in the absence of successful countermoves. Offensive counterforce operations in space do not come to grips with the dilemmas of spacepower, since proposed remedies are far more likely to accentuate than reduce satellite vulnerability.

This analysis leads inexorably to a deeply unsatisfactory and yet inescapable conclusion: Realizing the enormous benefits of spacepower depends on recognizing the limits of power. The United States now enjoys unparalleled benefits from the use of space to advance national and economic security. These benefits would be placed at risk if essential zones in space become unusable as a result of warfare. Spacepower depends on the preservation and growth of U.S. capabilities in space. Paradoxically, the preservation and growth of U.S. spacepower will be undercut by the use of force in space.

Because the use of weapons in or from space can lead to the loss or impairment of satellites of all major space powers, all of whom depend on satellites for military and economic security, we believe it is possible to craft a regime based on self-interest to avoid turning space into a shooting gallery. This outcome is far more difficult to achieve if major space powers engage in the flight-testing and deployment of dedicated ASAT weapons or space-to-Earth weapons. We therefore argue that it would be most unwise for the United States, as the spacepower with the most to lose from the impairment of its satellites, to initiate these steps. Similar restraint, however, needs to be exercised by other major spacefaring nations, some of which may feel that the preservation and growth of U.S. spacepower are a threat, or that it is necessary to hold U.S. space assets at risk. The United States is therefore obliged to clarify to others the risks of initiating actions harmful to U.S. satellites without prompting other spacefaring nations to take the very steps we seek to avoid. Consequently, a preservation and growth strategy for U.S. spacepower also requires a hedging strategy because, even if the United States makes prudent decisions in space, others may still make foolish choices.

Hedging

The exercise of restraint from using weapons in space is not easy for the world's most powerful nation or for other nations fearing catastrophic losses that they believe might be averted by disabling U.S. satellites. How, then, might U.S. spacepower influence the decisions of other nations to leave vulnerable satellites alone?

We maintain that a prudent space posture would clarify America's ability to respond purposefully if another nation interferes with, disables, disrupts, or destroys U.S. satellites, without being the first to take the actions that we wish others to refrain from taking. Thus, our proposed hedging strategy would not include the flight-testing and deployment of dedicated ASAT or on-orbit weapons because such steps would surely be emulated by others and would increase risks to vital U.S. space assets. Whatever preparations the United States takes to hedge against attacks on its satellites must be calibrated to maximize freedom of action and access in space. Hedging moves that create

an environment where the flight-testing and deployment of space weapons would be a common occurrence would thus be contrary to U.S. military and economic security.

Responsible hedges by the United States include increased situational awareness, redundancy, and cost-effective hardening of satellites and their links. The strongest hedge the United States possesses is its superior conventional military capabilities, including long-range strike and special operations capabilities. Since an attack on a satellite can be considered an act of war, the United States could respond to such an attack by targeting the ground links and launch facilities of the offending nation or the nation that harbors a group carrying out such hostile acts. Far more punishing responses might be applicable. A hedging strategy is also likely to include ground-based research and development into space weapons technologies, activities that are under way in major spacefaring nations.

The demonstration of dual- or multi-use space technologies that could be adapted, if needed, to respond to provocative acts would constitute another element of a responsible hedging strategy. Such technologies could include on-orbit rendezvous, repair, and refueling technologies and other proximity operations. These activities are also essential for expanded scientific and commercial use of space and would be key enabling technologies for long-duration missions such as the return to the Moon and the exploration of Mars.

A prudent hedging strategy would also align U.S. military doctrine and declaratory policy with America's national security and economic interest in preventing weapons in space and ASAT tests. In the context of a proactive Air Force counterspace operations doctrine and official disdain for negotiations that might constrain U.S. military options in space, the hedging strategy we advocate might be perceived as preliminary steps toward the weaponization of space, which we would oppose. Wise hedging strategies would also be accompanied by constructive diplomatic initiatives.

