PRESERVING U.S. DOMINANCE WHILE SLOWING THE WEAPONIZATION OF SPACE

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It is an honor to appear before the committee today to discuss the important topic of U.S. military space policy.

My main argument, based principally on my book published last year by Brookings, is that the weaponization of space should be delayed indefinitely by the United States. The United States should not embark on dedicated programs to develop antisatellite weapons, should not move quickly to place ballistic missile defenses in space, and should not develop space-to-Earth attack weapons.

My argument is not a philosophical recommendation for permanently banning greater military uses of the heavens. Space is heavily militarized, even if not weaponized, already. It is not clear what political or military principle should provide permanent sanctuary to satellites that are actively used to find, track, and thus help destroy targets on the battlefield. Such assets do not deserve special protection, given the nature of their functions. Technology trends will make it increasingly hard to prohibit space weapons even if we wanted to. The verification challenges would be formidable, if not insurmountable. In addition, there is a real possibility that, at some future point, the United States may have powerful reasons to develop antisatellite weapons itself.

Yet timing matters greatly in world politics, and partial restraint can be very important even when categorical bans or formal prohibitions are not appropriate. The United States enjoys a remarkably favorable military position in space today, without suffering much political and strategic fallout for making major use of the heavens for military purposes, and it should wish to preserve that situation as long as possible. To the extent the situation changes in coming years, moreover, the most important response for the United States is to work harder to preserve its own communications, navigation, and intelligence capabilities rather than to threaten the fledgling capabilities of potential adversaries. Moreover, most strategic and technological trends are gradual, not imminent, and thus do not require precipitous response. In particular, the image of a looming "space Pearl Harbor" created by the 2001 Rumsfeld commission is in my judgment still an overstatement of the nature of current and near-term dangers to American interests.

The basic backdrop for devising future U.S. space policy is roughly as follows:

- First, the United States uses space more and more for military purposes, particularly for tactical warfighting. It will surely continue to increase its dependency on reconnaissance, targeting, and communications satellites for such activities.
- Second, although the United States in particular, and certain other countries to a lesser extent as well, have militarized space in such ways, they have not yet weaponized space per se. That is, they have not placed weapons in orbit or developed weapons designed to attack satellites. However, the nuclear powers have ballistic missile forces that constitute latent ASAT capabilities, and the United States in particular is pursuing several ballistic missile defense programs that have latent ASAT potential as well.
- Third, the U.S. ability to rely on space systems cannot be assured indefinitely. Of particular concern are inherent vulnerabilities in low-altitude imaging satellites as well as commercial communications systems that a moderately capable adversary might eventually be able to exploit using microsatellites, lasers, or even nuclear weapons.
- Fourth, other countries will gradually gain a greater capability to use space for offensive military purposes themselves. In particular, they are likely to gain a capacity to find and target large mobile assets such as ships and major ground force formations—if not continuously, then at least sporadically.
- Fifth and finally, more futuristic space capabilities such as space-to-Earth weaponry or large constellations of space-based lasers for ballistic missile defense are likely to remain futuristic. But certain exotic concepts such as "brilliant pebbles" space-based ballistic missile defense rockets may be feasible within a decade or so.

Basic technological and strategic realities argue for a moderate and flexible U.S. military space policy. They argue against two extreme positions that have been espoused by prominent U.S. policymakers in recent years. The report of the Commission on Outer Space, which warned of a possible space "Pearl Harbor" and implied that the United States needed to rapidly take many steps—including offensive ones—to address such a purportedly imminent risk was alarmist. Most U.S. satellites are not vulnerable to attack today, and will probably not be in the years ahead—and to the extent they are vulnerable, they can often be protected through relatively passive measures rather than an all-out space weapons race. By racing to develop its own space weapons, the United States would cause two unfortunate sets of consequences. Militarily, it would legitimate a faster space arms race than is otherwise likely—something that can only hurt a country that effectively monopolizes military space activities today. Second, it would reinforce the current prevalent image of a unilateralist United States, too quick to reach for the gun and impervious to the stated will of other countries (as reflected in the huge majority votes at the United Nations in favor of negotiating bans on space weaponry). Among its other consequences, this perception can make it harder for the United States to oppose treaties that it has good reasons to oppose (as when the Bush administration withdrew from the ABM Treaty). It can also make it harder for the United States to uphold international nonproliferation norms since its own actions weaken its credibility in demanding that others comply with arms control regimes.