The flight-testing of multipurpose technologies, the possession of dominant power projection capabilities, and the growing residual U.S. military capabilities to engage in space warfare should provide a sufficient deterrent posture against a "space Pearl Harbor."[4] These capabilities would also clarify that the United States possesses the means to defend its interests in a competition that other major space powers claim not to want, as well as to react in a prompt and punishing way against hostile acts against U.S. space assets.

If all responsible spacefaring nations adhere to a "no further ASAT test" regime, and an adversary still carries out a "space Pearl Harbor" by using military capabilities designed for other purposes, the United States has the means to respond in kind. U.S. latent or residual space warfare capabilities exceed those of other spacefaring nations and are growing with the advent of ballistic missile defenses. We maintain that the existence of such capabilities constitutes another element of a hedging strategy, while providing further support for our contention that dedicated ASAT tests and deployments are both unwise and unnecessary.

Space Preservation and Growth Strategy

A successful hedging strategy preserves and grows U.S. spacepower. In contrast, the flight-testing and deployment of dedicated ASAT and on-orbit weapons produce conditions whereby U.S. space assets are unlikely to be available or could be gravely impaired when needed. Space control operations that foster the preservation and growth of U.S. spacepower are to be welcomed; space control operations that would have the net effect of placing U.S. satellites at greater risk are to be avoided.

The U.S. Air Force's doctrine on space control operations, *Counter-space Operations*, requires the identification of adversary space assets and space-related capabilities on Earth. Identified targets include on-orbit satellites (including third-party assets), communication links, launch facilities, ground stations, and command, control, computers, communications, intelligence, surveillance, and reconnaissance (C^4ISR) resources.[5] Many of these satellites or space-related assets can be targeted using multipurpose conventional capabilities. For example, launch facilities and ground stations can be targeted by ground forces, warships, and air-power. Communication links can be jammed using proven systems, and elements of C^4ISR can be neutralized using cyber attacks. Many space powers possess these capabilities to varying degrees, which may help explain why dedicated systems to attack satellites have rarely been flight-tested or deployed.

The vulnerability of terrestrial space assets can be mitigated in a number of ways. Equipment can be hidden, hardened, or operated stealthily. Depending on the order of battle and opposing military capabilities, some assets could be protected by overwhelming force, and assets lost in battle can sometimes be replaced. These considerations are quite different in space, where force replacement is usually problematic and protection measures operate, at best, on the margins of economic and technical possibility.

Major space powers should be adept at locating satellites in Earth orbit. Maneuvering in space, unlike terrestrial warfare, is usually very limited. While satellites can be placed in orbits that pass over regions with limited space surveillance capabilities, the nature of orbital mechanics dictates that, at some point, satellites will be visible to ground observers.[6] Fuel is a more precious commodity in space due to its weight and very limited prospects for refueling. Maneuvering for most spacecraft is limited to normal station-keeping operations. Moreover, satellites, unlike tanks, cannot be suitably armored for combat. They can be hardened to withstand some types of electromagnetic interference and small impacts, but it is not feasible to shield against an impact from even a marble-sized debris hit, much less an intentional physical attack. Spacecraft shielding increases launch weight and costs by approximately $10,000 per pound.[7]

Operating satellites in formations is quite different from operating aircraft carrier battlegroups. Valuable warships can survive direct hits of various kinds, and the debris from losses at sea sinks to the bottom of the ocean. In contrast, the debris from satellite warfare could impair constellations in space, placing at risk the orbit of the high-value

satellites meant to be protected. Arming satellites with defensive weapons is not a satisfactory solution for many reasons. Unlike warships or tanks that can maneuver and fire many weapons, satellites have little carrying capacity beyond that required to perform their missions. The fundamentals of space warfare described above—including the difficulties in dictating tactics and the choice of weapons, as well as the consequences of space debris—appear immutable. The marginal cost of attack will always be less than the marginal cost of defense, since attacking does not necessarily require technological sophistication and limited attacks can cause grievous injury.