By the same token, the categorical opposition to space weapons evidenced by large elements of the arms control community is too optimistic. For one thing, the United States will not realistically be able to continue its monopoly on the current array of space technologies, by which it uses space assertively and confidently for military intelligence, communications, and tactical warfighting while potential enemies cannot themselves do so. And it needs to recognize that other countries are already interested in challenging America's military space monopoly, regardless of their political rhetoric on the subject. Moreover, there is little reason to think that space should be seen as a sanctuary for any and all military applications in the present era. It is no longer used largely for purposes of reassurance, arms control verification, and strategic stability enhancement as in the latter decades of the Cold War. It has since become, as much as anything else, a medium for basing tools of the tactical warfighter.

So a moderate and nuanced policy, rather than an absolutist or ideological one, is the right path ahead for the country. But getting beyond broad ideological arguments and laying out concrete guidelines for the future requires a rather detailed type of analysis. This testimony provides such an analysis, at least in preliminary form. Its main thrusts are that a policy of slowing space weaponization now, while protecting key U.S. space assets and preserving U.S. military space options for the future, should have the following key elements:

- The United States should recognize that some of its military satellites and many of the commercial satellites on which its armed forces increasingly depend for communications are already vulnerable, and quite likely to become more so.
- Accordingly, the United States should explore, at the research and development level for now, various active self-defense mechanisms for satellites. These will of course require sensors for detecting and tracking possible threat satellites, such as microsatellites carrying explosives or other devices for interfering with them. But they could also entail short-range weapons, such as high-powered microwaves, low-intensity lasers, or deployable microsatellites that could pursue and somehow neutralize the enemy microsat once they reached it. Such self-defense weapons should not be deployed until concrete evidence shows that they are needed, however, since most could be used not just defensively but offensively. That same consideration argues against appropriating large additional sums for such activities, though modest increases may be in order.
- Partly because the future survivability of its own satellites cannot now be assumed, and partly because the future survivability of adversary satellites may not be tolerable under certain circumstances, the United States should not rule out the possibility of developing ASAT capabilities of its own. It should not hasten to develop, test, or deploy ASATs. But nor should it preclude their possibility, either by treaty or by excessive constraints on its basic research and development activities.
- In fact, the United States already possesses latent forms of ASAT capability. Of course, it has had nuclear-armed ICBMs and SLBMs for decades which could certainly be use for ASAT purposes if programmed to detonate at a certain time near a certain point in space. It also has MIRACL laser in New Mexico that could probably damage certain lower-altitude satellites. And the midcourse intercept system deployed in Alaska and California surely has at least latent capability against low-Earth orbit satellites (even if it might require software upgrades to accept targeting data from different sensors than would likely be used for missile defense).

The airborne laser will probably soon have similar capabilities. Again, it would need help from external sensors to find and track a satellite, and quite likely software upgrades to be able to accept the data from those sensors. The latent ASAT capabilities of these technologies are on balance desirable, not regrettable, and no technical or arms control measures should be adopted to preclude them. That said, the United States should keep such capabilities latent for now. It does not yet need them, and acquiring them would have substantial strategic fallout.

- The United States should not build a dedicated ASAT soon. It already has substantial leads in any ASAT competition in the form of its ABL and midcourse ballistic missile defense programs that suffice amply for present strategic requirements.
- Similarly, the United States should not hasten the development or deployment of space-based missile defenses, which would have inherent ASAT capabilities. They are not needed for missile defense, given the variety of ground-based options soon to be available. And if deployed for missile defense, they would have to be deployed in such large numbers (given absentee ratios due to the movement of satellites above the Earth) that they could pose a very serious threat to many satellites simultaneously.
- The United States should not expect, at least at this time, remarkable new capabilities from technologies such as microsatellite swarms. Such swarms, acting together to produce an integrated image or communications capability that today can only be created by a large device, are sometimes touted as a way to reduce American dependence on single, expensive, easily located and targeted satellites. However, swarms may not prove so survivable themselves, may not degrade gracefully if individual components are damaged or destroyed, or simply may not prove feasible and cost-effective. The underlying technology and software requirements for these capabilities are nowhere near ripe.
- Space-to-Earth weapons are an unpromising concept for the foreseeable future. In addition to their politically very provocative character, they offer few benefits to a global military power already capable of rapid intercontinental strike. The technologies within reach, such as tungsten rods that could be deorbited as a swarm, or a common aero vehicle that could function first as a reentry vehicle and then as a guided aerodynamic device, are undesirable. They are either too limited in

capabilities, too expensive, or too uninteresting for their attributes relative to ground-based systems to warrant deployment. Further conceptual exploration and basic research may be warranted; nothing more than that is desirable in the coming years (and hence budgets need not be substantially increased).

These ideas are developed further below.

HARDENING AND DEFENDING (OR DOING WITHOUT) U.S. SATELLITES

What are the basic ways in which military satellites can be protected? And to the extent protections are insufficient, how can satellite backups be developed for possible emergency use in war? The basic fact of the matter is that protection can be developed against a number of electronic threats, but that explosives are difficult to counter. As such, satellite vulnerability is here to stay as a physical fact of life. Moreover, the U.S. military's increasing dependence on commercial satellites for communications means that it is now vulnerable to relatively simple jamming as well. Arguments that hardening satellites, building spares, building decoys, and taking similar measures may suffice as antidotes against ASATs are often advanced.[1] But they are not completely reassuring, even if such steps are still justified to reduce U.S. vulnerabilities and delay the date by which they become more serious.

Several types of defensive responses can be imagined to counter a growing vulnerability of American satellites. At the simplest level, greater monitoring of space activities may be desirable so that the United States will know more confidently if and when its satellites are being threatened. Greater hardening and other passive defenses—against nuclear effects, against lasers and artificial heating, against homing microsatellites—is next on the list of increasingly assertive and active measures. Then some simple satellite defenses, such as greater fuel for maneuvering and possible means of attacking homing microsatellites, could be envisioned. Finally, if and when it is determined that all of the above cannot reliably defend U.S. space assets, alternatives may be needed—ranging from the capacity for rapid launching of replacement satellites to ground-based substitutes for satellites.

The specific recommendations that emerge from this analysis are straightforward. First, military satellites should continue to be hardened against nuclear effects, and to the extent possible should also employ radio transmission frequencies and signal strengths capable of penetrating a nuclear-disturbed atmosphere. These recommendations should be straightforward to implement; indeed, they already have been for some systems such as MILSTAR. Second, low-Earth orbit (LEO) satellites should have sensors capable of detecting laser illumination and possibly other attack mechanisms as well, together with the means to protect themselves temporarily against such harassment or attacks via shutter controls for protection of their optics. (Someday, they may also need means of cooling themselves against prolonged exposure from high-energy lasers.) Third, despite such measures, it should be assumed that most types of military satellites may not be available in future war, and alternatives thus maintained. This is particularly true for lower-altitude assets. Fourth, plans should be made in the event that commercial communications satellites, which probably cannot be hardened in any practical way, prove unavailable for purposes of warfighting. That assumption should lead the U.S. military to devise means for making do with much-reduced bandwidth in combat; it should also buttress efforts to develop more dependable means of communications such as laser satellite constellations.

Improved Space Monitoring

The United States needs to know if its satellites are under attack or likely to soon be under attack, to the extent possible.[2] Otherwise, evidence of attack may only occur as multiple simultaneous satellite failures allow for no other real possibility. Such sensors can trigger shields or other protective measures to be deployed against certain types of threats, such as jammers or lasers. They may allow for satellite maneuvers or other means of evading kinetic or explosive attack, as discussed more below. For example, if the enemy ASAT were in reasonably close proximity, it might be defeated with high-energy but short-range microwaves by a device that would not necessarily constitute a more general ASAT capability. But leaving aside the possible responses, which are not urgently needed at present, space awareness is important on multiple grounds and should be improved now.

Some U.S. satellites, including Defense Support Program early-warning assets and National Reconnaissance Office imaging satellites, already have some attack warning capability. But most U.S. satellites apparently do not.[3] The U.S. space surveillance network can track the movements of larger objects or boosters, and that may suffice for now against homing space mines. But at some future date, satellites may need their own warning of approaching microsats. And low-altitude satellites should soon have sensors that would alert them to artificial illumination by laser.

Greater Resilience to Jamming

Jamming is generally fairly easy against the communications links of satellites that have not been made resilient to such attacks. As one example, at the Air Force Research Laboratory, engineers “homebuilt” an effective jammer using about $7,500 worth of goods bought at electronics and hardware stores.[4]

A good deal of protection can be provided in this area. But it is unlikely to be practical for commercial satellites, on which the U.S. military does depend for many high-data-rate transmissions such as those needed in tactical targeting (even if not for most high-level strategic command and control operations). Among its other implications, that fact heightens the importance of moving along with the laser satellite communication system now under development by the Department of Defense, which will provide enormous bandwidth through the military’s own system.

But the military also needs to prepare for the possibility that it will not have as much available communications bandwidth as it would like in future conflicts. The United States needs to ensure some level of robust, survivable satellite communications. New DSCS satellite systems with bandwidths in the vicinity of 60 Mbps are a step in the right direction (well above the MILSTAR capacities of 1 to 2 Mbps).[5] Data transmission rates needs to be minimized as much as possible. That can be done through data compression techniques that can transmit high-fidelity data with one-tenth the bandwidth or slightly degraded data at one-hundredth the bandwidth of standard means.[6] It can also be done by maximizing the amount of analysis done by the platform obtaining the data.[7] Finally, the military needs to develop procedures for prioritizing its use of satellites so that it can make do with less capacity if necessary.