If essential but vulnerable satellites cannot be effectively defended by space weapons, their protection rests largely on deterrence. When offense is too lethal to use because its net effect would be to harm vital national assets and interests, the default option for freedom of action in space is to accept mutual vulnerability. Nuclear deterrence had many detractors during the Cold War, even though it helped prevent nuclear exchanges between well-armed foes. The more power a nation possesses, the harder it is to accept vulnerability. But the benefits of hard and soft spacepower inescapably depend on satellites that are far easier to attack than to defend.

Asymmetric capabilities and vulnerabilities in space do not negate the precepts of deterrence or the essence of mutual vulnerability. During the Cold War, for example, Beijing faced not one but two hostile superpowers and yet chose to maintain nuclear forces that were significantly inferior to those of the United States and the Soviet Union. Presumably, China's leadership concluded that relatively few mushroom clouds were needed to clarify superpower vulnerability.

We argue, by analogy, that asymmetries related to dependence on space and capabilities in space do not alter the fundamentals of vulnerability and deterrence. The country with the most to lose from attacks on satellites, the United States, also has the most capabilities to respond with lethal force, which would be more indiscriminate because of the impairment or loss of its satellites. We have argued elsewhere that space warfare and its effects are unlikely to be country-specific. Because space warfare can be more indiscriminate than terrestrial warfare, and because all space-faring nations are increasingly dependent on space assets for national and economic security, all major powers face the same fundamental dilemma that satellites are both essential and extraordinarily vulnerable, and that the use of weapons in space is likely to have unintended, negative consequences. Mechanical objects may be the initial victims of space warfare, but satellites are unlikely to be the only victims, since they are directly linked to soldiers, noncombatants, and nuclear weapons.

Nuclear deterrence was based on the repeated testing of nuclear weapons and their means of delivery, as well as on the deployment of many dedicated weapons systems in a high state of launch readiness. If we were to adopt such practices for dedicated ASAT or space-to-Earth weapons, satellite security would be greatly diminished, and relations among major powers, along with international space cooperation, would deteriorate. At best, a very uneasy standoff in space could result from the flight-testing and deployment of dedicated ASAT weapons. In our view, no further ASAT testing is required because,

for all practical purposes, this uneasy standoff already exists. Major spacefaring nations have already clarified their ability to disrupt or destroy satellites. Since these capabilities are well understood, they do not need to be demonstrated by further testing, the net effect of which would be more worrisome than reassuring.

Mutual assured destruction in space is therefore far easier to maintain than nuclear deterrence was during the Cold War, because mutual vulnerability from the use of weapons in or from space does not require repeated demonstrations of the weapons in question. And unlike nuclear deterrence, which had the practical effect of limiting freedom of action, acceptance of mutual vulnerability in space would maximize freedom of action and access. Despite these significant differences, there are two principal connecting threads between the acceptance of mutual vulnerability between major nuclear powers and major space powers. First, attacks on satellites in crises between major powers risk the use of nuclear weapons. And second, existential vulnerability to nuclear and satellite attacks is not solvable by military means.

Code of Conduct

We view a code of conduct for responsible spacefaring nations as a necessary complement to a hedging strategy and as an essential element of a space posture that provides for the preservation and growth of U.S. space capabilities. A code of conduct makes sense because, with the increased utilization and importance of space for national and economic security, there is increased need for space operators and spacefaring nations to act responsibly. While some rules and treaty obligations exist, there are many gaps in coverage, including how best to avoid collisions and harmful interference, appropriate uses of lasers, and notifications related to potentially dangerous maneuvers. Because the increased utilization of space for security and economic purposes could lead to friction and diminished space assurance, it serves the interests of all responsible spacefaring nations to establish rules of the road to help prevent misunderstandings, catastrophic actions in space, and grievances.

Another reason for pursuing rules of the road is that interactive hedging strategies could generate actions in space that diminish space security by nations concerned about the import of technology demonstrations and flight tests. We have therefore argued that hedging strategies are best accompanied by diplomatic initiatives to set norms that increase the safety and security of satellites vital to U.S. national and economic security. A code of conduct would serve these purposes.

No codes of conduct or rules of the road are self-enforcing. Despite traffic laws, some drivers still speed. But having rules of the road reduces the incidence of misbehavior and facilitates action against reckless drivers. We acknowledge that there are no traffic courts for misbehavior in space, but we nonetheless argue that having agreed rules of the road in this domain will also reduce the incidence of misbehavior, while facilitating the isolation of the miscreant as well as the application of necessary remedies. Without rules, there are no rule breakers.

Traditional arms control was devised to prevent arms racing between the superpowers. With the demise of the Soviet Union, concerns over arms racing have been replaced by concerns over proliferation and nuclear terrorism. Cooperative threat reduction initiatives have been designed to deal with contemporary threats. These arrangements have taken myriad forms, including rules of the road to prevent proliferation. Since the flight-testing, deployment, and use of weapons in space would increase security concerns, and since security concerns are drivers for proliferation, agreed rules of the road for space could supplement other codes of conduct that seek to prevent proliferation.

Codes of conduct supplement, but differ from, traditional arms control remedies. Skeptics of new arms control treaties to prevent ASAT tests and space-based weapons argue that it would be difficult to arrive at an agreed definition of space weapons, and that even if this were possible, it would be hard to monitor compliance with treaty obligations. A code of conduct would focus on responsible and irresponsible activities in space that, in turn, would obviate the need for an agreed definition of space weapons. For example, a code of conduct might seek to prohibit the deliberate creation of persistent space debris. Again, our focus is on behavior, not an agreed definition of space weapons. Moreover, the deliberate creation of persistent space debris is very hard to hide and can be monitored by existing technical means.

The United States has championed codes of conduct governing militaries operating in close proximity at sea in the 1972 Incidents at Sea Agreement, as well as in the air and on the ground, in the 1989 Dangerous Military Practices Agreement. More recently, the United States has championed codes of conduct to reduce proliferation threats, including The Hague Code of Conduct (2002) and the Proliferation Security Initiative (2003). The 2001 Space Commission Report chaired by Donald Rumsfeld also endorsed rules of the road for space.[8]

Codes of conduct typically take the form of executive agreements in the United States. They can begin as bilateral or multilateral compacts and they can expand with subsequent membership. Codes of conduct are either an alternative to, or a way station toward, more formal treaty-based constraints that often take extended effort.[9]

Some rules of the road, formal agreements, and elements of a code of conduct already exist for space. The foundation document that defines the responsibilities of spacefaring nations is the Outer Space Treaty (1967). Other key international agreements and institutions include the Liability Convention and the International Telecommunications Union.

There is growing sentiment among space operators to develop and implement several key elements of a code of conduct, including improved data sharing on space situational awareness; debris mitigation measures; and improved space traffic management to avoid unintentional interference or collisions in increasingly crowded orbits. A more comprehensive code of conduct might include elements such as notification and consultation measures; provisions for special caution areas; constraints against the harmful use of lasers; and measures that increase the safety, and reduce the likelihood, of

damaging actions against manmade space objects, such as harmful interference against satellites that create persistent space debris. Key elements of a code of conduct are useful individually, but they are even more useful when drawn together as a coherent regime.

Situationa Awareness

Space situational awareness (SSA)—the ability to monitor and understand the constantly changing environment in space—is one of the most important factors in ensuring the safety and security of all operational satellites and spacecraft. SSA provides individual actors with the ability to monitor the health of their own assets, as well as an awareness of the actions of others in space. Transparency measures can be particularly helpful in providing early warning of troubling developments and in dampening threat perceptions. One measure of U.S. spacepower and space prowess is America's unparalleled space situational awareness capabilities. Thus, the United States is in a position to become a leader in building space transparency, which is the foundation stone of norm setting and rules of the road in space.