New GPS satellites with greater power will also be helpful as counters to jamming, and should not be again postponed (the GPS 3 constellation is to begin deployment in 2011 according to current plans).[8] If possible, indeed, deployment should be hastened. For now, inertial guidance or other terminal guidance may still be needed as a supplement to GPS for munitions used against a capable foe.

Improved Electronic Hardening

Satellites can be hardened against the electronic interferences created by nuclear detonations. The concept of a Faraday cage is well known and practical. Costs may grow by a few percent, up to perhaps 10 percent, as a result, but for military satellites in particular, the costs are hardly onerous. If there has been any letup in such hardening since the Cold War ended, it s should be rectified; it is hardly beyond the realm of the conceivable that an enemy would attack U.S. satellites with nuclear weapons.

It is dubious that such hardening will ever occur for most commercial satellites, however, again underscoring the importance of not depending on such capabilities for wartime purposes indefinitely. Even if the government were prepared to subsidize such hardening, the satellites would remain vulnerable to jamming and to direct attack, calling into question the value of the effort.

For military systems, however, hardening should be de rigeur. It is important for low-Earth orbit systems. [9] It is also desirable at higher altitudes. Satellites in MEO are often already hardened, since normal Van Allen radiation is greater at such altitudes, necessitating protective measures. But standards may not be not sufficiently demanding for all altitudes, from what can be deduced through unclassified sources. If true, that situation should be remedied.

There is yet another reason for radiation hardening, apart from nuclear threats. Within perhaps 15 years, countries such as China could have the capacity to attack a variety of satellites using high-powered microwaves. The basic physics of radio-frequency weapons and high-powered microwave weapons is not particularly complicated. The engineering challenges associated with building devices that can emit very short pulses of radio energy, lasting perhaps just billionths of a second but reaching billions of watts in power, are considerable, but far from insurmountable.[10] So as satellites are designed and produced in the coming years, such possible enemy capabilities should form part of the assumed future threat environment.[11]

Increased Defenses Against Explosives

Alas, physically shielding satellites from the effects of nearby explosives is difficult to do, given the ability of a hunter-killer satellite or space mine to approach arbitrarily close to a target satellite before being detonated. It probably should be viewed as simply not worth the effort even to attempt.

Could satellites maneuver, or be given self-defense weapons, to evade hunter killer satellites? Maneuvering is a difficult proposition given the size of certain satellites; a ten-ton imaging satellite will have a hard time escaping from a 10-kg explosive charge with small boosters attached. As a general proposition, maneuvering may work against simple ASATs with poor terminal guidance, but is likely to fail against small, sophisticated ASATs.[12] Perhaps the larger satellite could be given small explosive charges of its own to fire at such a device. But this gets into a more assertive kind of space weapon capability. Increased maneuvering capability may not be a permanent solution, but it could buy the United States time down the road and should be retained as an option, albeit a costly one given the corresponding fuel requirements.

Backup Satellite Capabilities and Alternatives to Satellites

If the United States could take the expensive but prudent step of having some additional satellite capability in its inventory at all times, together with the ability to launch and make operational such satellites quickly, it would mitigate its vulnerability to antisatellite weapons. In particular, it would be better prepared against ASAT threats that were only capable of incapacitating a small number of its space assets.

Largely for this reason, Space Command would like to gain the capacity to replenish satellites in orbit within days. It hopes to have such an ability towards the end of the decade.[13] However, since that goal was articulated in 1998, the United States has not made rapid progress towards lowering launch costs or satellite costs.

Regardless of progress on the rapid relaunch front, the United States is probably entering an era when it should no longer count on its satellites remaining safe and secure. No foe is likely close to an ability to "clean up the heavens," systematically eliminating the dozens of GPS and communications satellites on hand for U.S. military use when needed. But satellites deployed now only in small numbers, such as imaging and signals intelligence satellites, may be more plausibly attacked. Over time, minisatellites or directed-energy weapons may even put the large constellations at risk. Although such a period of time is probably quite distant, the United States should avoid blind optimism in the availability of all satellite capabilities.

The United States needs backups to satellites. Even if they prove less capable or efficient than the satellites they would replace, they are important, because the United States cannot afford to develop "single-point failures" that would bring down whole warfighting systems after the loss of a single type of asset. Catastrophic degradation of U.S. military capabilities from a single type of action or attack must be prevented.