Traffic Management

The International Academy of Astronautics (IAA) "Cosmic Study on Space Traffic Management" defines *space traffic management* as:

> the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference.[10]

We also endorse intermediate steps toward this outcome and advocate empowering or creating an industry advisory group that could recommend actions and participate in the work of international bodies.

Notification and Consultations

The development of more formal processes for notification of satellite maneuvers is critical for ensuring space situational awareness; without such notification, satellite tracking and collision avoidance become much more difficult. Prelaunch notification could assist space surveillance as well as traffic management. Models for prelaunch notification could be the 2000 U.S.Russian Joint Data Exchange Center[11] and the 2000 U.S.-Russian Pre-and Post-Launch Notification Agreement.[12] Elements from these agreements—as well as other ideas for data provision—might be studied by the United Nations Committee on the Peaceful Use of Outer Space's (COPUOS's) Scientific and Technical Subcommittee and translated into recommendations for either a voluntary regime or a possible multilateral accord.

Special Caution Areas

The IAA Cosmic Study mentions two different approaches to what the Dangerous Military Practices Agreement has termed *special caution areas*. In space, these might consist of provisions for safe distances or zones around satellites or more general "zoning" rules that restrict certain activities in certain orbital planes. Further in-depth study of the technical requirements and legal considerations surrounding the establishment of special caution areas is required before judgments can be made on the practicality and utility of such approaches; this is work that the IAA or other organizations could easily pursue.

Debris Mitigation

The deliberate generation of persistent space debris constitutes a hazard to space operations. Debris mitigation is therefore a pressing problem related to space traffic management. It is also the code of conduct element that has been furthest developed. The Inter-Agency Space Debris Coordination Committee (IADC), comprised of the space agencies of the world's major space powers, has developed a number of debris mitigation guidelines. Several nations have incorporated the agreed measures into their national laws and regulatory systems, and others are moving to do so. The United States is a leader in codifying strong debris mitigation guidelines. Thus, the United States is well placed to use this element of its soft spacepower to set strong international norms and work toward legally binding, formal international accords.

No Harmful Use of Lasers

There are at least two precedents for restricting the use of lasers during peacetime: the Prevention of Dangerous Military Activities Agreement and the Incidents at Sea Agreement.[13] The multiple applications of lasers highlight the utility of establishing rules of the road that distinguish between acceptable uses—such as range-finding, communication, and information-gathering—and uses that could be considered acts of war, such as dazzling, blinding, and damaging satellites. Norms regarding laser power/configuration for tracking purposes might be discussed to reduce the likelihood of damage to satellites and to reduce miscalculation. We endorse the convening of a panel of technical specialists, perhaps under the auspices of the IAA, to discuss this. COPUOS might usefully propose procedures for dealing with laser incidents.

Increasing Satellite Safety and Reducing the Likelihood of Satellite Damage

A national space strategy designed to preserve and grow U.S. capabilities in space would benefit from steps to increase satellite safety and reduce the potential damage to satellites upon which that strategy rests. This would, of course, include technical protection measures. However, it would also entail proactive diplomatic measures to prevent weapons-related creation of space debris. As advocates of U.S. spacepower, we therefore believe it would be wise to set rules of the road against the further testing of ASATs or other weapons based in space that would create debris by applying energy against targets. The use of weapons that produce indiscriminate and long-lasting damage in ground combat has justifiably earned widespread opprobrium. The use of certain weapons in

space could be doubly injurious, since they could produce indiscriminate and long-lasting damage in orbit that, in turn, could prompt similar damage on Earth.