As a practical matter, this conclusion means several things are necessary. First, numerous airborne assets, particularly for imaging and signals intelligence, but also for targeting and guidance and communications, should be retained in the force posture despite their non-trivial cost. In addition, refurbishment or modernization programs for assets such as P-3 aircraft and EC-135 electronic reconnaissance aircraft need to be kept on track. Second, additional backup capabilities such as fiber optic land lines and undersea lines should be retained in numerous regions of the world to permit high-volume intercontinental communications even if satellites are lost. Third, naval fleets, ground-force units, and aircraft should retain the ability to communicate internally through line-of-sight and airborne techniques so that battle groups always have the ability to function as single entities even if their access to satellites is disrupted.

THE OFFENSIVE OPTION: ANTISATELLITE WEAPONS

Despite the wide range of available policy options in the defensive realm, the United States may also need offensive military capabilities in space at some point. Over the course of the next 10 to 15 years, the key question is how should the United States approach the issue of antisatellite weapons.

One rationale for a U.S. decision to develop ASAT capabilities could be the acquisition of good ASATs by U.S. rivals or enemies, coupled with an inability too protect American satellites robustly through passive and defensive measures like those discussed above. Latent ASAT capabilities are already in the hands of many U.S. rivals and foes, primarily in the form of nuclear-tipped ballistic missiles. Many countries capable of space launch could also probably develop, in fairly short order, ASATs similar in principle to the Soviet co-orbital interceptor concept developed in the 1970s. To date they have not yet done so, as far as we know, though it is remotely possible that a country could test such a capability under the guise of putting a satellite into space (by trying to guide it to a moving aimpoint following the trajectory of a simulated satellite). Development of microsatellites may give countries other, somewhat stealthier options as well over time. This is not a trivial undertaking; microsatellites need to be boosted into the general orbital vicinity of a target before being able to reach it, increasing the chances of detection. But the technology is advancing and can be expected to keep doing so. Finally, ground-based directed energy systems such as high-energy lasers may be of concern too. All of these types of capabilities would be difficult to prohibit using arms control arrangements and standard verification tools. If other countries developed ASAT capabilities themselves, a corresponding U.S. capability would probably be prudent as a deterrent if nothing else. But it would be fairly straightforward and quick simply to give existing ballistic missile defense systems ASAT capability, so this judgment need not imply a dedicated ASAT program and in fact should not at this time.

It is conceivable that, someday, the United States would wish to be the first to develop ASAT capabilities under certain future circumstances. Specifically, if an enemy could plausibly develop a war-winning capability, or even a notable military advantage, through use of its own satellites, the United States might decide that its security would be promoted by possessing ASATs. That might be true even if acquiring an ASAT spurred other countries to develop their own. If in a future conflict near their shores, China or Iran had imaging satellites capable of finding U.S. aircraft carriers in those theaters, then passing targeting information to platforms carrying long-range antiship missiles, U.S. aircraft carriers might be put at acute risk. ASATs might then be seen as the only way to make continued carrier operations in such waters feasible. Indeed, the United States might be willing to tolerate an ASAT arms competition in which its own satellites were put at greater risk in order to ensure incapacitation of the potential enemy's ability to strike large, valuable American targets. This would be particularly true if the United States heeded the above advice about defensive measures, and made sure its satellite capabilities were hardened, redundant, and backed up with non-orbiting assets that could take over the roles normally played by satellites if need be. In such circumstances, as the country projecting power, the United States might have a disproportionate dependence on large and vulnerable military assets; it would also probably have a greater ability to substitute other types of C4-ISR assets for satellites if necessary. So an ASAT competition might improve its prospects for decisive victory in such a war—and hence also improve its ability to deter the conflict in the first place—relative to an arrangement in which military space assets were granted de facto sanctuary.

Weighing the Pros and Cons of Weaponization

The above discussion is not meant to sanction development and use of antisatellite weapons. No U.S. decision to engage in an ASAT competition could ever be taken lightly. Given the degree of international opposition to the weaponization of space, the potentially destabilizing effects of attacking satellites that provide reassurance and communications during crises, and the debris that could be created in orbital zones near Earth from kinetic energy and explosive weapons in particular, ASATs could have major downsides. In addition, the United States benefits greatly from the status quo in space, in which it enjoys virtually exclusive capabilities to find and target enemy forces using satellite technology, and should try to preserve this state of affairs as long as possible. Whether the advantages of ASATs might outweigh these downsides at a future date is at least possible. But the time is not yet right for that approach.

A cautious military planner might naturally tend to disagree with the above assessment, and advocate more rapid progress towards various types of U.S. weapons in space. But cautious military planners should not make American security policy by themselves; their views should be balanced by cautious strategic planners. And the latter know that pursuit of unilateral military advantage sometimes leads to dynamics that can render one's own country, as well as the potential adversary, less secure. Examples abound in the realm of weapons of mass destruction. The United States has elected in modern times not to pursue chemical or biological arms. It made that decision on the grounds that deploying such arms would likely reduce its security—largely by legitimating weapons that the world community would be better off without to the extent possible, especially given the potential for such weapons to fall into the hands of irresponsible and aggressive countries. It made similar decisions in the Cold War in regard to missile defense, certain types of nuclear testing, nuclear weapons based in space, and indeed satellites as well. In most cases, it did not doubt its ability to out-compete its potential adversary in narrow terms. But it recognized that the action-reaction or arms-race dynamic that was almost certain to result would not advance its interests, and that in some cases it had asymmetric dependencies on assets such as satellites that argued for restraint in the development of weapons to threaten them.

Of course, many things have changed since the end of the Cold War. But that fact argues for rethinking a number of American security policies from first principles, not for discarding them simply because they arose under different strategic circumstances.

Spelling Out a Hedging Strategy

So what are the proper components of U.S. strategy towards the weaponization of space? What is a prudent hedging strategy? A central goal should be to make sure the United States is not surprised, and technologically outdistanced, by advances in ASAT capabilities that another country is able to achieve. A related goal should be to gradually explore technologies of potential use in ASATs in case the United States someday finds it in its interest to be the first to develop these weapons.

This philosophy argues for laboratory research on basic ASAT technologies at present. It also condones more advanced development and testing of systems with some inherent ASAT potential, such as the midcourse and airborne laser missile defense systems. But they should not now be given the final capabilities needed to work as ASATs (notably, means of finding and fixing on satellite targets) or tested in ASAT modes.

This approach could also involve some elements of formal arms control accords of indefinite duration. But any such limitations would have to be carefully defined and rather specific. Informal restraint, perhaps through temporary and unilateral pledges, would be preferable in most cases. More specifically, elements of a "lead, but with restraint" or a hedging strategy might include the following:

Pursue Laboratory Research at a Moderate Level. Basic research and development generally makes sense to conduct. But it need not be over-emphasized. Funding in the range of tens of millions of dollars a year for most basic types of technologies and basic concepts is adequate.

Because such indoor, laboratory activities cannot be remotely monitored, and because they provide the United States long-term options it may someday need, they should be allowed by international accords, and the United States should pursue them itself. However, the scale of effort should be restrained, given that the urgency of needing ASAT-related technologies is limited. Accelerating research now would waste money, risk sending the wrong message to other countries if and when the scale of a major program was revealed, and create bureaucratic and political pressures in the United States to ultimately field any system that was developed. None of those outcomes serve near-term to medium-term U.S. security interests.

Overall space-related R&D funding is robust now and need not go up more than already planned. Indeed, planned increases may be excessive in some cases, though it is difficult to know based on unclassified sources. In 1999, space-related research accounted for about $432 million or 39 percent of all Air Force science and technology funding; by 2005, the figures are expected to reach $847 million and 59 percent, respectively, and to keep going up thereafter. Main drivers include laser communications, miniaturization concepts, imagery systems, and other satellite concepts ranging from ballistic missile defense to communications to navigation.[14]

Continue Advanced Development Work on Various Missile Defense Concepts

Systems such as the Clinton administration's midcourse defense could easily have capabilities against low-altitude satellites, which move at roughly the altitudes and speeds characteristic of ballistic missile warheads. Other missile defense concepts may have similar capacity. Notable is the airborne laser, designed primarily for intercepting relatively short-range missiles in their boost phase. Even though satellites would not be located in the upper atmosphere, where the airborne laser is intended to do its work, they are probably no more difficult to reach with its beam than a burning rocket within the upper atmosphere. They would not be destroyed via the same mechanism as a liquid-fueled ballistic missile, the intended target of the ABL, but in many cases could be damaged or destroyed by its megawatt-class laser. The airborne laser is not quite as advanced as the Clinton midcourse system, but it could be capable of an intercept within several years.

These types of programs thus will provide real, if latent, ASAT capabilities rather soon. That fact is not reason enough to cancel or curtail the programs. Missile defense is a sufficiently worthwhile enterprise to justify the effort. LEO satellite trajectories are so similar to those of ballistic missiles—in fact, easier to intercept, since they are more predictable—that a long-range midcourse missile defense system is in effect also an ASAT by definition, at least within certain geographic constraints.

But this fact is not necessarily a downside of missile defense development. Because other means of countering enemy satellites—jamming downlinks and uplinks, destroying ground stations, hiding U.S. military assets or making them hard to track—are not foolproof, some ASAT backup may prove prudent in the future. The possibility that the United States will someday need ASAT capability is great enough that missile defense systems with potential ASAT applicability are useful to possess. At the same time, however, it is strongly preferable that they not yet be provided all the capabilities needed for ASAT purposes, or tested against satellites. An approach of hedging makes the most sense.

A Role for Arms Control?