Conclusion

We have argued that spacepower rests on a broad foundation, building upward to the orbital dance of satellites. We further argue that space-power is inextricably linked to, but different from, other forms of military power. The fundamental paradox of spacepower is that satellite effectiveness and vulnerability are inseparable, which makes hard power projection in and from space an extraordinarily risky undertaking. The preservation and growth of U.S. spacepower therefore requires the protection of satellites—vital assets that can readily be lost and quite difficult to replace in combat—by other means. We propose to address this dilemma through a variety of initiatives, including a hedging strategy and diplomatic initiatives centered on a code of conduct for responsible spacefaring nations.

Notes

1. See, for example, David E. Lupton, *On Space Warfare: A Spacepower Doctrine* (Maxwell Air Force Base, AL: Air University Press, June 1998); Colin S. Gray, "The Influence of Spacepower upon History," *Comparative Strategy* 15, no. 4 (October–December 1996), 293–308; James Oberg, *Spacepower Theory* (Washington, DC: U.S. Government Printing Office, 1999); and Air Force Doctrine Document 2–2, *Space Operations* (Maxwell Air Force Base, AL: Air Force Doctrine Center, November 27, 2001).
2. J.C. Liou and N.L. Johnson, "Risks in Space from Orbiting Debris," *Science* 311 (January 20, 2006), 340.
3. Frank Morring, Jr., "Worst Ever: Chinese Anti-satellite Test Boosted Space-debris Population by 10% in an Instant," *Aviation Week and Space Technology*, February 12, 2007, 20.
4. Department of Defense, "Report of the Commission to Assess United States National Security Space Management and Organization" (Washington, DC: Department of Defense, 2001), 22.
5. Air Force Doctrine Document 2.2–1, *Counterspace Operations* (Washington, DC: Department of the Air Force, August 2, 2004), 32–33.
6. Even classified satellites, for which no orbital data is publicly available, have been tracked by amateur ground observers using nothing more than a camera and a stopwatch. See, for example, the *Visual Satellite Observer's Home Page* Web site at <www.satobs.org/>.
7. Futron Corporation, "Space Transportation Costs: Trends in Price per Pound to Orbit 1990–2000," available at <www.futron.com/pdf/resource_center/white_papers/FutronLaunchCostWP.pdf>.
8. "Report of the Commission to Assess United States National Security Space Management and Organization," 18.
9. For more information regarding space code of conduct approaches, see Michael Krepon and Christopher Clary, *Space Assurance or Space Dominance: The Case Against Weaponizing Space* (Washington, DC: The Henry L. Stimson Center, 2003), and Theresa Hitchens, *Future Security in Space: Charting a Cooperative Course* (Washington, DC: Center for Defense Information, September 2004).
10. Corrine Contant-Jorgenson, Petr Lála, and Kai-Uwe Schrogl, eds., "Cosmic Study on Space Traffic Management" (Paris: International Academy of Astronautics, 2006), 10, available at <http://iaaweb.org/iaa/Studies/spacetraffic.pdf>.

11. Peter L. Hays, "United States Military Space into the Twenty-first Century," Institute for National Security Studies Occasional Paper 42 (Colorado Springs: U.S. Air Force Academy, September 2002), 115–116.
12. U.S. Department of State Fact Sheet, "Memorandum of Understanding on Notification of Missile Launches," December 16, 2000, available at <www.state.gov/t/ac/trt/4954.htm>; Philipp C. Bleek, "U.S., Russia Sign Missile- and Space-Launch Notification Deal," *Arms Control Today* (January–February 2001), available at <www.armscontrol.org/act/2001_01_02/usruslaunch.asp>; Hays, 116.
13. The Prevention of Dangerous Military Activities Agreement prohibits uses of lasers that might harm personnel or equipment; text of the agreement can be found in *International Legal Materials* 28, no. 2 (1989), 877–895. The Incidents at Sea accord prohibits the illumination of the bridges of the other parties' ships; see "Agreement Between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on the Prevention of Incidents on and over the High Seas," available at <http://dosfan.lib.uic.edu/acda/treaties/sea1.htm>.