Although the United States may need ASAT capability at some future date, certain restraints may be desirable. Some could be informal; some temporary. In general, they should be carefully tailored so as not to preclude development of various capabilities in the future. But they could still help reassure other countries about U.S. intentions at a time of still-unsettled great power relations, and help protect space against creation of excessive debris or other hazards to robust and safe use.

Some constraints might be formalized. For example, destructive testing of weapons such as the Clinton midcourse missile defense system against objects in satellite orbital zones would not only increase the risks of an ASAT competition. It would also create debris in LEO regions that would remain in orbit indefinitely (unless the testing occurred in what was effectively the higher parts of the Earth's atmosphere, where air resistance would ultimately bring down debris and where few if any satellites fly in any case). Tests to date have occurred at roughly 140 miles altitude, producing debris that de-orbits within roughly twenty minutes, but future tests will be higher. A ceiling of perhaps 300 to 400 miles might be placed on such tests, and a ban placed on using targets that are in orbit. One approach, as suggested by a prominent Air Force officer, would be for the United States to pledge unilaterally not to create space debris through testing or operations of any ASAT.[15] But it would be better yet for the idea to be codified in multilateral treaty form. (On a related, but non-weapons matter, it may also be worthwhile to consider requiring commercial satellite builders to de-orbit old satellites and adopt other debris-mitigation measures as a condition for gaining licences to put objects into space.[16])

But most restraints should be unilateral and thus reversible if necessary. Notably, the United States should state that it will not test missile defense systems such as the ABL against objects in space for the foreseeable future. Testing is not necessary to assure the inherent ASAT capabilities of such systems. Tracking and pointing at satellite targets can be tested without firing weapons, so a system such as ABL can be confidently assumed to have inherent ASAT capability without testing it in that mode.

Moreover, it is desirable to avoid the final steps of providing ABL with an ASAT capability. It is better to show some level of restraint, even as the basic technological wherewithal for someday developing an ASAT is ensured. Moving quickly and explicitly to an ASAT capability is not desirable, given the Pandora's box of international outcry and military and strategic responses it would likely engender at U.S. expense. Testing would only be needed at the final stage of weaponization, and the United States is nowhere near such a point. The hope is that it never will reach that point, if relations with the other great and space-faring powers can continue to be improved. Policy should serve that latter goal rather than the narrow goal of rapidly maximizing ASAT capabilities on the assumption that the United States will fight countries such as China in the future. Such assumptions are unwarranted and do not serve U.S. interests; if given free rein, they can become self-fulfilling prophecies. Again, military planners must not be allowed to trump broader strategic planners in the American security debate.

Emphasize Non-Destructive ASAT Concepts

To reduce the onus and negative symbolism of any ultimate development of ASAT technologies, the United States should focus preliminary laboratory research on technologies that would have the minimal destructive effects on any systems against which they were ultimately used. The goal of the United States should be, where possible, to avoid destroying satellites, even in a situation where some type of counter-satellite capability is deemed necessary.[17] Not only kinetic or explosive destruction, but even permanent damage to satellite optics or electronics, should be avoided if it proves possible to neutralize the satellites in a more temporary and benign fashion during conflict.

Options should include jamming communications and destroying or otherwise neutralizing ground stations. The latter was done in Desert Storm and could often be carried out, at least against countries only possessing fixed and known ground stations. The former will not necessarily work against a sophisticated adversary capable of frequency-hopping operations, but can generally work against less sophisticated adversaries. As such, the United States is now looking into a deployable jammer that could be used to deny adversaries use of communications systems during conflict (by being located in the combat theater, near enemy lines of communication, the jammer could not easily be tuned out by the enemy).[18] Over the longer term, by 2020 or so, high-powered microwaves could provide an option for either lethal effects (if used at maximum pulse power) or temporary effects (if used at a lower, steadier power).[19]

Other options should including nonlethal ASAT concepts such as devices launched into space that would unfurl large opaque shrouds just below enemy satellites so that the latter could not track objects on Earth or communicate with Earth. Such options may not always be dependable or quickly usable in the actual event of a crisis or war, but they should be investigated, and perhaps someday built if necessary. This could give the United States ASAT capabilities without crossing clearly over the line towards space weaponization.

CONCLUSION

The United States depends enormously on its military space assets today. They do not function as the great stabilizers and arms control facilitators of the Cold War; in general, they have become tools of the tactical warfighter. That reduces the strategic and political case for treating them as protected assets or viewing space as a sanctuary from military competition.

But any U.S. policy to pursue the actual weaponization of space in the near term would be a mistake. It would probably lead to an arms competition that would put American assets at risk sooner than they otherwise would be. Coming in the face of strong international opposition, it would further exacerbate the image of the United States as a go-it-alone power. That could in turn weaken Washington's ability to hold other countries to their arms control and nonproliferation commitments.

That said, military space competition will occur regardless of American policy, and other countries will gradually learn to use space as the United States does today. That calls for a two-tier approach from Washington. It must continue to anticipate, and protect against, attacks on its satellites to the extent possible. Commercial communications satellites and low-altitude military assets are probably the most vulnerable. Measures ranging from improved hardening against lasers to more maneuvering capability against microsats to retention of ground-based alternatives to satellites are thus required. In addition, with crossing the rubicon of weaponization or testing, the United States should keep its technology options open for development of antisatellite weapons of its own. Certain missile defense systems, together with laboratory research, provide such capabilities; no dedicated ASAT programs are needed or desirable.

The United States, leading the way on the increased militarization of space, may not be able to prevent its weaponization indefinitely. But slowing the process for as long as possible now appears the best way to serve its core military and strategic interests.

[1] See James Clay Moltz, "Reining in the Space Cowboys," *Bulletin of the Atomic Scientists* (January/February 2003), p. 66.
[2] U.S. Space Command, *U.S. Space Command Long-Range Plan* (1998), p. 21; Robert Wall and David A. Fulghum, "Satellite Self-Protection Gains Added Protection," *Aviation Week and Space Technology*, October 28, 2002, p. 68.
[3] Robert Wall and David A. Fulghum, "Satellite Self-Protection Gains Added Attention," *Aviation Week and Space Technology*, October 28, 2002, p. 68.
[4] William B. Scott, "Innovation Is Currency of USAF Space Battlelab," *Aviation Week and Space Technology*, April 3, 2000, p. 53.
[5] Communication to author at Vandenberg Air Force Base, November 8, 2002.
[6] Michael Sirak, "US Air Force targets UAV bandwidth problem," *Jane's Defence Weekly*, July 31, 2002, p. 28.
[7] David A. Fulghum, "It Takes a Network To Beat a Network," *Aviation Week and Space Technology*, November 11, 2002, p. 31.
[8] Jeremy Singer, "U.S. Air Force Scales Back GPS Upgrade Plans," *Space News*, January 27, 2003, p. 8.
[9] It may be possible to clean up electrons pumped into Van Allen belts after a nuclear explosion. In other words, it may be possible to reverse the so-called Christofilos Effect, specifically through the use of low-freqency kilohertz waves emitted from ground stations to make electrons "rain out" of orbit. This may help make low-altitude space usable within months instead of years, provided of course that subsequent nuclear explosions can be prevented, and that new satellites can be orbited reasonably quickly to replace those that had been lost.
Ian Steer and Melanie Bright, "Blind, Deaf, and Dumb," *Jane's Defence Weekly*, October 23, 2002, pp. 21-23.
[10] Ira W. Merritt, U.S. Army Space and Missile Defense Command, "Radio Frequency Weapons and Proliferation: Potential Impact on the Economy," statement before the Joint Economic Committee, 105 Cong. 2 sess. (February 25, 1998); David A. Fulghum, "Microwave Weapons Await a Future War," *Aviation Week and Space Technology*, June 7, 1999, pp. 30-31; Carlo Kopp, "The E-Bomb—A Weapon of Electrical Mass Destruction," Monash University (Australia), 1998; and Barbara Starr, "Russian Bomb-Disarming Device Triggers Concerns," *Jane's Defence Weekly*, March 18, 1998, p. 4.
[11] Robert Wall, "Chinese Advance In Electronic Attack," *Aviation Week and Space Technology*, October 28, 2002, p. 70.
[12] See Tom Wilson, "Threats to United States Space Capabilities," Paper prepared for the Commission to Assess United States National Security Space Management and Organization, 2001, pp. 41-46.
[13] U.S. Space Command, *U.S. Space Command Long-Range Plan* (1998), p. 24.
[14] John A. Tirpak, "Challenges Ahead for Military Space," *Air Force Magazine* (January 2003), pp. 25-26.
[15] Peter L. Hays, "Military Space Cooperation: Opportunities and Challenges," in James Clay Moltz, ed., *Future Security in Space: Commercial, Military, and Arms Control Trade-Offs* (Monterey, Calif.: Monterey Institute of International Studies, 2002), p. 42.
[16] Moltz, "Reining in the Space Cowboys," pp. 62-64.
[17] Space Command recognizes as much. See U.S. Space Command, *U.S. Space Command Long-Range Plan* (1998), p. 44.
[18] Michael Sirak, "Pentagon Eyes Near-Term Ability to Block Satcom," *Jane's Defence Weekly*, July 24, 2002, p. 8.
[19] U.S. Space Command, *U.S. Space Command Long-Range Plan* (1998), pp. 46, 63.